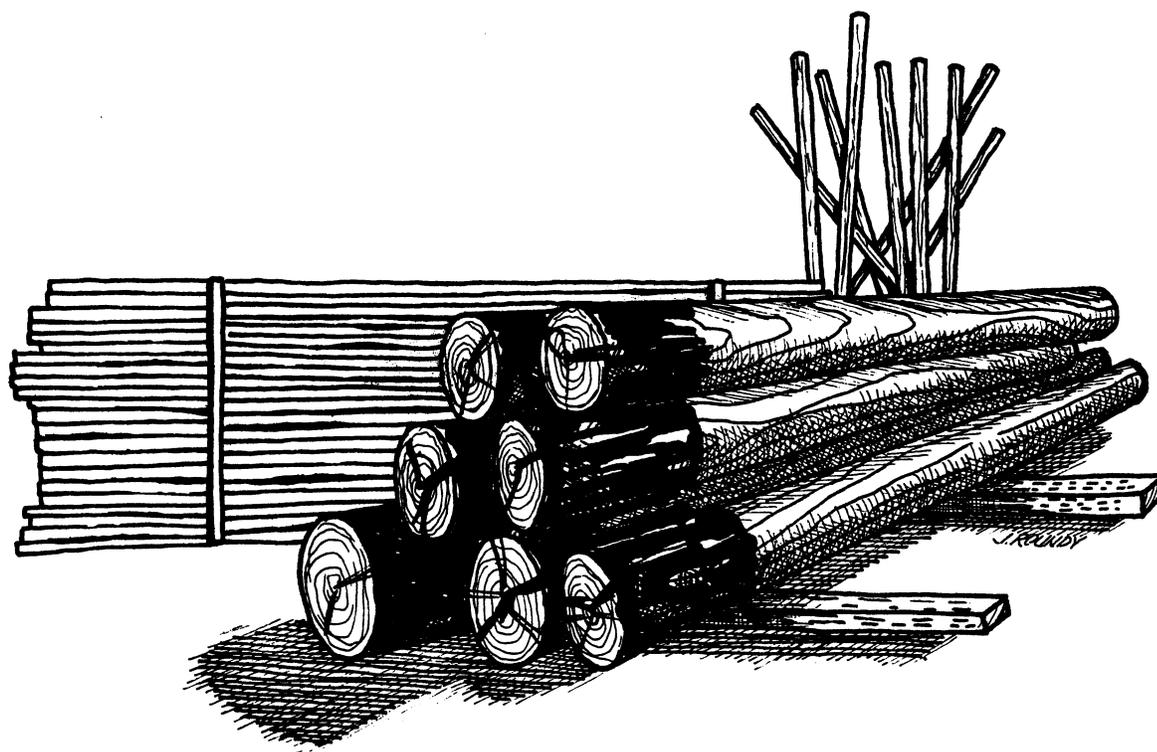


WOOD PRESERVATION PEST CONTROL

PESTICIDE APPLICATION
AND
SAFETY TRAINING
STUDY GUIDE



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STUDY GUIDE FOR WOOD PRESERVATION PEST CONTROL

The educational material in this study guide is practical information to prepare you to meet the written test requirements. It doesn't include all the things you need to know about your pest control profession. It will, however, help you prepare for your test.

Contributors include the Utah Department of Agriculture and Utah State University Extension Service. This study guide is based on a similar one published by the Colorado Department of Agriculture. Materials for that guide were prepared by Colorado State University Extension Service. Other contributors include: University Extension Service personnel of California, Kansas, New York, Oregon, Pacific Northwest, Pennsylvania, and Wyoming, the U.S. Department of Agriculture -- Forest Service, the U.S. Environmental Protection Agency (Region VIII), and the Department of Interior -- Bureau of Reclamation and Metro Pest Management.

The information and recommendations contained in this study guide are based on data believed to be correct. However, no endorsement, guarantee or warranty of any kind, expressed or implied, is made with respect to the information contained herein.

Additional topics that may be covered in your examinations include First Aid, Personal Protective Equipment (PPE), Protecting the Environment, Pesticide Movement, Groundwater, Endangered Species, Application Methods and Equipment, Equipment Calibration, Insecticide Use, Application, Area Measurements, and Weights and Measures. Information on these topics can be found in the following books:

1. *Applying Pesticides Correctly: A guide for Private and Commercial Applicators*. U.S. EPA, USDA and Extension Service, revised 1991.
2. *Applying Pesticides Correctly: A Supplemental Guide for Private Applicators*. U.S. EPA, USDA and Extension Service, December 1993, Publication E-2474.

These books can be obtained from the Utah Department of Agriculture or Utah State University Extension Service. Please contact your local Utah Department of Agriculture field representative or Utah State University extension agent.

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PREFACE

Federal regulations establish general and categorical standards that must be met before you can legally use certain pesticides and preservatives. Your state will provide the information necessary to help you meet the general standards.

This guide for applicators and handlers of wood preservatives and wood-treated products contains information you must know to meet categorical national standards. Because this guide was written to encompass the entire country, some information important to your individual state may not be included.

This guide discusses the prevention of wood deterioration and degradation. It includes:

- Recognition of pests and the damage they can cause.
- Methods of control.
- Environmental and safety precautions.

It's beyond the scope of this manual to discuss technical aspects of treating processes and quality-control in treating, except as they affect the safe handling and use of treating chemicals. Also, wood treatments such as for stabilization and fire retardancy which don't prevent or retard attack by wood-destroying organisms won't be discussed.

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INTRODUCTION

Wood-protecting pesticides (preservatives) extend the life of wood products by protecting them from damage by insects, fungi, marine borers, and weather. Preservatives are applied on the basis of how and where the products will be used, the expected conditions of exposure to wood-destroying agents, and the cost per year of service life. Crossties, poles, posts, and other wood products that contact the ground or are exposed to the weather must be protected with preservatives to insure a reasonable service life. Other wood products not in contact with the ground may be treated as a precautionary measure, even though they aren't exposed to moisture and the weather.

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

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

Many standards and specifications have been established to control the quality of treated wood and protect the purchaser. Federal and state specifications and requirements of the American Wood Preservers Association (AWPA) are the regulations most commonly accepted.

PESTS THAT DAMAGE 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. As a result, wood must be protected to insure maximum service life when used under conditions favorable to these pests.

WOOD-INHABITING FUNGI

Wood decay, mold, and most sapwood stains are caused by fungi. 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 fungus groups produce spores (similar to tiny seeds) which are distributed by wind and water. The spores can infest moist wood during storage, processing and use.

All fungi that grow on wood have certain basic requirements:

- Favorable temperature -- usually range from 50 to 90 degrees F. The optimum is about 70 to 85 degrees F. Wood is basically safe from decay at temperatures below 35 degrees F. and above 100 degrees F.
- Adequate moisture -- Fungi won't attack dry wood (including wood with a moisture content of 19 percent or less). Decay fungi require a wood moisture content (MC) of about 30 percent, the generally accepted **fiber saturation point** of wood, according to national design specifications. Thus, air-dried wood, usually with an MC not exceeding 19 percent, and kiln-dried wood with an MC of 15 percent or less can usually be considered safe from fungal damage **as long as the wood is kept dry**.
- Adequate oxygen -- Fungi can live in fairly-low-oxygen environments. If oxygen is excluded by burying wood in the ground or by spraying or soaking it with water, fungi can't live. Excluding oxygen by burial requires a depth of at least two feet. That depth could be considerably greater, depending on the porosity of the soil.
- 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; on wood surfaces as fan-shaped patches of fine, threadlike, cottony growth; or as rootlike shapes.

The color of these growths may range from white to light brown, bright yellow, and dark brown. The spore-producing bodies may be mushroomlike; shelflike brackets; or structures with a flattened, crustlike 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
- Soft 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:

- The dark brown color of the wood.
- Excessive shrinkage.
- Cross-grain cracking.
- 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 above-ground construction in the U.S. Brown rot, when dry, is sometimes called “dry rot.” This is a poor term, because wood must have moisture and won’t decay when it’s 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.”

White Rot

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

Soft Rot

Soft-rot fungi usually attack green wood (high MC), causing a gradual softening from the surface inward that resembles brown rot.

WOOD-STAINING FUNGI

Sap-staining Fungi

These fungi penetrate and discolor sapwood, especially of the softwood species. Typical sap-stain, unlike staining by

mold fungi, can’t be removed by brushing or planing. Sap-stain fungi may become established in the sapwood of standing trees, sawlogs, lumber and timbers soon after they are cut and before they can be adequately dried. The effect on wood strength is minimal. Affected 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).

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

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 that is piled during warm, humid weather may be noticeably discolored in five to six days or less. As with sap-stains, molds don’t reduce wood strength; however, they can increase the capacity of wood to absorb moisture, thereby increasing the possibility of 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. They usually can be prevented by rapid drying at relatively low temperatures during kiln drying.

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 can’t 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 don’t. 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 termites.
- Drywood termites.
- Dampwood termites.

Subterranean Termites

These termites attack wood products in buildings and other wood products throughout most of the continental U.S., 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 try 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, antlike 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

Most literature reports that drywood termites are found naturally in the U.S. only in Hawaii, Puerto Rico, and a narrow strip of land extending from southern California and Texas to Florida and along the Atlantic coast to Virginia. However, drywood termites have been identified in southern Utah and western Colorado between St. George, Utah, and Grand Junction, Colorado.

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 danger. However, it reproduces slowly and doesn't destroy wood as quickly as the subterranean termite.

Dampwood Termites

Dampwood termites are a serious pest along the Pacific Coast. They don't require contact with the soil but do need wood with a high moisture content.

CARPENTER 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 window sills 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) free of refuse and powdery wood. Mounds of sawdust indicate their presence.

POWDER-POST 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 one-sixteenth to one-twelfth-inch in diameter, packed with 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 emerged adults chew holes to the wood surface, where they lay eggs to produce another generation. Signs of damage by powder-post beetles are:

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

Anobiid Beetles

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.

Roundheaded 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's found in the Eastern and Gulf Coast States.

Larvae reduce sapwood to a powdery or sawdustlike 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 one-fourth 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 three-fourths 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 **shipworm** and **pholad** mollusks (related to clams and oysters) and **crustacean borers** (related to crabs and lobsters).

CONTROL OF PESTS THAT DAMAGE WOOD

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 not as effective as a properly applied chemical.
- Chemical treatment.

MOISTURE CONTROL

The moisture content of living trees and the wood products obtained from them may range from about 60 percent for heavy or hard woods to 200 percent for light or soft woods. Much of this moisture must be removed for most uses. Green lumber usually must be dried for these reasons:

- To prevent stain and decay.
- To reduce damage by insects.
- To reduce uncontrolled dimensional change (shrinkage).
- To reduce weight and increase strength.
- 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, then dried using a constant temperature between 212 and 220 degrees F. When the weight of the sample becomes constant (no more moisture will come out), a percentage of the weight difference between the dried and the undried sample is computed, and that percentage is used to express the moisture content.
- **The electrical method** -- Use of a moisture meter that measures moisture by electrical resistance.

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.

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

Unless lumber is properly stacked and protected, air-drying may result in surface-checking, end-cracking, warping, staining, and discoloration due to weathering.

Kiln-drying is widely used and is more efficient than air-drying. It offers better control of air movement, temperature, and drying rate. Although kiln-drying is more expensive in terms of capital investment and energy cost, it's much faster and generally provides more uniform and better-quality drying when proper stacking and operating procedures are followed.

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 reduce 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 that serves as a 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 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're 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 (such as chestnut) or in dimensions needed. Because of high costs for labor and materials, the variable and undependable resistance of these species precludes their use for most high-hazard construction applications.

Emphasis must be placed on the fact that studies of naturally resistant wood are based on old-growth trees. There are some observations, which have not been well documented, that wood cut from second-growth trees exhibits less resistance to decay and insects, even for those woods considered to be highly resistant.

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

Type of Preservatives

Wood preservatives fall into three broad categories:

- Creosote and creosote solutions.

- Oil-borne preservatives.
- Water-borne preservatives.

CREOSOTE AND CREOSOTE SOLUTIONS

Creosote, an oily by-product of making coke from bituminous coal, is widely used as a preservative for such products as railroad ties, large timbers, fence posts, poles and pilings. It's a restricted-use pesticide.

Advantages:

- Toxicity to wood-destroying fungi, insects, and some marine borers.
- Low volatility.
- Insolubility in water.
- Ease of handling and application.

Disadvantages:

- Dark color.
- Strong odor.
- Oily, unpaintable surface.
- Tendency to bleed or exude from the wood surface.
- Toxic fumes that make creosote-treated wood unsafe for use in homes or other living areas.

OIL-BORNE 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 oil-borne preservatives formulated as water-in-oil emulsions or dispersions in water.

Advantages:

- Toxicity to fungi, insects and mold.
- Ability to be dissolved in oils having a wide range in viscosity and vapor pressure and to which color may be added.
- Low solubility.
- Ability to be glued, depending on the solvent or carrier.
- Ease of handling and use.

Disadvantages:

- Can leave an oily, unpaintable surface, depending on the carrier.
- For some applications, provide somewhat less physical protection to wood than creosote does.
- Should not be used in homes or other living areas because of toxic fumes.
- May be toxic and irritating to plants, animals and humans.

Pentachlorophenol (penta) is the most commonly used oil-borne preservative. It's used commercially to treat poles, lumber, crossarms, timbers, and fence posts. Penta isn't recommended for marine installations, use inside buildings, or use close to plants. Penta is now a restricted-use chemical and requires licensing for purchase and commercial application.

Another oil-borne preservative that is increasing in use is copper naphthate. This preservative has much lower human toxicity than penta and isn't a restricted-use chemical.

WATER-BORNE 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. These arsenical compounds are on the list of restricted-use chemicals.

Advantages:

- Treatment presents no hazard from fire or explosion.
- Wood surface is left clean, paintable, and free of objectionable odors.
- Treated wood is safe for interior use and treatment of playground equipment.
- This preservative is leach-resistant.

Disadvantages:

- Unless re-dried after treatment, the wood is subject to warping and checking.
- Doesn't protect the wood from excessive weathering.

Wood treated with copper-8-quinolinolate has been approved for food-contact uses such as boxes, crates, pallets, truck decking, and related uses involving the harvesting, storage and transportation of food.

APPLICATION OF WOOD PRESERVATIVES

PREPARATION OF WOOD FOR TREATMENT

Most commonly used commercial wood-preservation treatments require some preparation of the wood prior to

the application. This preparation may include peeling, drying, conditioning, incising and cutting.

Peeling

The bark and cambium must be completely removed before treatment. This assures that the preservative will penetrate into the wood. Bark obstructs penetration, which may result in non-uniform treatment and/or possible untreated areas.

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 and reduces product weight and shrinkage with their potential for causing warping and checking after treatment. Kiln-drying is one method for speeding up drying under controlled drying conditions.

Conditioning

Operators of pressure-treatment 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, then subjected to a vacuum. The vacuum reduces the boiling point of water in the wood and speeds its removal. Then the evaporated water can be replaced by the preservative, applied under pressure.

Another method of conditioning green wood is boiling under vacuum (Boulton method). The wood is placed in a treating cylinder and submerged in hot oil. Then a vacuum is applied, removing water from the wood. With this method, wood can be conditioned at a lower temperature. Therefore, the Boulton method can be used to avoid damage to a wood species (such as Douglas fir) that 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 of 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 one-half to three-fourths 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 the holes.

Cutting

Cutting, shaping or drilling wood after treatment can expose untreated wood. This exposure can be avoided by cutting, shaping or boring the wood for its intended use before the preservative treatment. The treated wood can then be used without further machining.

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 chosen 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's quicker and more reliable than non-pressure methods.
- It can comply with code regulations and engineering specifications.

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

FULL CELL

In the full-cell process, the wood that is to be treated is placed in the treatment chamber. The air is then removed from the chamber to create a vacuum. This vacuum condition in the chamber causes the cells that make up the wood to give up the gases they contain. How much gas and from what depth within the wood these gases will be removed during this process is determined by the type of wood, the strength of the vacuum, the length of time the vacuum is maintained, and other factors. The wood preservative is then pumped into the chamber under hydraulic pressure and forced into the wood cells. This process is usually used when the finished wood-product will be exposed to extreme conditions.

EMPTY CELL

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

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

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

NON-PRESSURE PROCESSES

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

There are many methods of applying preservatives to wood without the use of pressure. These methods were

commonly used on farms and in other do-it-yourself projects prior to the common preservative chemicals being classified as restricted-use pesticides and before certification was required for their purchase and use.

BRUSHING, SPRAYING AND POURING TREATMENTS

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

DIPPING

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

COLD-SOAKING

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

STEEPING

The steeping process employs a **water-borne** salt-preservative solution applied to either dry or green wood. It consists of submerging the wood in a tankful of the solution at atmospheric temperature for several days or weeks. (Heating the solution would speed up penetration.) Absorption is rapid the first three days, then continues at a decreasing rate almost indefinitely. When flat-sawn

wood products are being treated, space should be provided 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 or even boiling water, followed by its immersion into a tank of cold preservative.

Most preservative absorption and penetration take 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 dispersion 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's then immersed in a second solution consisting of sodium arsenate and sodium chromate. When the copper sulfate is exposed to the sodium arsenate and the sodium chromate, a chemical change occurs that converts these soluble, leachable salts to more stable preservative compounds within the wood. The purpose of double diffusion is to convert very leachable, chemical salt 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, easily treatable woods, and products like pine window stock.

PRESERVATIVE PADS OR BANDAGES (Treatment on Site)

There are several ways to use this treatment concept:

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

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

The major task of this treating process involves removal of soil from around the pole to a depth of about 18 inches. This part of the pole below ground and the part up to 12 inches above ground is the portion most vulnerable to decay. 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 don't 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.

For protection, green logs, poles, and other round timbers should be processed soon after trees are felled. If they can't be processed promptly, the timbers should be stored submerged in water or be subjected to a continuous spray of water. When these storage methods aren't 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 pines. Since stain can develop within four 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-cut, green lumber on the moving “green chain” through a tank or through the treating solution. Stain treatments don’t provide long-lasting protection. Therefore, 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 Specification TT-W-571 and the standards of the American Wood Preservers Association (AWPA) are commonly used by the wood-preserving industry and consumers of treated wood 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 easily penetrated when well-dried and pressure-treated. The treatment of heartwood is much more variable than of sapwood. For instance, the heartwood of southern yellow pine and maple can be impregnated to depths of about one-fourth to one-half inch. Red oak can be completely penetrated, whereas it’s 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 can’t be achieved unless enough preservative stays in the wood. Retention is measured in **pounds per cubic foot** (lbs./cu. ft.) of wood. For example, the minimum retention of creosote for lumber used in coastal

(salt) waters is 25 lbs./cu. ft. (AWPA C-2), while for similar wood products in fresh water, only ten 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 specification 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 that 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 exposes untreated wood. When damaged in this way, the exposed wood should be re-treated. 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 M-4 standards).

End Use

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

This is mainly a result of differences in specified penetration and retention levels. For example, pilings treated to meet specifications for fresh water shouldn’t 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 re-treatment of wood, on the site, to prolong its service life.

PROTECTING HUMAN HEALTH

INTRODUCTION

Most chemicals used to protect wood from insects and decay have to be toxic to be effective. The goal is to choose chemicals and methods that will control the pests without harming the applicator, the user, the public, pets, or the environment. It's 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 is the law, and the provisions of the label 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 occur soon after treatment, rather than from use of the treated wood itself. The decision by the EPA to classify three of the major wood preservatives -- creosote, inorganic arsenicals and pentachlorophenol -- for restricted use was based on the potential human risk from chronic toxicity (exposure over a long period of time). Applicators as a group are the people most likely to be exposed over long periods, and therefore, they 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 reduce potential exposure but don't 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

Since many wood preservatives have a strong odor and taste, it's unlikely a person would swallow a dangerous amount. The more likely forms of exposure are dermal (skin) contact or inhalation of vapors, dust or particles, especially if use of protective clothing and other precautions aren't observed.

Toxicity

The decision by EPA to classify for restricted use the three principal wood-treatment preservatives* are 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 breathed air containing arsenic.
4. Pentachlorophenol has produced defects to the offspring of laboratory animals.
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:

* Except for brush-on treatment by inorganic arsenicals where use will be for commercial construction purposes only and not for household use.

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:

- Is 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 convulsion may occur. High levels of exposure can be fatal.
- Prolonged exposure can lead to an acnelike skin condition or other skin disorders, and it may cause damage to the liver, kidneys, or nervous system.

INORGANIC ARSENICALS:

- Exposure to high concentrations of arsenical compounds can cause nausea, headache, diarrhea, and abdominal pain (if material was swallowed). Extreme symptoms can progress to dizziness, muscle spasms, delirium and convulsion.
- Prolonged exposure can produce chronic, persistent symptoms of headache, abdominal stress, 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 (MSDS) 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 15 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 for medical help immediately.
- If creosote or penta was swallowed, first give the victim 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 help immediately.
- Never try 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. A 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 paper work, 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 **chemical-resistant gloves** for applying the preservatives and in all situations where dermal (skin) contact is expected (for example, 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

* Adapted in part from Federal Register, Friday, Jan. 10, 1986, Part III, Environmental Protection Agency, pp. 1334-1348, Vol. 51, No. 7.

may include coveralls, 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 are 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 coveralls, gloves and boots that are resistant to the wood-treatment solution, plus a respirator.

POISON INFORMATION CENTER

There is a poison information center in Utah that is equipped to provide up-to-date information on cases involving all poisons, including pesticides. They are staffed 24 hours per day, every day of the year. The toll-free number is:

1-800-456-7707 or
1-801-581-2151

Utah Poison Control Center
410 Chipeta Way
Suite 230
Salt Lake City, Utah 84108

TABLE 1. ACCEPTABLE GLOVE MATERIALS

I. Creosote

- A. Polyvinyl acetate (PVA)
- B. Polyvinyl chloride (PVC)
- C. Neoprene
- D. NBR (Buna-N)

II. Pentachlorophenol

- A. Polyvinyl acetate (PVA)
- B. Polyvinyl chloride (PVC)
- C. Neoprene
- D. NBR (Buna-N)
- E. Nitrile

** (MSHA) Mine Safety and Health Administration, (NIOSH), National Institute for Occupational Safety and Health.

III. Inorganic Arsenicals

- A. Vinyl
- B. Polyvinyl chloride (PVC)
- C. Neoprene
- D. NBR (Buna-N)
- E. Rubber
- F. Polyethylene

TABLE 2. ACCEPTABLE MATERIAL FOR OTHER PROTECTIVE EQUIPMENT

I. Creosote

- A. Neoprene
- B. Polyvinyl acetate (PVA)
- C. Polyvinyl chloride (PVC)
- D. NBR (Buna-N)

II. Pentachlorophenol

- A. Neoprene (for entering cylinders).
- B. Plastic-coated disposable coveralls resistant to dust (for dust protection).
- C. Tightly woven natural or synthetic fiber clothing (cotton or polyester), full-body covering (for working around treating plant).

III. Inorganic Arsenicals

- A. Vinyl
- B. Polyvinyl chloride (PVC)
- C. Neoprene
- D. NBR (Buna-N)
- E. Rubber
- F. Polyethylene

TABLE 3. ACCEPTABLE RESPIRATORS

I. Creosote

- A. MSHA/NIOSH-approved cartridge-type respirators that give protection against organic vapors and polynuclear aromatics.

II. Pentachlorophenol

- A. MSHA/NIOSH-approved organic-vapor and acid-gas respirators.
- B. MSHA/NIOSH self-contained breathing apparatus with a full facepiece (supplied air).

III. Inorganic Arsenicals

- A. MSHA/NIOSH-approved half-mask supplied-air respirators.
- B. Properly fitted, well-maintained, high-efficiency, filtered respirators approved for inorganic arsenic.

SPECIAL PRECAUTIONS

PENTACHLOROPHENOL:

- For prilled, powdered or flaked formulations of pentachlorophenol, a closed system must be used when emptying and mixing such formulations, as of September 1, 1987.
- For the spray method of application, spray apparatus must (1) be operated so as to minimize overspray (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 coveralls, gloves, boots, and head covering) that's resistant to the wood-treatment formulation, plus goggles.
- 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 eight-hour work day. This PEL is the same as the standard required by the Occupational Safety and Health Administration (OSHA).
- Processes used to apply inorganic arsenical formulations will leave no visible surface deposits on the wood. Small, isolated or infrequent spots of chemical on otherwise clean wood will be allowed.

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 the label allows you to use the preservative for the specific use you intend. Not all of these limitations are the responsibility of commercial treaters, but these limitations should be known. The following is a summary of wood-preservation use limitations.

- **Pentachlorophenol and creosote must not be applied indoors.**
- Pentachlorophenol- or creosote-treated wood must not be used where there may be contamination of feed, food, or drinking or irrigation water.
- **Pentachlorophenol** must not be applied to wood intended for use in interiors, except for millwork (with outdoor surfaces) and support structures that are in

contact with the soil in barns, stables, and similar sites and that are subject to decay or insect infestation. A sealer must be applied in those instances.

- **Creosote** must not be applied to wood intended to be used in interiors, except for those support structures that are in contact with the soil in barns, stables, and similar sites and that are subject to decay or insect infestation. 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 would be exposed to body contact, sealants must be applied.

Material Safety Data Sheet (MSDS)

Material safety data sheets 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 an MSDS on file for each different formulation that you use.

Consumer-Information Sheets

The treated-wood industry will develop model consumer-information sheets (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 individual wood treater'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 treaters will be free to add other information to their CISs 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 treaters. This voluntary program may be modified by EPA 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 inorganic arsenic to protect it from insect attack and decay. Wood treated with inorganic arsenic should be used only where such protection is important.”

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

USE-SITE PRECAUTIONS FOR INORGANIC-ARSENICAL PRESSURE-TREATED WOOD

Wood that is 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.

Don't use treated wood under circumstances where the preservatives may become a component of food or animal feed. Examples of such sites would be structures or containers for storing silage or food.

Don't use treated wood for cutting-boards or counter-tops. Only treated wood that is visibly clean and free of surface residues should be used in patios, decks and walkways.

Don't 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 through ordinary trash collection or burial. Treated wood shouldn't 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 (such as 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 air-borne sawdust from treated wood.

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

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

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 shouldn't 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 shouldn't 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 shouldn't be used in the interiors of farm buildings where there may be direct contact with domestic animals or livestock that may crib (bite) or lick the wood.

In interiors of farm buildings where domestic animals or livestock are unlikely to crib or lick the wood, creosote-treated wood may be used for building components that are in contact with the ground 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.

Don't use creosote-treated wood for farrowing or brooding facilities. Don't 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.

Don't use treated wood for cutting-boards or counter-tops. Only treated wood that is visibly clean and free of surface residues should be used for patios, decks and walkways.

Don't use treated wood for construction of those portions of beehives that may come into contact with the honey.

Creosote-treated wood shouldn't be used where it may come into direct or indirect contact with public drinking water or 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 shouldn't 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 (such as 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 air-borne sawdust from treated wood.

Avoid frequent or prolonged skin contact with creosote-treated wood. When handling treated wood, wear long-sleeved shirts and long pants, and use gloves resistant 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 of the skin 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 shouldn't be used for log homes.

Wood treated with pentachlorophenol shouldn't 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 shouldn't be used in residential, industrial or commercial interiors except for laminated beams or building components that are in ground contact, 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 shouldn't be used in the interior of farm buildings where there may be direct contact with domestic animals or livestock that may crib (bite) or lick the wood.

In interiors of farm buildings where domestic animals or livestock are unlikely to crib or lick the wood, pentachlorophenol-treated wood may be used for building components that are in contact with the ground, 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.

Don't use pentachlorophenol-treated wood for farrowing or brooding facilities. Don't 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.

Don't use treated wood for cutting-boards or counter-tops. Only treated wood that is visibly clean and free of surface residues should be used for patios, decks and walkways.

Don't use treated wood for construction of those portions of beehives that may come into contact with the honey.

Pentachlorophenol-treated wood shouldn't be used where it may come into direct or indirect contact with public drinking water or drinking water for domestic animals or livestock, except for uses involving incidental contact such as docks and bridges.

HANDLING PRECAUTIONS FOR PENTACHLOROPHENOL PRESSURE-TREATED WOOD

Dispose of treated wood by ordinary trash collection or burial. Treated wood shouldn't 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 (such as construction sites) may be burned only in commercial or industrial incinerators or boilers rated at 20 million BTU/hour or greater heat inputs or their equivalent in accordance with state and federal regulations.

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

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

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

If any preservative or sawdust accumulates on clothes, launder before reuse. Wash work clothes separately from other household clothing. Urethane, shellac, latex epoxy enamel and varnish are acceptable sealers for pentachlorophenol-treated wood."

TREATMENT OF WASTE

Waste Disposal

Wastes from preservative-treating operations can kill plant life and harm aquatic life if allowed to enter waterways. Oils and organic solids damage aquatic life by reducing oxygen supplies.

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

Door sumps should be used under pressure-chamber doors and under hard-surfaced drainage areas so they will channel any excess chemicals that drip or are rinsed from freshly treated material into the waste or recovery system. It's also important to contain the runoff from areas where toxic chemicals are used to protect stored logs, poles or lumber before processing or during seasoning.

The EPA requires treatment facilities to meet certain disposal standards and to obtain permits for discharge of excess chemicals. Compliance with these regulations should assure proper environmental protection.

Remember to read the label carefully for disposal information for the products you are using.

Storage and Disposal of Containers

Packaged chemicals should be stored in a dry, well-ventilated, securely locked area. Keep them in well-sealed containers whenever possible. Protect liquid storage against tank rupture.

Wherever spills, leaks or flooding could occur, be sure that runoff will drain into a recovery or disposal system. Safeguard concrete containment structures against cracking by protecting them from freezing and thawing cycles and by designing them to accommodate expansion and contraction.

Containers should be thoroughly rinsed and emptied into storage or treating tanks before disposal. Bury the containers in an approved landfill, or dispose of them by other approved means. Be especially careful not to contaminate streams or ground water.

Be sure to read and follow label requirements for storage and disposal for each preservative. If you are still in doubt about how to safely store a product or dispose of the empty containers, contact the supplier and follow his recommendations.

Spills

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

ENVIRONMENTAL EXPOSURE

PENTA*

Penta is common in the aquatic environment. Circumstantial evidence, including the identification of penta in rainwater, indicates that penta may occasionally be present in ambient air. Low levels of this compound have been detected in both wastewater and surface water. While the source of these residues is often unclear, it has been suggested that, in addition to direct contamination of water by penta, degradation of other organic compounds or chlorination of water may result in the chemical production of the compound.

Penta is moderately persistent in the aquatic environment. It was reportedly detected in lake water and fish six months after an accidental spill. The prevailing use-patterns of penta, primarily as a wood preservative, should preclude significant contamination of water as long as spills and industrial accidents are avoided.

Penta is moderately persistent in the soil. Published data report that persistence ranges from 21 days to five years. Under most conditions, penta will seldom persist in the soil for periods exceeding nine months, and its half-life will often be far less than this. Numerous studies have identified soil micro-organisms capable of degrading penta, but the extent of their distribution is unknown. Since the major use of penta (wood preservative) doesn't involve application to the soil, the likeliest source of soil contamination is the leaching or bleeding of the preservative from treated wood. Such phenomena may result in low levels of penta contamination in the immediate vicinity (within several inches) of the treated wood.

Available data indicate that penta isn't readily translocated by plants and that the compound is rapidly eliminated by mammals following exposure. Significant accumulation in plants and mammals isn't likely to occur.

*Adapted from The Biologic and Economic Assessment of Pentachlorophenol, Inorganic Arsenicals, Creosote. Volume 1: Wood Preservatives. 1980. USDA. Cooperative Impact Assessment Report. Technical Bulletin 165-1, 435 pp.

ARSENICALS

Published literature isn't available that indicates any adverse effects on the environment from arsenical wood preservatives. Arsenate (the salt form) that is present in aerobic soils is bound tightly to the soil components and becomes unavailable for plant uptake or leaching.

CREOSOTE

The amount of liquid creosote that enters the environment is relatively small. The fate of creosote in the environment isn't known, but most of its components are quickly biodegraded

THREATENED AND ENDANGERED SPECIES

The Endangered Species Act (ESA) was passed by Congress to protect certain plants and wildlife that are in danger of becoming extinct. This act requires EPA to ensure that these species are protected from pesticides.

Formulation of the Utah Threatened and Endangered Species/Pesticides Plan is a cooperative effort between federal, state, and private agencies and producers/user groups, and is a basis for continuing future efforts to protect threatened and endangered species from pesticides whenever possible. Furthermore, this plan provides agencies direction for management policies, regulations, enforcement and implementation of threatened and endangered species/pesticide strategies.

EPA has therefore launched a major new initiative known as the Endangered Species Labeling Project. The aim is to remove or reduce the threat to threatened and endangered species from pesticide poisoning. EPA has the responsibility to protect wildlife and the environment against hazards posed by pesticides. The ESA is administered by the U.S. Fish and Wildlife Service (FWS) in the U.S. Department of Interior. The Fish and Wildlife Service will determine jeopardy to threatened and endangered species and report to EPA. EPA and FWS will work cooperatively to ensure that there is consistency in their responses to pesticide users and to provide necessary information. The Utah Department of Agriculture is acting under the direction and authority of EPA to carry out the ESA as it relates to the use of pesticides in Utah.

Maps will show the boundaries of all threatened and endangered species habitats in affected counties. The

maps identify exactly where, in listed counties, use of active ingredients in certain pesticides is limited or prohibited. Product labels will be updated as necessary. The updated labels will reflect any additions or deletions to the project. Because EPA's approach to the protection of threatened and endangered species was in the proposal phase at the time this guide was published, any and all of the above information on threatened and endangered species is subject to change and may not be valid.

WORKER PROTECTION STANDARDS

This final rule, which was proposed in 1988 and that substantially revised standards first established in 1974, affects 3.9 million people whose jobs involve exposure to agricultural pesticides used on plants; people employed on the nation's farms; and in forests, nurseries and greenhouses. The standard reduces pesticide risks to agricultural workers and pesticide handlers. The standard is enforceable on all pesticides with the Worker Protection Standard labeling. The provisions became fully enforceable in January 1995.

Agricultural workers in Utah now have a far greater opportunity to protect themselves, their families and others. These workers will know, often for the first time, when they are working in the presence of toxic pesticides, understand the nature of the risks these chemicals present, and get basic safety instructions.

Among the provisions of the rule are requirements that employers provide handlers and workers with ample water, soap and towels for washing and decontamination and that emergency transportation be made available in the event of a pesticide poisoning or injury. The rule also establishes restricted-entry intervals -- specific time periods when worker entry is restricted following pesticide application -- and requires personal protection equipment (PPE) for all pesticides used on farms or in forests, greenhouses and nurseries. Some pesticide products already carry restricted re-entry intervals and personal protection equipment requirements; this rule raised the level of protection and requirements for all products.

Other major provisions require that employers inform workers and handlers about pesticide hazards through safety training, which handlers have easy access to pesticide-label safety information, and that a listing of

pesticide treatments is centrally located at the agricultural facility. Finally, handlers are prohibited from applying a pesticide in a way that could expose workers or other people.

GROUNDWATER CONTAMINATION BY PESTICIDES

Utah has implemented a comprehensive and coordinated approach to protect groundwater from pesticide contamination.

Formulation of the Groundwater/Pesticide State Management Plan is a cooperative effort between federal, state, and private agencies and producers/user groups; it provides a basis for continuing future efforts to protect groundwater from contamination whenever possible. Furthermore, this plan provides agencies with direction for management policies, regulations, enforcement and implementation of groundwater strategies.

While it's recognized that the responsible and wise use of pesticides can have a positive economic impact, yield a higher quality of crops, enhance outdoor activities, and give relief from annoying pests, the Utah Department of Agriculture is authorized by the U.S. Environmental Protection Agency (EPA) to enforce the protection of groundwater from pesticides. Product labels will be updated as necessary.

The Utah Department of Agriculture, in concert with cooperating agencies and entities, admonishes strict compliance with all pesticide labels, handling procedures and usage to protect groundwater in the state.

Groundwater can be affected by what we do to our land. Prevention of groundwater contamination is important, because once the water is polluted, it's very hard and costly to clean up. In some instances, it's impossible, especially if it's deep underground. City and urban areas

especially contribute to pollution because water runoff that contains pesticides runs into drainage tunnels, then into a river or an underground stream that drains into the river. For more complete information about what groundwater is and where it comes from, read the study manual "Applying Pesticides Correctly." Shallow aquifers or water tables are more susceptible to contamination than deeper aquifers. Sandy soils allow more pollution than clay or organic soils, because clays and organic matter absorb many of the contaminants.

The Federal Insecticide, Fungicide and Rodenticide Act (FIFRA), as amended, establishes a policy for determining the acceptability of a pesticide use or the continuation of that use, according to a risk/benefit assessment. As long as benefits outweigh adverse effects, a pesticide can be registered by the EPA. Although the intent of a pesticide application is to apply the pesticide to the target or pest, part of the pesticide will fall on the area around the target or pest. Rain or irrigation water then can pick up the part that isn't degraded or broken down and carry it to the groundwater via leaching.

The major factors that influence the amount of contamination that can get into water are the chemicals' persistence in soil, retention time or time it remains in the soil, the soil type, the time and frequency of the application(s), soil moisture, placement of the pesticide, and the ability of the chemical to persist once in the aquatic environment. Each of these factors will influence the amount of pesticide that can leave the root zone or soil surface and percolate to groundwater.

Although some pesticides may have a high absorption quality, when they are applied to sandy soil, they will still migrate to the water table because there are no fine clay particles or organic matter to hold them. The management and use of pesticides is up to the individual applicator and/or land owner as to whether safe practices are used. Water is one of our most valuable resources; we must keep it as pure as possible.

GLOSSARY

Defined below are some of the terms used in this manual. Definitions were taken mainly from *Wood as an Engineering Material, Wood Handbook*, USDA Agricultural Handbook No. 72, Revised 1974.

C

CELLULOSE -- The carbohydrate that is the principal constituent of wood that forms the framework of the wood cells.

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

D

DECAY -- The decomposition of wood substance by fungi. **Incipient decay** -- The early stage of decay that hasn't proceeded far enough to soften or otherwise perceptibly impair hardness of the wood. It's usually accompanied by a slight discoloration or bleaching of the wood. **Advanced (or typical) decay** -- The older stage of decay in which the destruction is readily recognized because the wood has become punky, or crumbly. Decided discoloration or bleaching of the rotted wood is often apparent.

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

G

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

H

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

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

K

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

L

LIGNIN -- The second most abundant constituent of wood, located mainly in the secondary wall.

M

MILLWORK -- Planed and patterned lumber for finish work in buildings, including items such as sash, doors, cornices, panelwork, and other items of interior or exterior trim. This doesn't include flooring, ceiling or siding.

MOISTURE CONTENT -- The amount of water contained in wood, usually expressed as a percentage of the weight of the oven-dry wood.

O

OVEN-DRY WOOD -- Wood dried to a relatively constant weight in a ventilated oven at 101 to 105 degrees C.

P

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

S

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

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

SOFT ROT -- A special type of decay developing under very wet conditions (as in cooling towers and boat timbers) in the outer wood layers, caused by microfungi.

SOFTWOODS -- Generally, one of the botanical groups of trees that, in most cases have needlelike or scalelike leaves; the conifers, also the wood produced by such trees. The term has no reference to the actual softness of the wood.

W

WEATHERING -- The mechanical or chemical disintegration and discoloration of the surface of wood caused by exposure to light, the action of dust and sand carried by winds, and the alternate shrinking and swelling of the surface fibers with the continual variation in temperature and moisture content brought by changes in the weather. Weathering doesn't include decay.

WHITE-ROT -- In wood, any decay or rot attacking both the cellulose and lignin and producing a generally whitish residue that may be spongy or stringy rot or pocket rot.

SOURCES OF INFORMATION

This manual is intended to provide basic information essential to safe handling of pesticides and to prepare treaters for certification. Changing of pesticide registration and use requires continuing study to keep you up-to-date.

Proceedings, standards, and other publications of the American Wood Preservers Association provide current information to wood preservers. Other trade publications will also prove helpful.

CALIBRATION FORMULAS

To Calculate Travel Speed in Miles Per Hour:

The travel speed of a sprayer is determined by measuring the time (seconds) required to travel a known distance (such as 200 feet). Insert the values in the following formula to determine the miles per hour.

$$\frac{\text{Distance in Feet} \times 60}{\text{Time in Seconds} \times 88} = \text{Miles Per Hour}$$

Example: $\frac{(200 \text{ feet}) \times (60)}{(30 \text{ seconds}) \times (88)} = \frac{12,000}{2640} = 4.55 \text{ mph}$

To Calculate the Gallons Per Minute Applied During Broadcast Spraying:

The application rate in gallons per minute (GPM) for each nozzle is calculated by multiplying the gallons per acre (GPA), times the miles per hour (MPH), times the nozzle spacing in inches (W); then dividing the answer by 5940. For small adjustments in GPM sprayed, operating pressure is changed. For large adjustments in GPM sprayed, travel speed (miles per hour) is changed.

$$\frac{\text{GPA} \times \text{MPH} \times \text{W}}{5940} = \text{GPM}$$

Example: $\frac{(12 \text{ GPA}) \times (4.5 \text{ MPH}) \times (24")}{5940} = \frac{1296}{5940} = 0.22 \text{ GPM}$



To Calculate the Gallons Per Minute Applied During Band Spraying:

Broadcast spraying applies chemicals to the entire area. Band spraying reduces the amount of area and chemicals sprayed per acre. To use the above formulas for band sprayer applications, use the band width (measured in inches) rather than nozzle spacing for the "W" value.

Discussion of Terminology:

The *active ingredients* of a pesticide are the chemicals in a formulation that control the target pests. The *formulation* is the pesticide product as sold, usually a mixture of concentrated active ingredients and an inert material. Restricted use pesticides are purchased in formulations requiring *dilution prior to application*. Formulations are diluted with inert substances such as water. The *percentage of active ingredients* in a pesticide formulation directly affects dilution and application rates. Given two pesticides, A = 50% active ingredients, B = 100% active ingredients; the applications with pesticide A will require twice the formulation of pesticide B.

To Determine Total Amount of Pesticide Formulation Required Per Tank:

To calculate the total amount of pesticide formulation needed per spray tank, multiply the recommended dilution, ounces/pints/cups/teaspoons/tablespoons/etc. of pesticide per gallon of liquid, times the total number of gallons to be mixed in the sprayer. A full or partial tank of pesticide spray may be mixed.

$$(\text{Dilution Per Gallon}) \times (\text{Number of Gallons Mixed}) = \text{Required Amount of Pesticide Formulation}$$

Example: $(3 \text{ ounces per gallon}) \times (75 \text{ gallons}) = 225 \text{ ounces}$

1 gallon = 128 ounces; with unit conversion $225 \text{ ounces} = 1.76 \text{ gallons}$

To Calculate the Amount of Pesticide Formulation Sprayed Per Acre:

The amount of pesticide formulation sprayed per acre is determined by multiplying the quantity of formulation (ounces/pounds/pints/cups/teaspoons/tablespoons/etc.) mixed per gallon of water, times the number of gallons sprayed per acre.

$$(\text{Quantity of Formulation Per Gallon}) \times (\text{Gallons Sprayed Per Acre}) = \text{Formulation Sprayed Per Acre}$$

Example: $(1/2 \text{ pounds per gallon}) \times (12 \text{ gallons per acre}) = 6 \text{ pounds per acre}$

Amount of Active Ingredients Sprayed Per Acre:

To calculate the amount of active ingredients (AI) applied per acre, multiply the amount (pounds, gallons, ounces, etc) of pesticide formulation required per acre, times the percentage of active ingredients in the formulation (100%, 75%, 50%, 25%, etc.), and divide the value by 100.

$$\frac{(\text{Amount of Formulation Required Per Acre}) \times (\text{Percentage of AI})}{100} = \text{Active Ingredients Per Acre}$$

Example: $\frac{(4 \text{ pounds formulation sprayed per acre}) \times (75\% \text{ AI})}{100} = 3 \text{ pounds of AI sprayed per acre}$

Note: 75% = 0.75

To Calculate the Gallons of Pesticide Mixture Sprayed Per Acre:

The amount of pesticide mixture sprayed per acre is determined by dividing the number of gallons sprayed by the number of acres sprayed.

$$\frac{\text{Gallons Sprayed}}{\text{Acres Sprayed}} = \text{Gallons Sprayed Per Acre}$$

Example: $\frac{200 \text{ Gallons Sprayed}}{10 \text{ Acres Sprayed}} = 20 \text{ gallons of pesticide mixture sprayed}$

UNIT CONVERSION AND CALIBRATION FORMULAS

Unit Conversion:

One acre = 43,560 square feet

One mile = 5,280 feet

One gallon = 128 fluid ounces

One quart = 2 pints = 4 cups = 32 fluid ounces

One pint = 2 cups = 16 fluid ounces

One tablespoon = 3 teaspoons = 0.5 fluid ounces

One pound = 16 ounces

One gallon = 231 cubic inches

Example: $\frac{1}{2}$ acre = 21,780 square feet

Example: $\frac{1}{4}$ mile = 1320 feet

Example: $\frac{1}{2}$ gallon = 64 fluid ounces

Example: 2 quarts = 64 fluid ounces

Example: $\frac{1}{2}$ pint = 1 cup = 8 fluid ounces

Example: 2 tablespoons = 1 fluid ounce

Example: $\frac{1}{4}$ pound = 4 ounces

Example: 2 gallons = 462 cubic inches

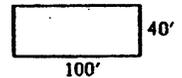
Area and Volume Calculations:

Area of Rectangular or Square Shape

The area of a rectangle is found by multiplying the length (L) times the width (W).

(Length) x (Width) = Area

Example: (100 feet) x (40 feet) = 4000 square feet

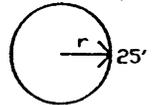


Area of Circle

The area of a circle is the radius (radius = one-half the diameter), times the radius, times 3.14.

(radius) x (radius) x (3.14) = Area

Example: (25 feet) x (25 feet) x (3.14) = 1962.5 square feet

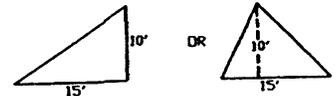


Area of Triangular Shape

To find the area of a triangle, multiply $\frac{1}{2}$ times the base width of the triangle, times the height of the triangle.

$(\frac{1}{2})$ x (base width) x (height) = Area

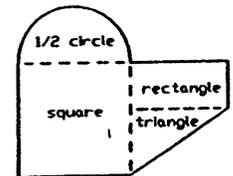
Example: $(\frac{1}{2})$ x (15 feet) x (10 feet) = 75 square feet



Area of Irregularly Shaped

Irregularly shaped sites can often be reduced to a combination of rectangles, circles, and triangles. Calculate the area of each shape and add the values of the individual areas to obtain the total area.

Example: a rectangle, a triangle, a square, and one-half of a circle



Another method is to convert the site into a circle. From a center point, measure the distance to the edge of the area in 10 or more increments. Average these measurements to find the radius, then calculate the area using the formula for a circle.

Example: approximate the area by calculating the area of a similarly sized circle

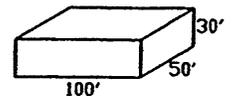


Volume of Cube and Box Shapes

The volume of a cube or box is found by multiplying the length, times the width, times the height.

(Length) x (Width) x (Height) = Volume

Example: (100 feet) x (50 feet) x (30 feet) = 150,000 cubic feet



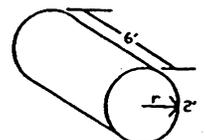
Volume of Cylindrical Shapes

The volume of a cylinder is found by calculating the area of the round end (see formula for circle) and multiplying this area times the length or height.

Example: (radius) x (radius) x (3.14) = Area of Circle

(Area of Circle) x (Length) = Volume of Cylinder

(2 feet) x (2 feet) x (3.14) x (6 feet) = 75.36 cubic feet



WEIGHTS AND MEASURES

Weights:

1 ounce	= 28.35 grams
16 ounces	= 1 pound
	= 453.59 grams
1 gallon water	= 8.34 pounds
	= 3.785 liters
	= 3.78 kilograms

Liquid Measures:

1 fluid ounce	= 2 tablespoons
	= 29.573 milliliters
16 fluid ounces	= 1 pint
	= 0.473 liters
2 pints	= 1 quart
	= 0.946 liters
8 pints	= 4 quarts
	= 1 gallon
	= 3.785 liters

Length:

1 foot	= 30.48 centimeters
3 feet	= 1 yard
	= 0.9144 meters
16 ½ feet	= 1 rod
	= 5.029 meters
5,280 feet	= 320 rods
	= 1 mile
	= 1.6 kilometers

Area:

1 square foot	= 929.03 square centimeters
9 square feet	= 1 square yard
	= 0.836 square meters
43,560 square feet	= 160 square rods
	= 1 acre
	= 0.405 hectares

Speed:

1.466 feet per second	= 88 feet per minute
	= 1 mph
	= 1.6 kilometers per hour (kph)

Volume:

27 cubic feet	= 1 cubic yard
	= 0.765 cubic meters
1 cubic foot	= 7.5 gallons
	= 28.317 cubic decimeters