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Acknowledgements

Information contained in this manual was compiled from several publications; these publications are listed below. The Ohio Department of Agriculture would like to thank these entities for the use of their publications.

1. “Wood Preservatives for Applicators” - written by the U.S. EPA.

2. “Wood Preserving Chemicals and Procedures” (out of print) - written by The Ohio State University Extension.

3. “Ohio Pesticide Applicator Training Wood Preservation Student Workbook” - written by The Ohio State University.


Author: Diana Roll

Editors: Kelly Boubary
Betty Whiting
OSUE Staff
William Pound
Chapter 1: STATE AND FEDERAL LAWS

LEARNING OBJECTIVES
1. The federal laws that regulate pesticides
2. The state laws that regulate pesticides
3. The category
4. The standards
5. Recertification

STATE AND FEDERAL LAWS
The Pesticide Applicator Core Packet discusses the federal and state laws that govern the handling and use of pesticides. Review the core packet and understand how laws and regulations affect pesticide practices and use. These laws include federal laws such as the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), the Occupational Safety and Health Act (OSHA), the Endangered Species Act, and the Federal Migratory Bird Treaty Act. Pesticide technicians should keep up-to-date copies of the laws and review their contents periodically. Copies of the state laws can be obtained from the Ohio Department of Agriculture.

FEDERAL LAWS

FIFRA
This is the basic federal law administered by the Environmental Protection Agency (EPA) that regulates pesticides (their use, handling, storage, transportation, sale, disposal, etc.). The Ohio Department of Agriculture (ODA) has a cooperative agreement with the EPA to enforce some provisions of FIFRA in Ohio. One of the provisions of FIFRA is that the EPA must register all pesticides except for 25b exempt pesticides. Pesticides must be registered with the State of Ohio before they can be sold within the state. The pesticides must be classified as either "general use" or "restricted use." General-use pesticides are those that can be purchased without restriction. Restricted-use pesticides are those that can be used only by or under the direct supervision of a certified applicator. FIFRA also stipulates that persons who misuse pesticides (in a way that is "inconsistent with the pesticide labeling") are subject to penalties.

OSHA
The U.S. Department of Labor (DOL) administers OSHA. OSHA governs the record-keeping and reporting requirements of all work-related deaths, injuries, and illnesses of businesses with 10 or more workers.

Endangered Species Act
This act requires the U.S. EPA to ensure that endangered or threatened plant and animal species are protected from pesticides. This act requires each pesticide label to limit its use in areas where these species could be harmed. Category 6d applicators must consider the possibility that the pesticides they apply may affect threatened or endangered species. The Ohio Department of Natural Resources (ODNR) Wildlife and
Fisheries Management divisions maintain the federal and state endangered or threatened species lists. Ohio applicators that want to be sure they are complying with the act must take the initiative and consult with the ODNR to be sure that there are no endangered or threatened species in their area. One of the goals of pest management is to protect off-target plants and animals from pesticides, whether they are endangered or not.

THE STATE LAW

The Pesticide Law
The Ohio Pesticide Law is the law that governs the pesticide applications in the state of Ohio. The Ohio Department of Agriculture is the state agency that regulates this law and the pesticide applicators that are licensed by the state. If you have any questions or concerns you should contact the Ohio Department of Agriculture, Plant Industry Division, Pesticide Regulation Section and we would be happy to assist you with any questions or concerns.

DEFINITION OF CATEGORY

The Definition
The definition for wood preservation as stated in the law is as follows: Category 4 is "Forest pest control" which means the application of pesticides to forested areas or forest products for the control of weed pests (other than vertebrate). The subcategory b “Wood preservation” means the application of pesticides to wood products such as crossties, poles, shingles, posts or other wood products that are not part of a structure when treated and are or will be exposed to insects, fungi, marine pests, or weather. This category does not include the treatment for the control of termites and other wood destroying organisms in houses or in an area as a pretreatment prior to the construction of a structure.

THE STATE PLAN FOR OHIO

The State Lead Agency
The state lead agency for the plan is the Ohio Department of Agriculture. The Governor assigned the responsibility of this plan to the Division of Plant Industry on March 12, 1973.

The State Plan Document
The plan is the document by which the Ohio Department of Agriculture, Pesticide Regulation Section, and The Ohio State University Extension were given the responsibilities for the certification and training of the commercial and private pesticide applicators in Ohio. The Ohio Department of Agriculture is responsible for the testing and licensing of all pesticide applicators in Ohio. The Ohio State University Extension is responsible for training the private applicator. Private Industry associations and companies who offer continuing education credits for those applicators that wish to re-certify and not re-test are very important to the plan.
The plan sets forth the standards by which the Ohio Department of Agriculture and The Ohio State University develop study materials, pesticide exams and pesticide training. These standards are called standards of competency.

**Standards of Competency**

Commercial and private applicators are required to demonstrate their knowledge and understanding of the handling and use of pesticides by means of written, closed book examinations; based on the standards of competency set forth in 40 CFR 171.4. Standards are set forth for the Core exam and for all the categories. The additional “Standards of Supervision” of non-certified applicators must be met, such as availability related to the hazard of the situation, instructions and guidance when presence is not required, and methods of contacting supervisor if and when needed.

**General standards**

- Commercial applicators interested in obtaining the 4b certification shall demonstrate practical knowledge of the principles and practices of pest control and safe use of pesticides
- A comprehension of labeling format and terminology together with and understanding of permitted uses, classification, associated warnings, precautions and other restrictions such as reentry
- Safety factors related to handling, storage and disposal of pesticides, particularly those factors pertaining to the prevention of personal injury through accidents, misuse, symptoms of pesticide poisoning and first-aid treatment
- Adverse environmental effects, such as water or soil pollution and injury to non-target organisms
- The recognition of common types of pests, their damage symptoms, basic developmental stages and optimum periods of pesticide susceptibility
- Types of formulations of pesticides (both chemical and functional), their modes of action, persistence and compatibility with various other compounds
- Application techniques for greatest effectiveness with minimal adverse side effects
- Appropriate state or federal laws pertaining to the production, distribution, sale or use of pesticides and to the supervision of non-certified applicators
- Potential of contaminating wells, ground water and surface water by pesticides
- Areas in the state where threatened and endangered species plants or animals are to be protected from pesticides

**Specific Standards**

Forest pest control Category “4”, Subcategory “b”, Wood Preservation: Commercial applicators shall demonstrate a practical knowledge of:

- Types of wood, tree anatomy, and physiology
- Disease and insect problems
- Factors affecting wood treatment such as moisture content
- Types of wood preservatives
Commercial Wood Preservation Study Guide

- Required safety equipment and cautions in use of preservatives
- Disposal of treated and unused wood
- Other pertinent information necessary for safe and adequate application of pesticides

PESTICIDE LICENSE INFORMATION

Application process
The application and fee are only valid for the licensing period noted on the application that is submitted. If all requirements are not met within the license period listed on the application, the application and fee are voided and the fee is non refundable. License fees cannot be transferred from one company to another. When a first time applicant submits the application and fee, study material will be sent to assist in preparation for the examinations. Categories are listed on the application.

Exams
Examination requirements are: the General-Core examination which covers the law, regulations, safety, disposal and related topics, and an examination for each category in which you need to be certified and licensed. The categorical examinations are specific to what area you will be applying the insecticide, herbicide, fungicide, etc. Most examinations consist of multiple-choice questions. The exams are not open book exams. For exams given at the Reynoldsburg address, results should be received within five (5) days of the exam; results are not given over the phone. For exams given in the outlying counties, exam results are mailed two-three weeks after the test date; they are not given over the phone. If you fail the exams, you must wait at least five days to retest. If you need to retest there is no additional fee required. Exams are only valid for 12 months from the date you pass the exam. If you do not meet the other qualifications within that year for a license to be issued within 12 months, the exams expire and you will need to retest. There is a Pesticide Applicator New School for new applicants conducted by The Ohio State University, which is held every year in late February or early March. Their web site is: http://pested.osu.edu. This site also offers other licensing information; test sites, recertification sites and study material.

Please call the Pesticide Regulation Section at (614) 728-6987 or 1-800-282-1955 to schedule your appointment to take the exams or register on line at www.state.oh.us/agr/. The application is only valid for the licensing year in which you have applied. (The year is listed on the application). If you do not meet requirements within the year that you have applied for, then a new application and fee will be required, and no refund is given. Ohio Dept. of Agriculture web site: http://www.ohioagriculture.gov look for regulatory programs click on it, then look for Pesticide Regulation.

Commercial Renewal and Recertification Information
Once you have passed the applicable exams for the license and a license has been issued, you are certified for three years. The license must be renewed continuously every year in order to keep the three-year certification valid. You need to renew the license every year (at the end of September), which consists of submitting a renewal application and fee. You need to recertify every three years (recertification due date is printed on your license) by retesting or attending recertification programs. Your recertification is based on the first year you obtained your license, which is based on the
license year you passed exams and met all other requirements. Once you have been issued a license, you may begin obtaining your recertification credits at any time during the three-year recertification cycle. You must obtain the following requirements for recertification - TOTAL MINIMUM OF FIVE HOURS OF TRAINING CONSISTING OF 1 HOUR OF CORE TRAINING AND 2 HOURS IN EACH CATEGORY YOU ARE LICENSED – HOWEVER, IT MUST BE A TOTAL MINIMUM OF FIVE HOURS. If you have met your category requirements you must still make sure you meet the time requirement by attending approved classes whether or not they are in your licensed category.

If you do not meet the recertification requirements of 1-hour minimum in Core, at least ½ hour in your licensed category or categories with a total minimum time of **5 hours** before the recertification expiration date listed on your license, then you must retest.
Chapter 2: BASIC WOOD INFORMATION

LEARNING OBJECTIVES
1. The structure of wood
2. The different types of wood

WOOD STRUCTURE
Understanding the minute structure of wood helps one explain the action of wood decay fungi and the impregnation of wood with preservative chemicals. Some basic similarities are found in all wood species and some striking differences are present in certain individual species. Only those characteristics that have a bearing on decay and treatment will be discussed here.

THE BASIC WOOD CELL
Even though wood may seem to be a solid material, it is plant material made of plant cells. The basic wood cell is often referred to as a fiber or a longitudinal trachea. Pinch a soda straw at both ends and you will have a model of what this wood fiber looks like. It is long, slender and hollow. The thickness of the cell wall varies, as does the size of the cell cavity. Early wood or spring wood cells usually have thin walls and large cavities. Each growing season produces both early wood and late wood. Each new annual growth ring is formed just beneath the bark of the tree.

CELLULOSE, HEMICELLULOSE AND LIGNIN
The cell walls of wood fibers are made up of small bits of cellulose imbedded in a matrix of hemicelluloses. A thin layer of lignin cements all of these wood fibers together, much like a mortar in a brick wall. All three of these constituents are sugars formed from carbon, hydrogen and oxygen.

PITS
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. In a like manner, the impregnation of wood with chemical solutions or oils is aided by the presence of these pits.

RAYS
All wood species have small tissues called rays that weave their way between the longitudinal fibers from the bark toward the pith. Rays are conductive structures that are situated in a radial direction of right angles to the annual rings. In most wood species, the rays are barely visible to the naked eye. Oak, beech, maple and sycamore are hard woods that have larger rays.
VESSELS AND PORES
Hardwoods have vessels but softwoods do not. The open ends of vessels are often called pores. Hardwoods are sometimes called porous woods because of these vessels. Several specialized longitudinal cells are joined together end to end in each vessel. The diameter and distribution of the vessels vary among the woods. Oak, elm and ash have large vessels in the early wood portion of each annual ring. Poplar, maple and gum have smaller vessels distributed evenly throughout the wood.

Fig. 2.1 Wood cells

SOFTWOODS AND HARDWOODS
Tree species with needles and cones such as the pines, spruces, true firs and Douglas fir are called softwoods. The broadleaf tree species such as the oaks, maples, gum and yellow poplar are called hardwoods. The wood of the softwood species is made up mostly of longitudinal fibers with a small percentage of rays. The woods of the hardwood species usually have larger rays and contain a significant volume of vessels.

Douglas fir and southern pine are the principal softwood species used for preservative treatment. These include construction lumber and round timbers. Oak and gum are the most commonly used hardwood with most of these in the form of rail ties.

SAPWOOD AND HEARTWOOD
Each new growth ring is formed between the bark and the wood of the previous season. This new wood is superimposed upon the wood of the previous season. This new wood will live and function as conductive tissue for about 15 years. It is called sapwood because its function is conducting water from the root system to the crown.

Annual rings of the trees that have served there time and are covered by 15 or so newer layers of wood die. There follows a period of transformation from sapwood to heartwood. The new heartwood becomes a disposal area for waste products of respiration carried on in other parts of the tree. Rays seem to be a means of transporting these waste products in the heartwood. The nature of this chemical varies from one tree species to another. Color, odor and toxicity to decay fungi are the variables.

The principal significance of sapwood and heartwood to the wood preserving industry is that heartwood is difficult or impossible to treat. The dry sapwood of southern pine is relatively easy to impregnate with preservative solutions. The heartwood segment of
these same timbers of lumber is difficult or impossible to impregnate. Other species of sapwood may be more difficult to treat with preservatives.

**NATURAL DECAY RESISTANCE**
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. The sapwood of all species is without this natural decay resistance.
Chapter 3: PESTS THAT DAMAGE WOOD

LEARNING OBJECTIVES
1. The types of pests
2. Their life cycles
3. How to identify the pests
4. How they damage the wood

Under proper use conditions, wood can give centuries of good service; but under unfavorable conditions, wood may readily be damaged and destroyed by fungi, insects, and marine borers. These pests can attack in many ways, using the wood for food or shelter. Consequently, wood must be protected to insure maximum service life when used under conditions favorable to these pests.

WOOD-INHABITING FUNGI
Fungi cause wood decay, mold and most sapwood stains. These fungi feed on living or dead wood. The many fungi that develop on or in wood can be divided into two major groups, depending on the damage they cause:

- wood-destroying fungi (decay fungi),
- wood-staining fungi (sap staining fungi, mold fungi).

Both of these fungi groups produce spores (analogous to tiny seeds), which are distributed by wind and water. The spores can infect moist wood during storage, processing and use.

All fungi that grow on wood have certain basic requirements:

- Favorable temperature - usually ranging between 50 degrees and 90 degrees F. The optimum is about 70 degrees to 85 degrees F. Wood is basically safe from decay at temperatures below 35 degrees F and above 100 degrees F.
- Adequate moisture - Fungi will not attack dry wood (i.e. wood with a moisture content of 19 percent or less). Decay fungi require wood moisture content (M.C.) of about 30 percent (the generally accepted fiber saturation point of wood). Thus, air-dried wood, usually with a M.C. not exceeding 19 percent and kiln dried wood with a M.C. of 15 percent or less can usually be considered safe from fungal damage.
- Adequate oxygen - Fungi cannot live in water-saturated wood.
- Food source (wood itself).
WOOD DESTROYING FUNGI
Both the sapwood and heartwood of most tree species are susceptible to decay. 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 the wood is destroyed.

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.

Wood decay fungi can be grouped into three major categories:

- Brown rot,
- White rot, and
- Soft rot.

**Fig 3.1 Brown rot**

**Brown rot** - Fungi that cause Brown rot are able to break down the cellulose component of wood for food, 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:

- dark brown color of the wood
- excessive shrinkage
- cross-grain cracking, and
- the ease with which the dry wood substance can be crushed to powder.

Brown-rot fungi are probably the most important cause of decay of softwood species used in aboveground construction in the United States. Brown rot, when dry, is sometimes called “dry rot”. This is a poor term, because wood must have moisture and will not decay when it is dry.

A few fungi that can decay relatively dry wood have water-conducting strands that are able to 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”.

**Fig. 3.2 White rot fungi**

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

**Soft rot** – Soft rot fungi usually attack green (water-saturated) wood (high M.C.), causing a gradual softening from the surface inward that resembles Brown rot.

**WOOD STAINING FUNGI**

**Fig. 3.3 Sap staining fungi**

**Sap staining fungi** - these fungi penetrate and discolor sapwood, particularly of the soft wood species. Typical sap stain, unlike staining by mold fungi, cannot be removed by brushing or planning. Sap stain fungi may become established in the sapwood of standing trees, saw logs, lumber and timbers soon after they are cut and before they can be adequately dried. Strength of the wood is little affected, but the wood may not be fit for uses where appearance is important (such as siding, trim, furniture and exterior millwork that is to be clear-finished).

Southern pine beetles often carry blue stain fungi into trees. This can cause the wood of infected trees to be stained before they are cut.

**Fig. 3.4 Mold fungi**

**Mold fungi** - these 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 in 5 to 6 days or less. As with sap stains, molds do not reduce wood strength, however, they can increase the capacity of wood to absorb moisture, thereby opening the door to attack by decay fungi.
CHEMICAL STAINS
Chemical stains may resemble blue or brown stains, but are not caused by fungi. These stains result from chemical changes in the wood during processing or seasoning. The most important chemical stains are the brown stains that can downgrade lumber for some uses. Rapid drying at relatively low temperatures during kiln drying usually can prevent them.

INSECTS
Several kinds of insects attack living trees, logs, lumber and finished wood products for food and/or shelter. These pests include various termites, ants, and beetles.

Termites
Termites use wood for food and shelter and are the most destructive of all wood insects.

Ants cannot use wood for food, but they are often confused with termites because the two look somewhat similar. However, there are several distinct differences in their physical appearance. Ants have ‘elbowed’ antennae; termites do not. Ants have narrow waists whereas termites' bodies are broad. Ants' wings have few veins and the hind wings are smaller than the front wings. Both pairs of termite wings are similar in shape and size and have very small veins.

Termites are divided into three major groups:

- Subterranean or ground-inhabiting termites
- Drywood Termites
- Dampwood Termites

Fig. 3.5 Subterranean Termite

Subterranean Termites - These termites attack wood products in buildings and other wood products throughout the continental United States, but most damage occurs in the warm, southern coastal regions along the Atlantic Ocean and Gulf of Mexico.
At certain seasons of the year, winged males and females are produced by the termite colony. They swarm, mate, lose their wings, and attempt to begin a new colony in the soil. Termites build tunnels through earth and around obstructions to get to a source of food (either sound or decaying wood). They also require a constant source of moisture - usually obtained from the soil.

The presence of subterranean termites may be noted by:

- the swarming of winged, ant-like insects and the discarded wings observed after swarming
- earthen shelter tubes built over masonry or other foundations to a source of wood
- the presence of white workers when termite shelter tubes are broken open
- the hollowed-out condition of badly infested wood products

Drywood Termites - Drywood termites are found naturally only in Hawaii, Puerto Rico, and in a narrow strip of land extending from southern California and Texas to Florida and along the Atlantic coast to Virginia. Although Drywood termites are naturally found in these places, they can be transported to other parts of the country by wood infested with the termite. Wood shipped to other cities and ports, infested with the Drywood termites, should be treated as soon as possible.

After swarming, drywood termites enter cracks and crevices in dry, sound wood. In excavating their galleries, they occasionally discharge oval-shaped fecal pellets through temporary openings in the wood surface. The ability of the drywood termite to live in dry
wood without direct contact with the soil increases its menace. However, it reproduced slowly and does not destroy wood as quickly as the subterranean termite.

**Ants**

Carpenter ants may be black or red. They usually live in stumps, trees, or logs, but often damage poles or structural timbers set in the ground. Elevated portions of buildings, such as windowsills and porch columns, are susceptible to damage. Carpenter ants use wood for shelter not for food. They usually prefer wood that is naturally soft or has been softened by decay. The galleries are large, smooth and, unlike those of termites, are free of refuse and powdery wood. Mounds of sawdust indicate their presence.

![Carpenter Ant](image)

**Beetles**

**Powder Post or Lyctus Beetles** - Powder post beetles attack both freshly cut and seasoned hardwoods and softwoods. They attack the sapwood of ash, hickory, oak, and other hardwoods.

Adults lay eggs in the wood pores. The larvae burrow through the wood, making tunnels from 1/16 to 1/12-inch in diameter, packed with a fine powder. After a larval period (from a few months to a year, or longer - depending on the species) and a much shorter pupal stage, newly formed adults chew holes through the wood surface and emerge to lay eggs for another brood. Signs of damage by powder post beetles are:

- small round 1/16-inch holes in the surface of the wood made by emerging adults, and
- fine powder that falls from the wood.
Anobiid beetles - May attack softwoods in damp and poorly ventilated spaces beneath buildings. Eliminating the source of moisture will cause the colony to slowly die out.

Roundhead Borers - A longhorn beetle, commonly known as the old house borer, damages seasoned pine timbers. The larvae bore through the wood. Over many years 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 in the Eastern and Gulf Coast States.

Roundhead borer adults (longhorn beetles) have long antennae that reach the tip of the elytra in the females, and can be four to five times the length of the body in the males (see Fig. 3.10 below). The elytra is wider than the pronotum.

Roundhead borer larvae are large and robust with the head and body generally the same width.
A. Ponderosa pine bark borer, \((Acanthocinus princeps)\)
B. Ponderosa pine bark borer, \((Acanthocinus princeps)\) (larva in tunnel of pine tree)
C. Cottonwood borer, \((Plectrodera scalator)\)
D. Swollen stem (gall) of poplar with tunnels and the larval stage of \((Saperda populnea)\)
E. Sugar maple borer \((Glycobius speciosus)\)
F. Drawing by L.H. joutel showing life cycle of the Sugar maple borer\((Glycobius speciosu)\)

![Image of insect life cycle]

Fig. 3.10 Roundhead Borers

1. eggs laid in bark
2. larva after one summer season
3. nearly full grown larva
4. female adult
5. emergence hole
6. borings packed in burrow

Most representatives of this family infest and feed on dead or dying trees. However, several are important pests of living healthy trees and shrubs. The boring of the larval form into the cambium and sapwood of woody plants can cause great harm and injury and even kill.
Larvae reduce sapwood to a powdery or sawdust-like consistency. They may take several years to complete their development. While working in the wood, they make a ticking or gnawing sound. When mature, the adult beetle makes an oval emergence hole about 1/4 inch in diameter in the surface of wood.

**Flathead Borers** - Flathead 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 3/4 inch long, with wing covers usually rough, like bark.
Marine Borers

Extensive 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 United States they are especially active in the warm waters of the Pacific, Gulf, and South Atlantic coasts. Untreated timbers can be destroyed in less than a year.

The major marine borers are the shipworm and pholad mollusks (related to the clams and oysters), and the crustacean borers (related to the crabs and lobsters).
Chapter 4: WOOD HANDLING
AND TYPES OF WOOD
PRESERVATIVES

LEARNING OBJECTIVES
1. Learn about moisture control and how to use moisture
2. The seasoning of wood
3. How to properly store wood
4. Type of preservatives oilborne or waterborne

If wood is to be used where it will be subject to pest attack, it must be protected. This protection can be achieved by:

- control of moisture content
- use of a wood that is naturally resistant to the pests chemical treatment

In addition, mechanical barriers (such as metal termite shields and caps on pilings, poles and posts) are sometimes used, but are usually ineffective.

MOISTURE CONTROL
The moisture content of living trees and the wood products obtained from them may range from about 30 percent to more than 200 percent. Much of this moisture must be removed for most uses. ‘Green’ lumber usually is dried:

- to prevent stain and decay,
- to reduce damage by insects,
- to reduce uncontrolled dimensional change (shrinkage),
- to reduce weight and increase strength, and
- to prepare the wood for treatment with chemical preservatives.

The amount of water in wood (its moisture content) is usually expressed as a percentage of its oven dry weight. The moisture is measured by:

- the oven-drying method – a small sample of wood is weighed, dried, and reweighed until it has reached a constant weight when subjected to temperatures of 212°F - 220°F.
- the electrical method - use of a moisture meter that measures moisture by electrical resistance.

Timber or logs stored for a long time before processing can be protected from fungi and insects by:

- keeping the logs submerged in a pond of water
- keeping them under constant water spray
The water reduces the oxygen content and temperatures necessary for growth of fungi.

**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

The most efficient and most widely used system is kiln drying. It offers better control of air movement, temperature and drying rate than air-drying. Although kiln drying is more expensive in terms of capital investment and energy cost, it is much faster and provides more uniform and better quality drying. Unless lumber is properly stacked and protected, air-drying may result in surface checking, end cracking, warping, staining and discoloration due to weathering.

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

**Storage and Handling**
To avoid pest induced degrading of lumber during storage or handling, you should:

- Convert logs into lumber as quickly as possible.
- Dry the lumber as quickly as practical, even after pressure treatment with a preservative chemical, to prevent degrading (surface checking, and end cracking).
- Locate air-drying yards and sheds on well-drained sites with good air circulation, and keep the yards free of weeds.
- Practice good sanitation by removing debris or rotted wood, which serves as source of fungal infection and insects.
- Inspect stored wood products often. Termites, for example, may invade untreated stacked lumber if it remains undisturbed for long periods.
- Avoid rough handling of treated wood. Chipping, gouging, or splitting can expose unprotected interior wood and allow attack by decay fungi.

**Use of 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 species is quite resistant. Examples are the heartwood of old-growth bald cypress (limited supply), cedar, redwood, and post oak. They are resistant but definitely not immune to attack by decay fungi and insects. Black locust and resinous southern pine heartwood, called ‘fatwood’ or ‘lighterwood’ is also highly resistant to decay.

Unfortunately, some naturally resistant woods are expensive or unavailable in commercial quantities (i.e. chestnut) or in dimensions needed. Because of high costs for labor and materials, the variable and undependable resistance of these species should preclude their use for most high hazard construction applications.
CHEMICAL CONTROL
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, method of application, proportion of sapwood to heartwood, moisture content of the wood, amount of preservative retained, depth of chemical penetration and distribution. Sapwood of most commercial species accepts preservatives much better than heartwood, and 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.

Type of Preservatives - Wood preservatives fall into two broad categories:

I. Oilborne preservatives
II. Water-borne preservatives

Many different chemicals are in each of these classes, and each has differing effectiveness in various 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). In this chapter, both oilborne and water-borne preservative chemicals are described as to their potential and uses. Some active ingredients can be used in both oilborne and water-borne preservatives.

I. Oilborne Preservatives
These chemicals are generally insoluble in water. They are usually dissolved in petroleum or other organic solvents in order to penetrate wood. Research developments have recently made available oilborne 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,
• can be glued depending on the diluent or carrier, and
• ease of handling and use.

Disadvantages:

• can leave an oily, unpaintable surface, depending on the carrier,
• for some applications, provides somewhat less physical protection to wood than creosote,
should not be used in homes or other living areas because of toxic fumes, and,

- 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.

A. Coal-Tar Creosote

Coal-tar creosote (creosote) is a black or brownish oil made by distilling coal tar that is obtained after high temperature carbonization of coal. Advantages of creosote are:

1. High toxicity to wood-destroying organisms;
2. Relative insolubility in water and low volatility, which impart to it a great degree of permanence under the most varied use conditions;
3. Ease of application;
4. Ease with which its depth of penetration can be determined;
5. Relative low cost (when purchased in wholesale quantities);

The character of the tar used, the method of distillation, and the temperature range in which the creosote fraction is collected all influence the composition of the creosote. Therefore, the composition of the various coal-tar creosotes available may vary considerably. However, small differences in composition do not prevent creosotes from giving good service. Satisfactory results in preventing decay may generally be expected from any coal-tar creosote that complies with the requirements of standard specifications.

Several standards prepared by different organizations are available for creosote oils of different kinds. Although the oil obtained under most of these standards will probably be effective in preventing decay, the requirements of some organizations are more exacting than others. The American Society for Testing and Materials Standard D390 for coal-tar creosote has been approved for use by U.S. Department of Defense agencies. This standard covers new coal-tar creosote and creosote in use for the preservative treatment of piles, poles, and timber for marine, land, and fresh water use. Under normal conditions, most creosote producers can meet requirements of this standard without difficulty. The requirements of this specification are similar to those of the AWPA standard P1/P13 for creosote, which is equally acceptable to the user. Although coal-tar creosote (AWPA P1/P13) or creosote solutions (AWPA P2) are well suited for general outdoor service in structural timbers, this creosote has properties that are undesirable for some purposes. The color of creosote and the fact that creosote-treated wood usually cannot be painted satisfactorily make this preservative unsuitable where appearance and paintability are important. Creosote is commonly used for heavy timbers, poles, piles, and railroad ties.

The odor of creosote-treated wood is unpleasant to some people. Also, creosote vapors are harmful to growing plants, and foodstuffs that are sensitive to odors should not be stored where creosote odors are present. Workers sometimes object to creosote-treated wood because it soils their clothes, and creosote vapor photosensitizes exposed skin. With normal precautions to avoid direct skin contact with creosote, there appears to be no dangers to the health of workers handling or working near the treated wood. The EPA or the person treating the wood should be contacted for specific information on this subject.
In 1986, creosote became a restricted-use pesticide and is available only to certified pesticide applicators. For use and handling of creosote-treated wood, refer to the EPA-approved Consumer Information Sheet (Table 14-1).

Freshly creosoted timber can be ignited and burns readily, producing a dense smoke. However, after the timber has seasoned for some months, the more volatile parts of the oil disappear from near the surface and the creosoted wood usually is little, if any, easier to ignite than untreated wood. Until this volatile oil has evaporated, ordinary precautions should be taken to prevent fires. Creosote adds fuel value, but it does not sustain ignition.

B. Coal-Tar Creosotes for Non-pressure Treatments
Special coal-tar creosotes are available for non-pressure treatments, although these creosotes can only be purchased by licensed pesticide applicators. Special coal-tar creosotes differ somewhat from regular commercial coal-tar creosote in (a) being crystal-free to flow freely at ordinary temperatures and (b) having low-boiling distillation fractions removed to reduce evaporation in thermal (hot and cold) treatments in open tanks. Consensus standards do not exist for coal-tar creosote applied by brush, spray, or open-tank treatments.

C. Other Creosotes
Creosotes distilled from tars other than coal tar are used to some extent for wood preservation, although they are not included in current Federal or AWPA specifications. These include wood-tar creosote, oil-tar creosote, and water-gas-tar creosote. These creosotes protect wood from decay and insect attack but are generally less effective than coal-tar creosote.

D. Creosote Solution
For many years, either coal tar or petroleum oil has been mixed with coal-tar creosote, in various proportions, to lower preservative costs. These creosote solutions have a satisfactory record of performance, particularly for railroad ties and posts where surface appearance of the treated wood is of minor importance. The ASTM D391 "Creosote-Coal-Tar Solution" standard covers creosote-coal-tar solution for use in the preservative treatment of wood. This standard has been approved for use by agencies of the U.S. Department of Defense. This specification contains four grades of creosote solutions:

- (land and fresh water), contains no less than 80% coal-tar distillate (creosote) by volume
- (land and fresh water), contains no less than 70% coal-tar distillate (creosote) by volume
- (land and fresh water), contains no less than 60% coal-tar distillate (creosote) by volume
- Marine

The AWPA standard P2 similarly describes the requirements for creosote solutions. The AWPA standard P3 (for creosote petroleum oil solution) stipulates that creosote-petroleum oil solution shall consist solely of specified proportions of 50% coal-tar
creosote by volume (which meets AWPA standard P1/P13) and 50% petroleum oil by volume (which meets AWPA standard P4). However, because no analytical standards exist to verify the compliance of P3 solutions after they have been mixed, the consumer assumes the risk of using these solutions.

Compared with straight creosote, creosote solutions tend to reduce weathering and checking of the treated wood. These solutions have a greater tendency to accumulate on the surface of the treated wood (bleed) and penetrate the wood with greater difficulty because they are generally more viscous than is straight creosote. High temperatures and pressures during treatment, when they can be safely used, will often improve penetration of high viscosity solutions.

Even though petroleum oil and coal tar are less toxic to wood-destroying organisms and mixtures of the two are also less toxic in laboratory tests than is straight creosote, a reduction in toxicity does not necessarily imply less preservative protection. Creosote-petroleum and creosote-coal tar solutions help reduce checking and weathering of the treated wood. Posts and ties treated with standard formulations of these solutions have frequently shown better service than those similarly treated with straight coal-tar creosote.

E. Pentachlorophenol Solutions

Water-repellent solutions containing chlorinated phenols, principally pentachlorophenol (penta), in solvents of the mineral spirits type, were first used in commercial dip treatments of wood by the millwork industry about 1931. Commercial pressure treatment with pentachlorophenol in heavy petroleum oils on poles started about 1941, and considerable quantities of various products soon were pressure treated. The standard AWPA P8 defines the properties of pentachlorophenol preservative. Pentachlorophenol solutions for wood preservation shall contain not less than 95% chlorinated phenols, as determined by titration of hydroxyl and calculated as pentachlorophenol. The performance of pentachlorophenol and the properties of the treated wood are influenced by the properties of the solvent used.

The AWPA P9 standard defines solvents and formulations for organic preservative systems. A commercial process using pentachlorophenol dissolved in liquid petroleum gas (LPG) was introduced in 1961, but later research showed that field performance of penta/LPG systems was inferior to pentalP9 systems. Thus, penta/LPG systems are no longer used.

The heavy petroleum solvent included in AWPA P9 Type A is preferable for maximum protection, particularly when wood treated with pentachlorophenol is used in contact with the ground. The heavy oils remain in the wood for a long time and do not usually provide a clean or paintable surface.

Pentachlorophenol in AWPA P9, Type E solvent (dispersion in water), is only approved for aboveground use in lumber, timber, bridge ties, mine ties, and plywood for southern pines, coastal Douglas fir, and redwood.

Because of the toxicity of pentachlorophenol, care is necessary when handling and using it to avoid excessive personal contact with the solution or vapor. Do not use indoors or where human, plant, or animal contact is likely. Pentachlorophenol
became a restricted-use pesticide in November 1986 and is only available to certified applicators. For use and handling precautions, refer to the EPA-approved Consumer Information Sheet (Table 14-1).

The results of pole service and field tests on wood treated with 5% pentachlorophenol in a heavy petroleum oil are similar to those with coal-tar creosote. This similarity has been recognized in the preservative retention requirements of treatment specifications. Pentachlorophenol is effective against many organisms, such as decay fungi, molds, stains, and insects. Because pentachlorophenol is ineffective against marine borers, it is not recommended for the treatment of marine piles or timbers used in coastal waters.

F. Copper Naphthenate
Copper naphthenate is an organometallic compound that is a dark-green liquid and imparts this color to the wood. Weathering turns the color of the treated wood to light brown after several months of exposure. The wood may vary from light brown to chocolate-brown if heat is used in the treating process. The AWPA P8 standard defines the properties of copper naphthenate, and AWPA P9 covers the solvents and formulations for organic preservative systems.

Copper naphthenate is effective against wood-destroying fungi and insects. It has been used commercially since the 1940s for many wood products. It is a reaction product of copper salts and naphthenic acids that are usually obtained as byproducts in petroleum refining. Copper naphthenate is not a restricted-use pesticide but should be handled as an industrial pesticide. It may be used for superfi-cial treatment, such as by brushing with solutions with a copper content of 1% to 2% (approximately 10% to 20% copper naphthenate).

G. Chlorothalonil
Chlorothalonil (CTL) [tetrachloroisophthalonitrile] is an organic biocide that is used to a limited extent for mold control in CCA-treated wood (AWPA P8). It is effective against wood decay fungi and wood-destroying insects. The CTL has limited solubility in organic solvents and very low solubility in water, but it exhibits good stability and leach resistance in wood. This preservative is being evaluated for both aboveground and ground contact applications. The solvent used in the formulation of the preservative is AWPA P9 Type A.

H. Chlorothalonil/Chlorpyrifos
Chlorothalonil/chlorpyrifos (CTL/CPF) is a preservative system composed of two active ingredients (AWPA P8). The ratio of the two components depends upon the retention specified. CTL is an effective fungicide, and CPF is very effective against insect attack. The solvent used for formulation of this preservative is specified in AWPA P9.

I. Oxine Copper (copper-8-quinolinolate)
Oxine copper (copper-8-quinolinolate) is an organometallic compound, and the formulation consists of at least 10% copper-8-quinolinolate, 10% nickel-2-ethylhexanoate, and 80% inert ingredients (AWPA P8). It is accepted as a stand-alone preservative for aboveground use for sapstain and mold control and is also
used for pressure treating (Table 14-2). A water-soluble form can be made with dodecylbenzene sulfonic acid, but the solution is corrosive to metals.

Oxine copper solutions are greenish brown, odorless, toxic to both wood decay fungi and insects, and have a low toxicity to humans and animals. Because of its low toxicity to humans and animals, oxine copper is the only EPA registered preservative permitted by the U.S. Food and Drug Administration for treatment of wood used in direct contact with food. Some examples of its uses in wood are commercial refrigeration units, fruit and vegetable baskets and boxes, and water tanks. Oxine copper solutions have also been used on nonwood materials, such as webbing, cordage, cloth, leather, and plastics.

J. Zinc Naphthenate
Zinc naphthenate is similar to copper naphthenate but is less effective in preventing decay from wood-destroying fungi and mildew. It is light colored and does not impart the characteristic greenish color of copper naphthenate, but it does impart an odor. Water-borne and solvent-borne formulations are available. Zinc naphthenate is not used for pressure treating and is not intended as a stand-alone preservative.

K. Bis(tri-n-butylin) Oxide
Bis(tri-n-butylin) oxide, commonly called TBTO, is a colorless to slightly yellow organotin compound that is soluble in many organic solvents but insoluble in water. It is not used for pressure treating or as a stand-alone preservative for in-ground use. TBTO concentrate contains at least 95% bis(tri-n-butylin) oxide by weight and from 38.2% to 40.1% tin (AWPA P8). This preservative has lower mammalian toxicity, causes less skin irritation, and has better paintability than does pentachlorophenol, but it is not effective against decay when used in ground contact. Therefore, TBTO is recommended only for aboveground use, such as millwork. It has been used as a marine antifoulant, but this use has been almost eliminated because of the environmental impact of tin on shellfish.

L. 3-Iodo-2-Propynyl Butyl Carbamate
3-Iodo-2-propynyl butyl carbamate (IPBC) is a preservative that is intended for nonstructural, aboveground use only (for example, millwork). It is not used for pressure treating applications such as decks. The IPBC preservative is included as the primary fungicide in several water-repellent-preservative formulations under the trade name Polyphase and marketed by retail stores. However, it is not an effective insecticide. Water-borne and solvent-borne formulations are available. Some formulations yield an odorless, treated product that can be painted if dried after treatment. IPBC is also being used in combination with didecyldimethylammonium chloride in a sapstain-mold formulation (NP-1). IPBC contains 97% 3-iodo-2-propynyl butyl carbamate, with a minimum of 43.4% iodine (AWPA P8).

M. Alkyl Ammonium Compound
Alkyl ammonium compound (AAC) or didecyldimethylammonium chloride (DDAC) is a compound that is effective against wood decay fungi and insects. It is soluble in both organic solvents and water and is stable in wood as a result of chemical fixation reactions. It is currently being used as a component of ammoniacal copper quat (ACQ) (see section on Water-borne Preservatives) for aboveground and ground contact and is a component of NP-1 for sapstain and mold control.
N. Propiconazole
Propiconazole is an organic triazole biocide that is effective against wood decay fungi but not against insects (AWPA P8). It is soluble in some organic solvents, but it has low solubility in water and is stable and leach resistant in wood. It is currently being used commercially for aboveground and sapstain control application in Europe and Canada. Solvents used in the formulation of the preservative are specified in either AWPA P9 Type C or Type F.

O. 4,5-Dichloro-2-N-Octyl-4-Isothiazolin-3-One
4,5-dichloro-2-N-octyl-4-isothiazolin-3-one is a biocide that is effective against wood decay fungi and insects. It is soluble in organic solvents, but not in water, and is stable and leach resistant in wood. This biocide is not currently being used as a wood preservative. The solvent used in the formulation of the preservative is specified in AWPA P9 Type C.

P. Tebuconazole
Tebuconazole (TEB) is an organic triazole biocide that is effective against wood decay fungi, but its efficacy against insects has not yet been evaluated. It is soluble in organic solvents but not in water, and it is stable and leach resistant in wood. Currently, TEB has no commercial application. The solvents used in the formulation of this preservative are specified in either AWPA P9 Type C or Type F.

Q. Chlorpyrifos
Chlorpyrifos (CPF) is a preservative recently put into standard (AWPA P8). It is very effective against insect attack but not fungal attack. If fungal attack is a concern, then CPF should be combined with an appropriate fungicide, such as chlorothalonil - chlorpyrifos or IPBC - chlorpyrifos.

R. Water-Repellent and Nonpressure Treatments
Effective water-repellent preservatives will retard the ingress of water when wood is exposed above ground. Therefore, these preservatives help reduce dimensional changes in the wood as a result of moisture changes when the wood is exposed to rainwater or dampness for short periods. As with any wood preservative, the effectiveness in protecting wood against decay and insects depends upon the retention and penetration obtained in application. These preservatives are most often applied using nonpressure treatments like brushing, soaking, or dipping.

Preservative systems containing water-repellent components are sold under various trade names, principally for the dip or equivalent treatment of window sash and other millwork. Many are sold to consumers for household and farm use. Federal specification TT-W-572 stipulates that such preservatives (a) be dissolved in volatile solvents, such as mineral spirits, (b) do not cause appreciable swelling of the wood, and (c) produce a treated wood product that meets a performance test on water repellency.

The preservative chemicals in Federal specification TT-W-572 may be one of the following:
• Not less than 5% pentachlorophenol
• Not less than 1% copper in the form of copper naphthenate
• Not less than 2% copper in the form of copper naphthenate for tropical conditions
• Not less than 0.045% copper in the form of oxine copper for uses when foodstuffs will be in contact with the treated wood

The National Wood Window and Door Association (NWWDA) standard for water-repellent preservative non-pressure treatment for millwork, IS 4-94, permits other preservatives, provided the wood preservative is registered for use by the EPA under the latest revision of the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) and that all water repellent preservative formulations are tested for effectiveness against decay according to the soil block test (NWWDA TM 1).

The AWPA Standard N1 for non-pressure treatment of millwork components also states that the EPA, under the latest revision of FIFRA, must register any water-repellent preservative formulation for use. The preservative must also meet the Guidelines for Evaluating New Wood Preservatives for Consideration by the AWPA for non-pressure treatment.

Water-repellent preservatives containing oxine copper are used in non-pressure treatment of wood containers, pallets, and other products for use in contact with foods. When combined with volatile solvents, oxine copper is used to pressure-treat lumber intended for use in decking of trucks and cars or related uses involving harvesting, storage, and transportation of foods (AWPA P8).

II. Waterborne Preservatives - This class of preservatives includes various metallic salts and other compounds. The principal compounds used are combinations of copper, chromium, arsenic and fluoride.

Water-borne preservatives have gained increasingly wider usage for lumber, plywood, fence posts, poles, pilings and timbers.

Advantages:
• treatment presents no hazard from fire or explosion,
• the wood surface is left clean, paintable and free of objectionable odors,
• safe for interior use and treatment of playground equipment, and
• leach resistant.

Disadvantages:
• unless re-dried after treatment, the wood is subject to warping and checking,
• does not protect the wood from excessive weathering.

Water-borne preservatives are often used when cleanliness and paintability 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 piling.

Test results based on seawater exposure have shown that dual treatment (water-borne copper-containing salt preservatives followed by creosote) is possibly the most effective method of protecting wood against all types of marine borers. The AWPA standards have recognized this process as well as the treatment of marine piles with high retention levels of ammoniacal copper arsenate (ACA), ammoniacal copper zinc arsenate (ACZA), or chromated copper arsenate (CCA). Poorly treated or untreated heartwood faces of wood species containing "high sapwood" that do not require heartwood penetration (for example, southern pines, ponderosa pine, and red pine) have been found to perform inadequately in marine exposure. In marine applications, only sapwood faces should be allowed for water-borne-preservative-treated pine in direct seawater exposure.

Water-borne preservatives leave the wood surface comparatively clean, paintable, and free from objectionable odor. CCA and acid copper chromate (ACC) must be used at low treating temperatures (38°C to 66°C (100°F to 150°F)) because they are unstable at higher temperatures. This restriction may involve some difficulty when higher temperatures are needed to obtain good treating results in woods such as Douglas fir. Because water is added to the wood in the treatment process, the wood must be dried after treatment to the moisture content required for the end use intended. Inorganic arsenicals are a restricted-use pesticide. For use and handling precautions of pressure-treated wood containing inorganic arsenicals, refer to the EPA-approved Consumer Information Sheet.

Standard wood preservatives used in water solution include ACC, ACZA, and CCA (Types A and C). Other preservatives in AWPA P5 include alkyl ammonium compound (AAC) and inorganic boron. Water-borne wood preservatives, without arsenic or chromium, include ammoniacal copper quat (ACQ) (Types B and D), copper bis(dimethylthiocarbamate) (CDDC), ammoniacal copper citrate (CC), and copper azole-Type A (CBA-A), for aboveground use only.

A. Acid Copper Chromate
Acid copper chromate (ACC) contains 31.8% copper oxide and 68.2% chromium trioxide (AWPA P5). The solid, paste, liquid concentrate, or treating solution can be made of copper sulfate, potassium dichromate, or sodium dichromate. Tests on stakes and posts exposed to decay and termite attack indicate that wood well-impregnated with ACC gives acceptable service, but it is more prone to leaching than are most other water-borne preservatives. Use of ACC is generally limited to cooling towers that cannot allow arsenic leachate in cooling water.

B. Ammoniacal Copper Zinc Arsenate
Ammoniacal copper zinc arsenate (ACZA) is used in the United States but not in Canada. It is commonly used on the West Coast for the treatment of Douglas fir. The penetration of Douglas fir heartwood is improved with ACZA because of the chemical composition and stability of treating at elevated temperatures. Wood treated with ACZA performs and has characteristics similar to those of wood treated with CCA.
ACZA should contain approximately 50% copper oxide, 25% zinc oxide, and 25% arsenic pentoxide dissolved in a solution of ammonia in water (AWPA P5). The weight of ammonia is at least 1.38 times the weight of copper oxide. To aid in solution, ammonium bicarbonate is added (at least equal to 0.92 times the weight of copper oxide).

A similar formulation, ammoniacal copper arsenate (ACA), is used in Canada. This preservative is used most commonly to treat refractory species, such as Douglas fir. Service records on structures treated with ACA show that this preservative provides protection against decay and termites. High retention levels of preservative will provide extended service lives to wood exposed to the marine environment, provided pholad-type borers are not present. ACZA replaced ACA in the United States because ACZA has less arsenic and is less expensive than ACA.

C. Chromated Copper Arsenate

Three types of chromated copper arsenate (CCA)-Types A, B, C-are covered in AWPA P5, but Type C is by far the most commonly used formulation. The compositions of the three types are given in Table 14-4. Standard P5 permits substitution of potassium or sodium dichromate for chromium trioxide; copper sulfate, basic copper carbonate, or copper hydroxide for copper oxide; and arsenic acid, sodium arsenate, or pyroarsenate for arsenic pentoxide.

1. CCA Type A (Greensalt)-Currently, CCA Type A is only being used by a few treaters in California. CCA Type A is high in chromium. Service data on treated poles, posts, and stakes installed in the United States since 1938 have shown that CCA Type A provides excellent protection against decay fungi and termites.

2. CCA Type B (K-33)-Commercial use of this preservative in the United States started in 1964, but it is no longer used in significant quantities. CCA Type B is high in arsenic and has been commercially used in Sweden since 1950. It was included in stake tests in the United States in 1949 and has been providing excellent protection.

Table 4-1. Composition of the three types of chromated copper arsenate

<table>
<thead>
<tr>
<th>Component</th>
<th>Chromated copper arsenate (parts by weight)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Type A</td>
</tr>
<tr>
<td>Chromium trioxide</td>
<td>65.5</td>
</tr>
<tr>
<td>Copper oxide</td>
<td>18.1</td>
</tr>
<tr>
<td>Arsenic pentoxide</td>
<td>16.4</td>
</tr>
</tbody>
</table>

*As covered in AWPA P5.

3. CCA Type C (Wolman)-Currently, Type C is by far the most common formulation of CCA being used because it has the best leach resistance and field efficacy of the three CCA formulations. CCA Type C composition was selected by AWPA technical committees to encourage a single standard for CCA preservatives. Commercial preservatives of similar composition have been tested
and used in England since 1954, then in Australia, New Zealand, Malaysia, and in various countries of Africa and Central Europe; they are performing very well.

High retention levels (40 kg/m$^3$ (2.5 lb/ft$^3$)) of the three types of CCA preservative will provide good resistance to Limnoria and Teredo marine borer attack. In general, Douglas-fir heartwood is very resistant to treatment with CCA.

**D. Ammoniacal Copper Quat**
There are basically two types of ammoniacal copper quat (ACQ) preservatives (AWPA P5):

- Type B (ACQ-B) [ammoniacal]
- Type D (ACQ-D) [amine-based]

The compositions of these two types are given in Table 14-5. ACQ is used for many of the same applications as are ACZA and CCA, but it is not recommended for use in salt water. ACQ-B, the ammoniacal formulation, is better able to penetrate difficult to treat species such as Douglas fir; ACQ-D provides a more uniform surface appearance. Wood products treated with ACQ Type B and D are included in the AWPA Commodity Standards (Table 14-2).

**E. Copper bis(dimethyldithiocarbamate)**
Copper bis(dimethyldithiocarbamate) (CDDC) is a reaction product formed in wood as a result of the dual treatment of two separate treating solutions. The first treating solution contains a maximum of 5% bivalent copper-ethanolamine (2-aminoethanol), and the second treating solution contains a minimum of 2.5% sodium dimethyldithiocarbamate as covered in AWPA P5. $^b$DDAC is didecyldimethylammonium chloride. (AWPA P5). CDDC-treated wood products are included in the AWPA Commodity Standards (Table 14-2) for uses such as residential construction. Like CCA and ACQ-D, CDDC is not recommended for treatment of refractory species such as Douglas fir.

<table>
<thead>
<tr>
<th>Component</th>
<th>Ammoniacal copper quat (parts by weight)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Type B</td>
</tr>
<tr>
<td>Copper oxide</td>
<td>66.7</td>
</tr>
<tr>
<td>Quat as $^b$DDAC</td>
<td>33.3</td>
</tr>
<tr>
<td>Formulation</td>
<td>ammoniacal</td>
</tr>
</tbody>
</table>

**F. Ammoniacal Copper Citrate**
Ammoniacal copper citrate (CC) has 62.3% copper as copper oxide and 35.8% citric acid dissolved in a solution of ammonia in water (AWPA P5). CC-treated wood products are included in the AWPA Commodity Standards (Table 14-2). Like other ammonia-based preservatives, CC can be used to treat refractory species such as Douglas fir.

**G. Copper Azole-Type A**
Copper azole-Type A (CBA-A) has 49% copper as Cu, 49% boron as boric acid, and
2% azole as tebuconazole dissolved in a solution of ethanolamine in water (AWPA P5). Wood products treated with CBA-A are included in the AWPA Commodity Standards for aboveground use only (Table 14-2).

H. Inorganic Boron (Borax/Boric Acid)
Borate preservatives are readily soluble in water, are highly leachable, and should only be used above ground where the wood is protected from wetting. When used above ground and protected from wetting, this preservative is very effective against decay, termites, beetles, and carpenter ants. Borates are odorless and can be sprayed, brushed, or injected. They will diffuse into wood that is wet; therefore, these preservatives are often used as a remedial treatment. Borates are widely used for log homes, natural wood finishes, and hardwood pallets.

The solid or treating solution for borate preservatives (borates) should be greater than 98% pure, on an anhydrous basis (AWPA P5). Acceptable borate compounds are sodium octaborate, sodium tetraborate, sodium pentaborate, and boric acid. These compounds are derived from the mineral sodium borate, which is the same material used in laundry additive.
Chapter 5: APPLICATION OF WOOD PRESERVATIVES

Learning Objectives
1. Wood preservative descriptions
2. Where they are used
3. Personal Protective Clothing (PPE)
4. Safety
5. First Aid
6. Disposal
7. Wood treatment processes

DESCRIPTION OF PRESERVATIVES

CCA (chromated copper arsenate): used for fence posts, railroad ties etc. Creosote: 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 (oilborne preservatives): crystalline compound dissolved in light petroleum oil. Products treated with penta include construction lumber and timber, utility poles and crossarms, and fence posts.

Inorganic arsenicals (water-borne preservatives): compounds of arsenic, chromium, copper, zinc, and fluoride. They differ from creosote and penta in that they are water-soluble inorganic substances, as opposed to oily, organic substances. Wood treated with inorganic arsenicals may be used for patios, decks, playground equipment, and interiors.

Borates
The borates are compounds of one or more metallic elements combined with the borate radical ($\text{B}_2\text{O}_3$). This group forms two subgroups, the hydrous borates and the anhydrous borates.

Hydrous Borates - The hydrous borates are borates that have water ($\text{H}_2\text{O}$) in their structure. These minerals are soft, brittle, and white to very lightly colored. Many are soluble in water, and are found in dry lake deposits.

Anhydrous Borates - The anhydrous borates represent very few minerals. They form from igneous or metamorphic sources, as opposed to the hydrous borates, which form in arid regions usually at dry lake deposits. The anhydrous borates contain no water in their structure. They are rare and have no industrial value. Their composition is stable; they are strong minerals and are usually very hard.
HARMFUL EFFECTS AND SYMPTOMS
EPA's decision to restrict the use of these preservatives was based on their toxicity. Some of the adverse health effects associated with their use are listed below:

**Creosote:** This chemical may cause skin cancer in persons regularly exposed to it. Prolonged and repeated exposure may lead to dermatitis (inflammation of the skin). The liquid and vapors can irritate eyes and the respiratory tract. Symptoms of exposure include vomiting, dizziness, headache, convulsions, and respiratory difficulties.

**Penta:** It has produced defects in the offspring of laboratory animals. Exposure to it during pregnancy should be avoided. Symptoms of exposure include irritation of eyes, nose and throat, sneezing and coughing, weakness, anorexia, weight loss, sweating, headaches, dizziness, nausea, vomiting, chest pains, fever, and dermatitis.

**Inorganic arsenicals:** These compounds have been associated with cancer in humans who either drank water contaminated with arsenic or who breathed air-containing arsenic. Symptoms of exposure are weakness, loss of appetite, nausea, vomiting, and diarrhea. Results may be liver damage, loss of hair and fingernails, anemia, and skin disorders.

For maximum protection during the application and mixing process and in all situations where skin contact is expected, you must wear long-sleeve shirts, long...
pants, gloves, and an impermeable apron. Gloves should be long enough to protect the wrist and should be worn over the sleeves to prevent the preservatives from running up the arm. **ALWAYS WEAR GLOVES WHEN YOU HANDLE FRESHLY TREATED WOOD.** If you enter pressure-treatment cylinders or other related equipment that is contaminated with the wood treatment solution, **YOU MUST WEAR PROTECTIVE CLOTHING.** This includes overalls, jacket, gloves, and nonskid boots that are impervious to the wood treatment solution. Protective clothing should be made of vinyl, polyvinyl chloride, neoprene, rubber or polyethylene.

Wear clean clothes daily. If you get a spill on your clothing, change immediately. Do not bring contaminated clothing home with you. Leave any worn-out protective clothing, work shoes, or boots at the treatment plant. Dispose of them in any general landfill, or with the trash. **IF YOU MUST WASH PROTECTIVE CLOTHING AT HOME, WASH IT SEPARATELY FROM OTHER LAUNDRY.**

**SAFETY PRECAUTIONS WHEN SPRAYING PRESERVATIVES**
Avoid inhaling vapors. If it cannot be avoided, you must wear a high efficiency half-mask canister or cartridge respirator. You must always wear a respirator when applying the preservatives by a spray method, or entering, cleaning, or repairing vats, tanks, and other related equipment contaminated with the wood treatment solution.

Respirators must fit properly, be well-maintained, and approved for polynuclear aromatics, organic vapors, and acid gases. For a proper fit, it is important to be clean-shaven. A beard or heavy sideburns may prevent a good seal. Also wear goggles, or a face piece, and head coverings that are impervious to the treatment solution.

**Do not over apply. Always check for leaks in the system.**

After every use, the goggles and face piece should be washed with detergent and water, rinsed, dried, and stored in a clean, dry place. Change cartridges and canisters if you have trouble breathing, or if you smell the preservatives. Disposal regulations for used cartridges and canisters are the same as for the preservatives. **REFER TO THE MANUFACTURER'S INSTRUCTIONS ON THE USE AND CARE OF THE RESPIRATOR BEFORE YOU USE IT.**

**FIRST-AID IN CASE OF ACCIDENTS**
The label on each preservative must include directions for first aid in case of an accident. **YOU SHOULD BE FAMILIAR WITH THEM BEFORE APPLYING THE PRESERVATIVES.** Have the phone number of your local hospital, your doctor, or a poison control center on hand. Chemicals can be absorbed through the skin, inhaled, or swallowed. Here are some basic first-aid instructions to follow in case of an accident:

1. For chemicals in your eyes - flush eyes with clean running water immediately for at least 15 minutes. Keep the water pressure low. **See a doctor as soon as possible.**
2. Be careful not to spill the chemicals on your skin or clothing. If you do, remove contaminated clothing immediately and wash the affected areas with mild soap and water. Soap, clean water, or a waterless hand cleaner should be readily available. **If skin becomes inflamed, see a doctor.**

3. If you swallow a chemical, get medical attention at once. Drink large quantities of water and induce vomiting. **Do not make an unconscious person vomit.**

4. Anyone overcome by fumes must be moved to fresh air. If the victim is not breathing, apply artificial respiration. **Call for emergency medical assistance immediately.**

**DISPOSAL REQUIREMENTS**

Improper disposal of pesticides (including certain preservatives) is a violation of Federal law. Always refer to the label for disposal instructions. If you cannot dispose of these wastes according to the label, contact your State pesticides office (listed on page 25) or your Regional EPA Waste Management Office for guidance.

Rinse and drain all chemical containers before disposal. Do not reuse empty containers. Bury containers in an approved landfill or dispose of them according to approved methods. **REFER TO THE LABEL FOR INSTRUCTIONS ON THE SAFE DISPOSAL OF CONTAINERS.**

Treated wood from residential use can be disposed of by burial or in ordinary trashcans. Do not burn it in open fires or in stoves, fireplaces, or residential boilers because toxic chemicals may be produced as part of the smoke and ashes.

Treated wood from commercial or industrial use, such as in construction sites, may be disposed of only in commercial-industrial incinerators or boilers rated at a minimum of 20 million BTU (British thermal unit) per hour, or its equivalent, in accordance with State and Federal regulations.

**LIMITATIONS ON USING TREATED WOOD**

EPA regulations restrict uses of treated wood. You should be aware of these restrictions and the proper precautionary measures. Treated wood should be used only where it is necessary to protect wood from insect attack and decay. Below are restrictions that apply to wood treated with creosote, penta, and inorganic arsenicals.

- wood treated with inorganic arsenicals may be used inside homes as long as all sawdust and other construction debris are cleaned up and disposed of.
- wood treated with creosote and penta should not be used inside homes because of toxic fumes.
- wood treated with creosote and penta should not be used inside farm buildings where domestic animals or livestock may bite or lick the wood.
- wood treated with inorganic arsenicals does not require sealers. Even frequent contact is safe because absorption through the skin is negligible.
Two coats of appropriate sealer must be applied on:

- wood treated with creosote or penta if it will frequently come into contact with bare skin, such as in outdoor furniture;
- treated wood used for support structures inside industrial buildings;
- treated wood that has been used in support structures where it is unlikely that the domestic animals or livestock will bite or lick the wood; and
- wood treated with penta and used on outdoor surfaces of doorframes, windows, and patio frames.

Urethane, epoxy, and shellac are acceptable sealers for all creosote-and penta-treated wood. For wood-block flooring treated with creosote, coal-tar pitch and coal-tar pitch emulsion are effective sealers.

Do not use treated wood:

- for farrowing or brooding facilities;
- where the preservative may become a component of food or animal feed, such as in silos;
- for cutting-boards or countertops;
- for parts of beehives that may come into contact with the honey;
- on logs intended for building log homes; and
- where it may come into direct or indirect contact with public drinking water, or drinking water for domestic animals or livestock, except for incidental contact such as with docks and bridges.

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

OTHER SAFETY PRECAUTIONS

1. Cut wood to size before treating it with creosote and penta.
2. Wear a dust mask to avoid inhaling sawdust when sawing and machining treated wood.
3. Wear goggles to protect your eyes from flying particles.
4. Whenever possible, work outdoors to avoid indoor accumulation of sawdust.
5. Wash exposed body areas thoroughly after working with the wood and before eating or drinking, or before using tobacco products.
APPLICATOR TRAINING

If you wish to become a certified applicator, contact your State agency for information about the certification and training program. Below are the contacts in the EPA Region 5 States:

**Illinois**
Illinois Dept. of Agriculture
Bureau of Envir. Programs
PO Box 19281
Springfield, IL 61794-9281
Contact: Sherri Powell,
Licensing Administrator
(217) 785-2427

**Indiana**
Indiana State Chemist Office
175 S. University Street
Purdue University
West Lafayette, IN 47907-2063
Contact: Carl R. Rew, Manager
Certification & Licensing
(765) 494-1594

**Michigan**
Michigan Dept. of Agriculture
Pesticide & Plant Pest
Management Division
P.O. Box 30017
Lansing, MI 48909-7517
Contact: Larry Swain,
Pesticide Certification Mgr
(517) 335-6838

**Minnesota**
Minnesota Dept. of
Agricultural Chemical Infor-
mation & Certification Unit
90 West Plato Blvd.
St. Paul, MN 55107-2094
Contact: Rick Hansen,
Unit Supervisor
(651) 297-7175

**Ohio**
Ohio Dept. of Agriculture
Pesticide Regulation Section
8995 E. Main Street
Reynoldsburg, OH 43068
Contact: William Pound
Agriculture Inspection Mgr.
(614) 728-6987

**Wisconsin**
Wisconsin Dept. of Agri.,
Trade & Consumer Protection
P.O. Box 8911
Madison, WI 53708-8911
Contact: Edward Bergman,
Certification & Licensing
(608) 224-4546

If you wish more information on wood preservatives, contact EPA's Regional Pesticides Office in Chicago at (312) 353-2192.

**Preparation of Wood for Treatment**
For most of the commercial wood treatments in common use, wood must be prepared in some way before a preservative is applied. This preparation may include peeling, drying, conditioning, incising, cutting, and framing.

**Peeling** - The bark and cambium must be completely removed before treatment. This allows the preservative to penetrate into the wood. Bark obstructs penetration, resulting in exposed untreated wood.

**Drying** - In most treating methods, a high moisture content prevents or slows the entrance of the preservative into the wood cells. Drying the wood allows better penetration of the preservative, reduces product weight and shrinkage with its potential for warping and checking after treatment. Kiln drying is one method for accelerating drying under controlled drying conditions.
Conditioning - Operators of pressure treating plants can use several other methods besides conventional drying to condition wood for treatment. In the steaming and vacuum process, green wood is steamed in a treating cylinder or retort for several hours and then subjected to a vacuum. The vacuum reduces the boiling point of the water in the wood and speeds its removal. Then the preservative, applied under pressure, can replace the evaporated water.

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, removing water from the wood. With this method, wood can be conditioned at a lower temperature. Consequently, it can be used to avoid damage to a wood species (such as a Douglas fir), which is sensitive to 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 or an organic compound, such as xylene, which gradually vaporizes and removes the water.

Incising - Incising consists of making a series of narrow holes or slits in the wood about 1/2- to 3/4-inch deep. This allows preservatives to better penetrate impregnation-resistant wood species (such as Douglas fir). Incising makes possible a more uniform penetration to at least the depth of holes.

Cutting and Framing - 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 then can be used without further machining.

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. The treating method selected depends greatly on the ultimate use of the product. The two major types of treatment are pressure and non-pressure methods. Many variations of these methods are described in the standards and specifications of the American Wood Preservers Association (AWPA), the Federal Government, and other organizations.

Pressure Processes - We might expect wood to treat easily because of its porous structure, but wood is surprisingly resistant to deep penetration by preservatives. The basic principle of pressure processes involves the placement of wood materials in an airtight, steel cylinder or retort and immersing it in a preservative under pressure to force the preservative into the wood. Impregnation of preservatives by pressure is the most common method used in the commercial treatment of wood. It has several advantages:

- it gives a deeper and more uniform penetration,
- it allows better control over retention,
- wood can be preconditioned in the chamber,
- it is quicker and more reliable than non-pressure methods, and
- it can comply with the code regulations and engineered specifications.
There are two basic variations of the pressure treatment method: the full-cell process and the empty-cell process. With either method, it is 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),
- treating time,
- type of preservative, and
- concentration of the preservative.

**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.

There are many methods of applying preservatives to wood without the use of pressure. Some of the more widely-used methods are described:

**Brushing, Spraying and Pouring Treatments** - With these methods, creosotes, oilborne preservatives, or water-borne salts are applied to the surfaces of the wood product to be treated. The wood should be thoroughly air-dried before treatment and, if oilborne 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 dried and soaked into the wood. 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.

**Dipping** - Treatment by dipping consists of immersing wood in a preservative solution for several seconds or several minutes. As with brushing-type treatments, the wood should first 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 2 to 4 years of protection over untreated wood, dipping is unsatisfactory for uses subject to abrasion. Probably the principal use of dipping is for window frames employing an immersion of 3 minutes.

**Cold Soaking** - Cold soaking is commonly used for treating round, fence posts and sawn timbers using pentachlorophenol or other viscous, oilborne preservatives. The process involves the soaking of dried wood for 2-7 days in a vat containing the unheated liquid oil preservative. Cold soaking has been popular for farm use because of its simplicity and low cost.
**Steeping** - The steeping process employs a water-borne salt preservative solution to either dry or green wood. It consists of submerging the wood in a tank full of the solution at atmospheric temperature for several days or weeks (heating the solution would speed up penetration). Absorption is rapid the first 3 days then continues at a decreasing rate almost indefinitely. When treating flat-sawn, wood products space should be provided between and around each piece of wood to permit complete exposure to the preservative material.

**Hot and Cold Bath (Thermal Process)** - The hot and cold bath or thermal process, also called the boiling and-cooling or open-tank treating method, is suitable with 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 first is immersed into a hot solution usually of the preservative, itself, or even boiling water, followed by its immersion into a tank of cold solution. Most preservative absorption and penetration takes place during the cold bath. When one tank is used, heating can be discontinued, allowing the wood and preservative to cool together.

**Double Diffusion** - Treatment by double diffusion is a two stage dispersing of a preservative liquid into a piece of 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. The purpose of double diffusion is to convert very leachable, chemical salt solutions into fixed and stable preservatives within the wood.

**Vacuum Process** - In the vacuum process, wood products are enclosed in an airtight container from which air is removed with a vacuum pump. The container then is filled with the preservative without additional pressure and without the air re-entering. The partial removal of air from the wood, by the vacuum, followed by addition of the preservative creates a slight pressure that drives the preservative into the wood. Vacuum treatment works well with penta and easily treatable woods and products like pine, window stock.

**Preservative Pads or Bandages (Treatment on Site)** - There are several variations of employing this treating concept: The preservative can be applied to the surfaces of the wood, can be injected into the wood or placed into holes drilled in the wood. The preservative used can be water-borne, solvent in oil or have a consistency of grease or mayonnaise.

This method is most often used to extend the life of standing poles that had previously been treated. Since treated poles are costly, consideration must be given to replacement costs, including treatment and installation, so a 5-year increase of service life would be a very worthwhile expenditure for preservative bandage treatment.

The major task of this treating process involves removal of soil from around the pole for a depth of about 18”. This part of the pole, below ground, and the part 12” above ground are the portions most vulnerable to decay and failure. All
decayed wood and soil must be removed from the pole and the preservative should be applied thoroughly to the 'cleaned' portion of the pole. This treated area should then be wrapped with a heavy duty, water resistant paper or plastic film to confine the preservative to the pole.

**Sapstain (Blue Stain) Prevention** - Sapstain fungi do not decay their wood host, but they degrade lumber and other wood products and lower their value. Also, sapstain fungi often precede the decay fungi because conditions favorable for attack (high temperatures and humidity) are comparable for both types of fungi.

To protect green logs, poles and other round timbers, they should be processed soon after trees are felled. If they cannot be processed promptly, the timbers should be stored submerged in water or be subjected to a continuous spray of water. When these storage methods are not feasible, protection for several months can be afforded by application of a chemical spray containing a solution of benzene hexachloride and penta in fuel oil. The entire log and especially the ends must be sprayed thoroughly soon after a tree is felled and bucked into logs.

With regard to lumber, during prolonged periods of warm, humid weather, the prospect of staining is almost inevitable in the sapwood of untreated, susceptible species such as the pines. Since stain can develop within 4 days, under favorable conditions, chemical treatment should be applied within 24 hours after sawing green logs. Sapstain preventing solutions are available under various trade names. Protection is usually provided at the sawmill by carrying the rough sawn, green lumber on the moving "green chain" through a tank or through the treating solution. Stain treatments do not provide long-lasting protection. Consequently, after treatment, the lumber should be stickered and properly piled for rapid air-seasoning or kiln drying.

**Factors Influencing the Effectiveness of Wood Preservatives**

Federal Specifications 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 to regulate the wood preserving process and better insure its suitability for specific applications.

**Penetration** - The effectiveness of a wood preservative depends on several treatment factors, one of which is the depth of its penetration into the wood. Inadequate chemical penetration may allow fungi and insects to enter through checks or cracks in the thin shell of treated wood in order 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 and the treatment process used. The sapwood of most species is fairly easily penetrated when well-dried and pressure treated. The treatment of heartwood is much more variable than 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 can be completely penetrated, whereas it is almost impossible to penetrate the
heartwood of white oak or western red cedar with commercial pressure treating processes.

**Retention of Preservatives** - Even with the proper preservative penetration, good protection cannot be achieved unless enough preservative stays in the 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. By contrast, water-soluble salt preservatives only require retentions of 0.2 lbs. to 2.25-lbs./cu. ft. depending on use.

**Selection and Conditioning of Wood** - Federal Specifications TT-W0571 and AWPA Standards identify the wood species that are acceptable for treatment for various uses. Selection of a species or grade of wood for a particular use should be based on the applicable grading rules. These rules take into consideration such properties of the wood as knot sizes, warp, splits and grain, which may limit some uses.

The drying and conditioning of wood before treatment significantly influences the effectiveness of the treatment, as discussed earlier in this chapter.

**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 expose untreated wood. When damaged in this way, the exposed wood should be retreated. This is usually done by in-place treatment (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 M4 Standards).

**End Use** - Treated wood that is used for a purpose for which it was not intended may result in an unsatisfactory service life. 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 other uses and will result in a shorter service life. The cost of replacement for some end-uses may justify periodic retreatment of wood, on site, to prolong its service life.
Chapter 6: PROTECTING HUMAN HEALTH

Learning Objectives
1. Hazards
2. Protecting the applicator
3. Types of exposure
4. Toxicity of chemicals

Introduction
Most chemicals used to protect wood from insects and decay are toxic in order to be effective. The goal is to select chemicals and methods that will control the pests without harming the applicator, the user, the public, or pets. It is the responsibility of the management of any wood preserving operation to ensure that the proper handling procedures, protective clothing and any necessary equipment (such as respirators) are supplied to workers in conformance with label instructions to protect their health.

The EPA-approved labeling on pesticide products, including wood preservatives, 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, and it is the provisions of the label, which are enforced by state regulatory agencies. Thus, the label for each formulated product used at a wood treatment operation should be readily available, and all responsible personnel should be familiar with their contents.

Hazards to Applicators
All handlers of wood preservatives need to know about potential hazards and necessary precautions. Since risks are directly related to degree of exposure, most of the risks associated with wood preservatives come from their application and the volatilization that occurs soon after treatment, rather than from use of the treated wood itself. The decision by 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 over a long period of time). Applicators as a group, are the people most likely to be exposed over long periods, and consequently, need to take precautions as a normal and routine part of working with wood preservatives.

Exposure to wood preservatives can occur in a variety of ways: during 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 mechanically handling treated wood help to reduce potential exposure, but do not eliminate the possibility of some routine or accidental exposure for workers.
Wood preservatives, like other pesticides, can enter the body in three ways:

- oral
- dermal
- respiratory

**Toxicity**

The decision by the Environmental Protection Agency to classify for restricted use the three principal wood treatment preservatives is based on evidence that:

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

Because of the potential hazard of these preservatives, there are new EPA 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 health effects.

**Creosote**

- Can cause skin irritation; vapors and fumes are irritating to the eyes and respiratory tract; and prolonged and repeated exposure may lead to dermatitis.

**Pentachlorophenol:**

- Irritating to eyes, skin and respiratory tract.
- Ingestion of penta solutions, inhalation of concentrated vapors or excessive skin contact may lead to fever, headache, weakness, dizziness, nausea, and profuse sweating. In extreme cases, coordination loss and convulsions may occur: high levels of exposure can be fatal.
- Prolonged exposure can lead to an acne-like skin condition or other skin disorders, and may cause damage to the liver, kidneys or nervous system.

**Inorganic arsenicals**

- Exposure to high concentrations of arsenical compounds can cause nausea, headache, abdominal pain (if material was swallowed); extreme symptoms can progress to dizziness, muscle spasms, delirium and convulsions.
Prolonged exposure can produce chronic, persistent symptoms of headache, abdominal distress, salivation, low-grade fever, and upper respiratory irritation.

Long-term effects can include liver damage, loss of hair and fingernails, anemia and skin disorders.

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 Material Safety Data Sheets supplied by chemical manufacturers. The following general steps are applicable for accidental exposure to wood preservatives:

- In cases of skin contact, first remove contaminated clothing that's in contact with the skin, immediately wash the affected areas with mild soap and water. Don't irritate the skin with vigorous scrubbing. Later, if you notice inflamed skin, redness or itching in the affected area, consult a doctor.
- In cases of eye contact, immediately flush the eyes with running water. Lift the upper and lower eyelids for complete irrigation and continue for fifteen minutes, then see a doctor.
- If accidental inhalation has occurred, move the victim to fresh air and apply artificial respiration as needed. Get medical help immediately.

If chemical preservative has been swallowed, call medical help immediately:

- If creosote or penta was swallowed, first give one or two glasses of water, induce vomiting, then administer two tablespoons of ‘USP Drug Grade’ activated charcoal in water.
- If an arsenical chemical has been swallowed, drink large quantities of water, or milk if available. Get professional medical help immediately.
- Never attempt to give anything by mouth to an unconscious person.
- Never induce vomiting in an unconscious person.

Protecting the Applicator

General

- Good work habits are reflected in the general precautions included on all wood preservative labels. These basic, common-sense hygiene rules can significantly reduce risks of chronic exposure to wood preservative chemicals.

For example:

- 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 laundered at home, wash them separately from other laundry.

• Protective clothing requirements will be specified on the label. These will include use of impermeable gloves for applying the preservatives and in all situations where dermal (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.

Special Precautions

**Pentachlorophenol:**

• For prilled, powdered or flaked formulations of pentachlorophenol: Until August 31, 1987, a closed emptying and mixing system must be used or protective clothing, including respirator, gloves, long-sleeved shirt and long pants or disposable coveralls, must be worn when emptying and mixing prilled, powdered or flaked formulations of pentachlorophenol. After September 1, 1987 a closed system must be used when emptying and mixing such formulations of pentachlorophenol.

• For the spray method of application, spray apparatus must (1) be operated so as to minimize over spray (i.e., no visible mist) and (2) be free of leaks in the system. Should there be a visible mist, spray applicators in the zone in which mist is visible must wear respirators and protective clothing (including overalls, jacket, gloves, boots, goggles and head covering) impervious to the wood treatment formulation.

• Exposure to pentachlorophenol during pregnancy should be avoided.

**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/m3) average over an 8 hour work day. This PEL is the same as the standard required by the Occupational Safety and Health Administration.

• Processes used to apply inorganic arsenical formulations shall leave no visible surface deposits on the wood. Small isolated or infrequent spots of chemical on otherwise clean wood shall be allowed.
Limitations on Use
Recent EPA regulations on wood preservatives include some limitations on treating wood intended for certain uses, and on certain uses of treated wood. 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. The following is a summary of wood preservations use limitations:

- **Pentachlorophenol and creosote cannot be applied indoors.**
- Pentachlorophenol or creosote-treated wood must not be used where there may be contamination of feed, food, drinking or irrigation water.
- **Pentachlorophenol cannot be applied to wood intended for use in interiors,** except for millwork (with outdoor surfaces) and support structures which are in contact with the soil in barns, stables, and similar sites and which are subject to decay or insect infestation. **A sealer must be applied in those instances.**
- Creosote cannot be applied to wood intended to be used in interiors except for those support structures which are in contact with the soil in barns, stables, and similar sites and which are subject to decay or insect infestations. **Two coats of a sealer must be applied.**
- The application of pentachlorophenol to logs for construction of **log homes is prohibited.**
- If creosote or pentachlorophenol is applied to wood intended to be used where it will be exposed to body contact, sealants must be applied.

Material Safety Data Sheets (MSDS)
MSDS are available from the manufacturers and distributors of the wood preservatives they sell. 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 MSDS on file for each different formulation that you use. Some states may have ‘right-to-know’ laws that will require you to do this.

Voluntary Consumer Awareness Program
In order to apprise the consumer 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.

The treated wood industry will develop a model Consumer Information Sheet (CIS) containing use site precautions and safe working practices for each of the three types of preservatives. The CIS will serve as the main vehicle for conveying information about treated wood to consumers. The focus of the CAP will be on ensuring the dissemination of the CIS at the time of sale or delivery to end-users.
The individual wood applicator's CIS will, at a minimum, contain the language agreed to by AWPI, SAWP, NFPA, and EPA on the model CIS to the extent it applies to the wood preserver's product.

Wood applicator will be free to add other information to their CIS's such as the member's name, address, and logo; but in all cases, the use site precautions and the safe handling practices information will be separate, legible, and prominent.

The primary responsibility for ensuring that the CIS is disseminated to the consuming public will reside with the wood applicator. EPA may modify this voluntary program at a later date.

**Inorganic Arsenical Pressure-Treated Wood**

The following wording will appear on the Consumer Information Sheet (CIS) for inorganic arsenical pressure-treated wood:

**Consumer Information**

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

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

**Use site Precautions for Inorganic Arsenical Pressure-Treated Wood**

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

- Do not use treated wood under circumstances where the preservatives may become a component of food or animal feed. Examples of such sites would be structural or containers for storing silage or food.
- Do not use treated wood for cutting-boards or countertops.
- Only treated wood that is visibly clean and free of surface residue should be used 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 for Inorganic Arsenical Pressure-Treated Wood**

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

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

**Creosote Pressure-Treated Wood**
The following wording will appear on the Consumer Information Sheets (CIS) for creosote pressure-treated wood:

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

When power-sawing and machining, wear goggles to protect eyes from flying particles.
After working with the wood, and before eating, drinking, and use of tobacco products, wash exposed areas thoroughly.

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

Coal tar pitch and coal tar pitch emulsion are effective sealers for creosote-treated wood-block flooring. Urethane, epoxy and shellac are acceptable sealers for all creosote-treated wood.

Pentachlorophenol Pressure-Treated Wood
The following wording will appear on the Consumer Information Sheets (CIS) for pentachlorophenol pressure-treated wood:
**Consumer Information**
This wood has been preserved by pressure treatment with an EPA-registered pesticide containing pentachlorophenol to protect it from insect attack and decay.

Wood treated with pentachlorophenol should be used only where such protection is important.

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

**Use Site Precautions for Pentachlorophenol Pressure-Treated Wood** - *Logs treated with pentachlorophenol should not be used for log homes.*

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

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

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

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

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

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

1. The basic wood cell is often referred to as a fiber or a longitudinal tracheid.
   A. True
   B. False

2. Cell walls of wood fiber are made up of:
   A. Small bits of cellulose
   B. A matrix of hemicellulose
   C. Thin layer of lignin
   D. All of the above

3. The pits in wood cell structures are important for:
   A. Water movement in living trees from cell to cell
   B. Movement of water in drying lumber
   C. Movement of chemical solutions in impregnation of wood
   D. All of the above

4. All wood species have small tissues called rays that weave their way between the longitudinal fibers from the bark toward the pith.
   A. True
   B. False

5. Sapwood is:
   A. Wood that is located near the cambium layer
   B. Made up of inactive cells
   C. More dense and drier than heartwood
   D. All of the above

6. Heartwood:
   A. Consists of inactive cells
   B. Includes waste material which darkens wood
   C. Is more dense and drier wood
   D. All of the above

7. Fungi, which are a simple type of non-chlorophyll containing plants, cause wood decay.
   A. True
   B. False

ANSWERS ON NEXT PAGE
CORRECT ANSWERS
1. A
2. D
3. D
4. A
5. A
6. D
7. A