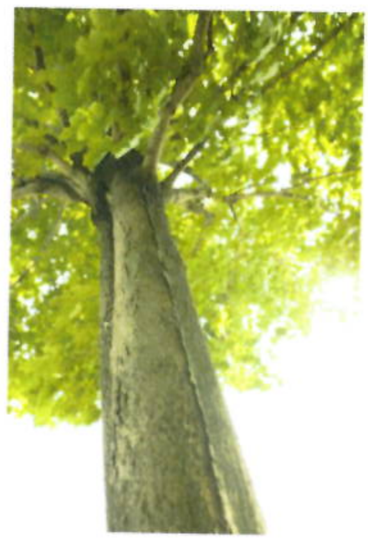
Guidelines for the Use, Handling and Disposal of Treated Wood



Parks Canada Agency
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List of Acronyms

ACA	Ammoniacal copper arsenate
ACQ	Ammoniacal copper quaternary
ACZA	Ammoniacal copper zinc arsenate
CA	Copper azole
CCA	Chromated copper arsenate
CuN	Copper naphthenate
DOT	Disodium octaborate tetrahydrate
HDPE	High density polyethylene
IC&I	Industrial, commercial and institutional
LDPE	Low density polyethylene
PAH	Polycyclic aromatic hydrocarbon
PCF	Pounds per cubic foot
PCP	Pentachlorophenol
PE	Polyethylene
PTW	Pressure treated wood
ZnN	Zinc naphthenate

1. Guideline Objectives

The main objective of these guidelines is to provide Parks Canada management and staff with the necessary information and tools to reduce environmental impacts and health risks to employees, as well as visitors when using treated wood in various construction structures.

These guidelines also establish the best practices regarding the use, handling and disposal of treated wood within Parks Canada's field units. These guidelines focus on various types of preservatives used to treat wood that may be used to extend the service life of wood.

2. Introduction

Across Canada, wood has been the material of choice for many applications such as building construction, decking, retaining walls, outdoor furniture, playground equipment, bulkheads, piers, pilings, utility poles, and many other uses. Wood has many advantages such as strength, appearance, ease of fabrication, availability, renewability, and cost, but when it is used in certain situations, particularly outdoors, wood is subject to attack by fungi, insects, and marine organisms (Dickey, 2003).

A wide range of wood preservative treatments has since been developed to protect wood and prolong its useful life. Wood preservatives have been used around the world for many years and across Canada for more than 100 years. During which time, wood preservatives have proven to be an effective treatment against natural degradation agents (CITW, 2004).

Treated wood was most commonly produced with chromated copper arsenate (CCA). Chromium (a bactericide), copper (a fungicide) and arsenic (an insecticide) were combined to prevent decay and insect infestation. Other arsenic containing preservatives include ammoniacal copper arsenate (ACA) and ammoniacal copper zinc arsenate (ACZA). Despite being aware of possible risks from CCA treated wood since the late 1970's, it was still widely used in Canada and the United States up to December 2003.

In February 2002, the U.S. Environmental Protection Agency (EPA) announced that the treated wood industry would voluntarily phase out use of CCA wood preservatives for residential applications (MTURI, date NA). Canadian wood preservation companies announced a similar phase-out as Health Canada's Pest Management Regulatory Agency (PMRA) followed in the footsteps of its American counterpart. Other countries also have restrictions or proposed restrictions. They include Japan, Denmark, Sweden, Germany, Australia and New Zealand.

Wood produced prior to the voluntary phase out is expected to remain in-service for many years. Moreover, this voluntary phase-out still allows the use of CCA treated wood outside residential settings.

3. Best Practices

3.1 Existing Treated Wood Structures and Facilities

Many structures and facilities built with treated wood can be found in sites managed by Parks Canada. These structures and facilities should be handled as follows:

1. If they are in good condition, existing structures and facilities built with any type of treated wood should not be replaced, unless they are in direct contact with drinking water.

2. The surfaces of all structures and facilities that have been treated with a CCA wood preservative and that may be touched regularly by visitors must be completely covered with a penetrating, oil-based finish, such as a stain or water-resistant sealer. It is preferable to use a durable, high-quality product. In addition to waterproofing the wood, the application of such sealers reduces the release of chemicals contained in CCA-treated wood by 80% to 95%. Another coat of penetrating oil-based sealer should be applied when the current finish begins to show signs of deterioration. Particular attention should be paid to structures that are regularly touched by visitors (e.g. handrails, picnic tables, etc.). (Stilwell and Musante, 2003).

3. The use of non-penetrating finishes, such as paint or urethane, is not recommended because peeling and flaking can have an impact on the wood's durability and on exposure to preservatives contained in the wood.

4. It may not be justifiable to add a coat of preservative to a structure made from old treated wood. This practice would not extend the structure's durability. Instead, the replacement of the existing structure should be considered if it has reached the end of its useful life.

5. Old structures made with CCA-treated wood should be monitored carefully and replaced before the end of their useful lives, i.e. before the wood begins to break down or decompose, in order to avoid the release of highly toxic arsenic.

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

3.2 New Treated Wood Structures and Facilities

1. The use of CCA-treated wood in proposed construction and development projects should be limited as much as possible. The use of alternative products should be promoted. CCA-treated wood should only be used when such protection is important, as in areas where the wood is subject to decay or insect attack, or is in contact with damp soil or water and that no alternate measure is available.

2. CCA-treated wood must not be used in the construction of play structures, and landscaping timbers. Other types of treated wood products should be promoted for patios, walkways/sidewalks or footbridges.

3. No treated wood should be used in the construction of items that may come in direct contact with food or that may introduce chemicals into the food chain: feeders, picnic tables, silos, feed storage structures, hives, drinking troughs, compost bins and wood chip mulch.

4. Creosote-treated wood should not be used inside dwellings or areas where it may come into frequent contact with human hands, such as handrails.

5. Pentachlorophenol-treated wood should not be used inside dwellings and is generally not recommended for areas where it may come into frequent contact with human hands, such as handrails.

3.3 Appropriateness and Justification of the Use of Treated Wood

1. Project proponents should be able to determine the most appropriate products and should be able to justify their use.

2. Treated wood should only be used when it is important that the wood be protected (risk of decay, attack by insects or contact with water or damp soil). Wood treatment should not be a substitute for good construction design.

3. Use treated wood that has undergone a fixation or stabilization process.

3.4 Usage of Treated Wood in Aquatic Environments

Particular attention should be given to the environmental risks associated with all structures placed in aquatic environments. Since the long-term impacts of treated wood on aquatic environments are relatively unknown and may vary depending on many factors, a preventive approach is essential.

1. Treated wood should not be used under water or where it has contact with a body of water.

2. Proponents must conduct a thorough evaluation of the receiving environment before choosing the most appropriate construction material.

3. If appropriate, after having demonstrated the need to use treated wood in an aquatic environment, proponents must identify the most suitable type of wood treatment given the characteristics of the receiving environment.

4. The use of treated wood should always be managed so that the resulting water and sediment concentrations of preservative active ingredients (including background concentrations) remain below water quality criteria and sediment benchmarks or quality criteria, where they exist.

5. Restrictions may be placed on the period when work can be carried out in order to protect sensitive aquatic species and reduce the risk of exposure to toxic elements during particularly sensitive life stages.

6. Polyethylene (PE) wear strips should be used to prevent abrasion of treated wood structures in aquatic environments.

3.5 Safe Handling of Treated Wood

1. Project managers should ensure that the treated wood to be used has been certified according to the standards of the treated wood industry.

2. Treated wood must be visually inspected before use to ensure that it appears clean and its surface is free of preservative residues. Otherwise, the lumber should not be used and should be disposed of in accordance with the manufacturer's guidelines and with local and provincial regulations.

3. Anyone who handles treated wood should wear gloves and a long-sleeve shirt. When sawing, sanding and shaping treated wood, workers should also wear dust masks and goggles to avoid touching or inhaling sawdust.

4. Workers must always cut and work with treated wood outdoors or in an adequately ventilated area.

5. Anyone who works with treated wood should wash their hands immediately after finishing their work, and especially before eating, drinking or smoking.

6. During and after construction, all remaining scraps, cuttings, wood chips and sawdust must be collected efficiently and in a timely manner. All wood waste must be disposed of in accordance with the manufacturer's guidelines and with local and provincial regulations.

3.6 Installation and Maintenance of Treated Wood

1. If exposed, cut ends should be protected with a preservative applied in accordance with the manufacturer's instructions, preferably in a protected cutting area and before installation.

2. If the chemical solution is accidentally spilled while ends are being treated, the spill should be cleaned up immediately with a disposable absorbent substance (soil, sawdust, forest litter or rags). Dispose of the contaminated absorbent material safely, in accordance with local and provincial regulations.

3. Corrosion-resistant fastenings should be used to minimize moisture damage.

4. The use of cleaning and bleaching products containing sodium hypochlorite, sodium hydroxide, sodium percarbonate or citric or oxalic acid on treated wood should be avoided because these products can cause the wood to release toxic chemicals.

3.7 Disposal of Treated Wood

1. Never dispose of treated wood by burning.

2. Do not compost scraps, wood chips or sawdust from treated wood.

3. Contact the local or provincial government for information on how to dispose of this material in the community.

4. Re-use treated wood to the extent possible.

3.8 Recommended Hardware for Treated Wood

3.8.1 Connectors

1. Connectors used for ACQ- or CA-treated wood should be manufactured from steel and be either galvanized in accordance with ASTM A653, G185 designation, or be galvanized after manufacture in accordance with ASTM A123. Stainless steel connectors (type 304 or 316) are recommended for maximum service life or severe applications.

2. For borate-treated wood used inside buildings, the same connectors can be used as for untreated wood.

3.8.2 Fasteners

1. Fasteners for ACQ- or CA-treated wood should be galvanized in accordance with ASTM A153. Stainless steel may be used for maximum service life or severe applications. Where appropriate, copper fasteners may also be used.

2. Fasteners used in combination with metal connectors must be the same type of metal to avoid galvanic corrosion caused by dissimilar metals.

3. For borate-treated wood used inside buildings, the same fasteners can be used as for untreated wood.

3.8.3 Flashing

1. Flashing used in contact with treated wood must be compatible with the treated wood.

2. Copper and stainless steel are the most durable metals for flashing. Galvanized steel, in accordance with ASTM A653, G185 designation, is also suitable for use as flashing. Fasteners should be compatible to avoid galvanic corrosion.

3.8.4 Other Hardware

1. There may be additional products such as polymer or ceramic coatings, or vinyl or plastic flashings that are suitable for use with treated wood products. Consult the individual fastener, connector or flashing manufacturer for recommendations for use of their products with treated wood.

4. Various Types of Wood Preservatives

Wood preservatives have been used around the world for many years and across Canada for more than a hundred years. During that time, wood preservatives have proven to be an effective treatment against natural wood degradation agents such as fungi and insects. Wood used in outdoor applications, with the exception of naturally rot-resistant species such as cedar and redwood, should be treated with preservatives if it is expected to last more than a few years.

In the past few years, several new wood preservatives have been developed. Some confusion has come about with this broadened range of wood preservatives. Hence, it has become necessary to clarify which substances are contained in treated wood and what types of treated wood can be used in the various environments.

Identification of wood preservatives can be simplified by classifying them as either waterborne or oilborne, depending on the chemical composition of the preservative and the carrier solvent used during the treating process. The following section describes the most common types of wood preservatives.

Table 4.1 Wood Preservatives and Carriers (Arnold Lumber, date NA).

Wood Preservatives and Carriers				
Carrier	Creosote (Tar Oil)	Heavy Petroleum Oil	Water	Water & Ammonia
Preservative	Creosote	Pentachloro-phenol (PCP)	Chromated Copper Arsenate (CCA), Borates	ACQ, AZCA, CA

4.1 Waterborne Wood Preservatives

Chromated copper arsenate (CCA), alkaline copper quaternary compounds (ACQ), copper azole (CA), and ammoniacal copper zinc arsenate (ACZA) are waterborne preservatives that react with or precipitate in the wood substrate and become "fixed" to prevent leaching. Waterborne preservatives have a dry paintable surface, which is the main reason behind their common use in residential applications. These preservatives are primarily used to treat softwood species and are very effective for this application. However, because their cellular structure is different, hardwoods treated with waterborne preservatives may not be adequately protected in some types of exposures or environments (Lebow and Tippie, 2001). Waterborne wood preservatives may increase corrosion of unprotected metal, and so all metal fasteners used with treated wood should be hot-dipped galvanized or stainless steel. Although, not all stainless steel fasteners are acceptable for use with treated wood (Simpson, 2005). Borates are another type of waterborne preservative, but borate-based preservatives have the disadvantage of not being fixed in the wood and thus are readily leached if exposed to rainfall or standing water (Lebow and Tippie, 2001).

Figure 4.1 Wood treated with waterborne preservatives is often used for decking, such as in this wetland boardwalk (Lebow and Tippie, 2001).

4.1.1 Chromated Copper Arsenate (CCA)

Chromated copper arsenate (CCA) is a waterborne preservative containing arsenic, chromium and copper. This type of preservative is used for the long-term protection of wood against attack by fungi, insects and marine borers. CCA-treated wood typically has a light green color but it may also be factory stained or dyed to various shades of brown. A water-repellent treatment may also be applied to help prevent checking and splitting when the wood is used on a flat surface, such as decking. CCA-treated wood has little or no odour associate to it (Lebow and Tippie, 2001).

Until January 2004, CCA was the most widely used wood preservative in North America (Health Canada, 2005). For over seventy years, CCA was the preservative of choice for the pressure-treatment of wood. (Harrison, 2003). Wood preservation companies in the U.S. and Canada did pledge to phase out the use of the arsenic-based preservative CCA in treated wood because of consumer pressure. Prior to the voluntary phase-out of CCA usage by the Wood Treatment industry, CCA-treated wood was commonly used in residential construction such as playground structures, fences, gazebos and decks. Although, it may still be used for industrial uses such as utility and construction poles, marine timbers and pilings (Health Canada, 2005).

4.1.2 Alkaline Copper Quaternary (ACQ)

Alkaline copper quaternary (ACQ) is one of several wood preservatives that have been developed in recent years because of environmental or safety concerns with CCA. This preservative contains copper and a quaternary ammonium compound. Multiple variations of ACQ have already been standardized but some are still in the process of standardization (USDA Forest Service, date NA). ACQ-B is formulated using ammoniacal copper, and like ACZA, ACQ-B is able to penetrate Douglas fir and other difficult-to-treat wood species. This preservative is marketed primarily on the West Coast. ACQ-B treated wood has a dark greenish brown color and may have an ammonia odour until the wood dries. ACQ-D is formulated using amine copper, which gives the wood a light brown color and little noticeable odour. It does not penetrate difficult-to-treat wood as well as ACQ-B and is most commonly used for treatment of thick sapwood pine species (Lebow and Tippie, 2001).

The multiple formulations of ACQ allow some flexibility in achieving compatibility with a specific wood species and application. When ammonia is used as the carrier solvent, ACQ has an improved ability to penetrate difficult-to-treat wood species. However, if the wood species is readily treated, such as southern pine, an amine carrier may be used to provide a more uniform surface appearance. All the ACQ treatments accelerate corrosion of metal fasteners relative to untreated wood, and hot-dipped galvanized or stainless steel fasteners are recommended (USDA Forest Service, date NA).

4.1.3 Copper Azole (CA)

Copper azole (CA) is another recently developed wood preservative that contains copper, boric acid, and tebuconazole. These three active ingredients work together to protect against decay fungi and insects. CA has not been standardized for use in seawater. Because CA was developed very recently, it is not yet widely used and may not be available in some areas. CA is able to provide good treatment for southern pine and hemlock/fir species groups (Lebow and Tippie, 2001). Douglas fir may adequately be treated when ammonia is included in the CA formulations. However, including ammonia is likely to have slight affects on the surface appearance and initial odour of the treated wood. The CA treatments do increase the rate of corrosion of metal fasteners relative to untreated wood, and hot-dipped galvanized or stainless steel fasteners are recommended (USDA Forest Service, date NA). CA-treated wood has a uniform greenish brown color and little or no odour. It can also be painted or stained (Lebow and Tippie, 2001).

4.1.4 Ammoniacal Copper Zinc Arsenate (ACZA)

Ammoniacal copper zinc arsenate (ACZA) contains copper, zinc, and arsenic. ACZA is a refinement on the original formulation, ACA. ACZA protects against attack by decay fungi, insects, and most types of marine borers. Its uses are very similar to those of CCA-C and include treatment of poles, piling, and timbers. Because of its ability to penetrate Douglas fir and other difficult-to-treat wood species, it is most widely used on the West Coast. The color of the treated wood is dark brown to bluish green. The wood initially has a slight ammonia odour, but soon dissipates after treatment as the wood dries (Lebow and Tippie, 2001).

4.1.5 Borate-Based Preservatives

Borate preservatives are salts such as sodium octaborate (disodium octaborate tetrahydrate – DOT), sodium tetraborate, and sodium pentaborate that are dissolved in water. They are also referred as "oxides of boron" (SBX) Borates are effective preservatives against decay fungi, wood-boring insects and subterranean termites (PTW-SafetyInfo, date NA). Borate preservatives are diffusible, and with appropriate treating practices, they can achieve excellent penetration in species that are difficult-to-treat with other preservatives. However, the borate in the wood remains water-soluble and readily leaches out in soil or rainwater (Lebow and Tippie, 2001). Borate-treated wood is not considered suitable for unprotected outdoor use, such as for fence posts or poles, but is suitable for most building construction purposes (Gegner, 2002) and for applications where the wood is kept free from rainwater, out of standing water, and away from ground contact. An example of such a use is in the construction of wooden buildings in areas of high termite hazard. Borate-treated wood is odourless and colorless and may be painted or stained (Lebow and Tippie, 2001).

4.2 Oilborne Wood Preservatives

The most common oilborne preservatives are creosote, pentachlorophenol (PCP), and copper naphthenate (CuN). These types of preservatives are commonly used for applications such as utility poles, bridge timbers, railroad ties, pilings, and laminated beams. They are less frequently used for applications that involve frequent human skin contact or for inside dwellings because they may be oily and/or have a strong odour. These preservatives also act as water repellants because of their oily nature, and can help to prevent the checking and splitting of wood (Lebow and Tippie, 2001).

Figure 4.2 Oilborne preservatives are often used for treatment of glulam beams, such as in this bridge (Lebow and Tippie, 2001).

4.2.1 Creosote

Creosote is a distillate of coal tar, which is a byproduct of the carbonization of coal during coke production. Unlike the other oilborne preservatives, creosote is not typically dissolved in oil, but it does maintain properties that make it look and feel oily. Creosote contains a chemically complex mixture of organic molecules, up to 80% of which are polycyclic aromatic hydrocarbons (PAHs). Creosote is effective in preventing attack by decay fungi, insects, and is most particularly effective in repelling marine borers. Creosote is widely used in railroad ties, utility poles, bridge timbers, and piling. It has a dark brown-black color with a noticeably oily surface and strong odour. It is very difficult to paint, stain, or seal a piece of wood or structure treated with creosote (Lebow and Tippie, 2001).

4.2.2 Pentachlorophenol (PCP)

Pentachlorophenol (PCP) is a crystalline solid that can be dissolved in various types of oils. Petroleum oils are generally used as carriers of PCP (NEIA, 1993). This type of preservative is very effective against fungi and insects but does not protect well against ocean marine borers. It is widely used to treat utility poles, bridge timbers, laminated beams, and fresh water and foundation piling. The appearance of PCP-treated wood depends greatly on the type of oil that it is used as a carrier solvent: a very light brown color and dry surface if a light oil is used or a dark brown color and somewhat oily surface if a heavy oil is used (Lebow and Tippie, 2001). The oil used as a carrier for PCP also provides extra protection against moisture-content changes, providing more stability and resistance to splitting (NEIA, 1993). PCP-treated wood is generally more durable if heavy oil is used as a carrier. Hence, light oil is most often used to treat wood for above ground constructions or in covered structures. PCP itself is odourless, but the carrier solvent may have a distinct odour that can be noticed when approaching this type of treated wood. Wood that is pressure treated using PCP in light oil as the carrier solvent is easier to paint or stain which, otherwise, may be difficult to do (Lebow and Tippie, 2001).

4.2.3 Copper Naphtenate (CuN)

Copper naphthenate (CuN) is the reaction product of naphthenic acids and copper salts dissolved in oil. This type of preservative is effective against decay fungi and insects but is not recommended for use in marine applications. CuN is not as widely used as creosote or PCP, but it is used for the treatment of utility poles, highway construction (Lebow and Tippie, 2001) bridges and is commonly available in retail lumberyards for use in fencing and decking (Hutton and Samis, 2000). Like PCP, the properties of CuN are dependent on the type of oil used as the carrier. The oils that are most commonly used as carrier solvents are fuel oil and mineral spirits. The color of the CuN-treated wood varies from light brown to dark green, depending on the type of carrier solvent and the applied treating process. The carrier solvents for CuN-treated wood give it a distinct odour. Wood that is treated using CuN in light oil is easier to paint or stain than wood treated with CuN in dark oil. CuN is widely applied for hand dressing on end cuts or holes bored into treated wood during construction (Lebow and Tippie, 2001).

5. Definitions

The following definitions have been added to help the reader grasp the various technical terms included in this document and to better comprehend the complexity of this matter.

Alkaline Copper Quaternary (ACQ)	Wood preservative containing copper oxide and dimethyl (octadecyl) ammonium chloride.
Borate	Natural mineral, harmless to humans and animals, effective in protecting wood against rot and insects. Borates are water-soluble.
Cambium	The cambium is a thin layer of generative tissue lying between the bark and the wood of a stem, which is most active in woody plants. The cambium produces new layers of phloem on the outside and of xylem (wood) on the inside, thus increasing the diameter of the stem.
Chromated Copper Arsenate (CCA)	Waterborne wood preservative containing arsenic, chromium and copper.
Copper Azole (CA)	Wood preservative containing copper, boric acid and tebuconazole.
Disposal	Consists of the final disposal of the material (e.g., landfill), or treatment (e.g., stabilization) prior to final disposal.
Fasteners	The hardware (e.g. nails, screws, bolts, joist hangers) used to secure treated wood. Since treated lumber is used for durability, fasteners should be hot-dipped galvanized or stainless steel, especially with water borne preservatives, which contain corrosive salt.
Fixation	The chemical process in which the preservative metals in waterborne solution reacts with and bond to wood fiber molecules.
Fungi	Organisms (plant-like) that lack chlorophyll and must obtain their food by microscopic, root-like filaments that penetrate wood tissue and absorb its energy rich chemicals.

Hardwood

The term hardwood designates wood from deciduous trees. Hardwood contrasts with softwood, which generally comes from coniferous trees. They are in typically of higher density and hardness, but there is considerable variation in actual wood hardness in both groups, with a large amount of overlap.

Heat-Treated Wood

Wood that is heat-treated in oxygen-free kilns at temperatures of between 180 C and 280 C. This process makes wood harder, darker and more resistant to decay and compression. However, it loses its elasticity and deals less well with bending, shear force and impact.

Heartwood

This inert or dead portion is called heartwood. Its name derives solely from its position and not from any vital importance to the tree.

Lignin

The stiffening material inside cell walls. Allows trees to grow tall and out-compete other plants for sunlight. Accounts for about 30% of the dry weight of wood.

Marine Borers

Xylophagous bivalve molluscs of the *Teredinidae* family. Their reduced shell is striated with toothed rings used as drills to bore tunnels in submerged wood.

Moisture Content

The weight of water in wood, expressed as a percent of the oven-dried weight of the wood.

On-Site Release

An "on-site release" is an on-site discharge of a pollutant to the environment. This includes emissions to air, discharges to surface waters, on-site releases to land and deep-well underground injection, within the boundaries of the facility.

Pesticide

Chemical substance or product capable of destroying or limiting the growth of living organisms (micro-organisms, animals or plants) that are considered harmful.

Phloem

In vascular plants, phloem is the living tissue that carries organic nutrients, particularly sucrose to all parts of the plant where needed. In trees, the phloem is part of the bark.

Pressure-Treated Wood
Wood preservation process consisting in the pressure injection of a fungicidal, insecticidal preservative into the wood.

Sapwood
Sapwood is comparatively new wood, comprising living cells in the growing tree. All wood in a tree is first formed as sapwood. Its principal functions are to conduct water from the roots to the leaves and to store up and give back according to the season the food prepared in the leaves.

Sealant
A water repellent, which may be forced into the wood along with the chemical preservative in a closed cylinder under pressure. However, treated wood should be cleaned and resealed yearly to maintain optimum appearance.

Severe Damage
Damage, which prevents use of equipment or installations permanently.

Softwood
Wood from conifers are generally referred to as softwood; the term is also used as an adjective for the trees that produce softwood.

Treated Wood
Wood saturated with pesticides to ensure durable resistance to wood-destroying organisms.

Xylem
In vascular plants, the xylem is the tissue that carries water up the root and stem. Wood is composed almost entirely of xylem tissue.

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Appendices

Appendix 1 – Understanding the Structure of Wood

First, a tree has all the characteristics of green plants. Beyond that, a tree is a tall plant with woody tissue. It has the capability to "push" its crown (the primary location for photosynthesis) above other vegetation competing for light. A tree has a distinct light-gathering advantage of having its leaves high above other plants. Although, getting the water and soil nutrients to the upper tissues may be problematic. At the opposite end of the tree, the roots system is dependent upon materials produced way up in the crown. The structure of the tree trunk allows for this problem to be solved, which is the most distinctive feature of trees (Fung et al., 2004).

A tree trunk is primarily composed of dead tissue and serves only to support the weight of the crown. The very outside layers of the tree are the only living portions of a tree trunk. This layer transports materials from the crown to the roots and is called the phloem. The cambium, which produces new wood and new bark tissue, is found on the outside of the phloem. A band of sapwood, called xylem, is found inside the phloem. It transports water to the crown, but is not necessarily a living tissue. The heartwood can be found inside the xylem (Fung et al., 2004).

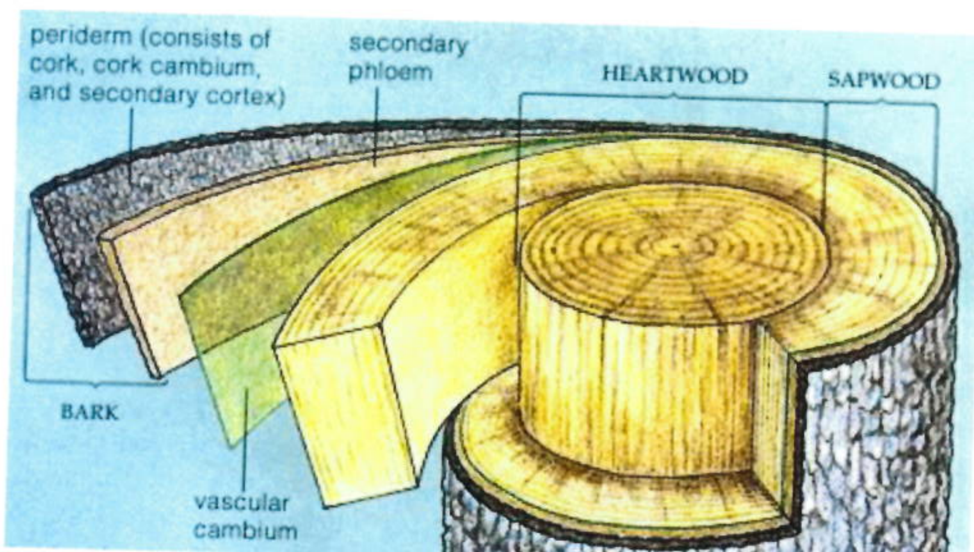

Figure A1.1 Structure of a stem with extensive secondary growth (Fung et al., 2004).

The wood in a tree consists of two general regions: the heartwood and the sapwood. Typically, the heartwood – or center part of the tree – may be quite dense and less porous than the sapwood, and is also generally darker in color (see figure A1.1). This difference is primarily due to the presence of substances called extractives, which are deposited as a result of the tree's growth processes (Hoffman et al., 1995), but also makes it less accepting of preservative (AWP, Inc. 2005). Since sapwood does not contain extractives, it is non-durable even in species with heartwood of high durability. Table Aa.1 lists the heartwood durability of various woods commonly available and their estimated ranges of service life.

Table A1.1 Life expectancy of various species of untreated heartwood in ground contact (Hoffman et al., 1995).

Durability	Species	Life Expectancy of Untreated Heartwood (years)
Very Durable	Eastern Red Cedar	30+
	Redwood	10-30*
	Western Red Cedar	10-25
Durable	White and Burr Oak	10-15
	Northern White Cedar	5-15
Moderately Durable	Tamarack	8-10
	Red Oak	6-8
	Douglas Fir	4-6
Non-Durable	Red and Jack Pine	2-6
	Aspen (poplar) and Cottonwood	3-4
	Ponderosa Pine	3-4
	White Birch	3-4
	Spruce and Balsam Fir	3-4
	Basswood	<5
	Maple	2-4
	Ash	<5
	Willow	<5

**Although tests at the Forest Products Laboratory in Madison, Wisconsin show that redwood durability can be good, it is at best quite variable. Their recommendation is treatment of redwood whenever it is used in ground contact* (Hoffman et al., 1995).

It should be noted that the durability of heartwood varies not only between species but also between trees of the same species, and within the tree itself. As a result, wide ranges of service life in the lumber of even a highly durable wood may be experienced and rapid decay may be occasionally reported (Hoffman et al., 1995).

Hardwood and softwood are the two main categories of tree anatomy. Softwoods are classified as the conifers, or the trees that bear seeds without a seedpod. Hardwoods, or deciduous trees, have seeds encased in pods, which are found in the tree's flowers and fruits. The terms "hardwood" and "softwood" do not indicate the strength of the wood, but rather specify the type of water conducting cells in the living tree. In accordance with it's original source, wood will vary in texture, strength, and color. Some softwood, like pine, is considered very sturdy, while some hardwoods, like balsa wood, are very flimsy and weak (The Mint Museums, date NA). The following table shows the levels of durability generally associated with common North American softwood species

Table A1.2 Natural Durability of North American Softwoods (FCC and CWC, 2005b).

Species	Predominant In the Tree	Heartwood Durability
Western Red Cedar (Thuja plicata)	Heartwood	Durable
Eastern White Cedar (Thuja occidentalis)	Heartwood	Durable
Yellow Cedar (Chamaecyparis nootkatensis)	Heartwood	Durable
Redwood	Heartwood	Durable
Douglas Fir (Pseudotsuga menziesii)	Heartwood	Moderately Durable
Southern Pine	Sapwood	Moderately Durable
Western Larch (Larix occidentalis)	Heartwood	Moderately Durable
Tamarack (E. Larch) (Larix laricina)	Heartwood	Moderately Durable
Western Hemlock (Tsuga heterophylla)	Heartwood	Slightly Durable
Eastern Hemlock (Tsuga canadensis)	Heartwood	Slightly Durable
White Spruce (Picea glauca)	Heartwood	Slightly Durable
Engelmann Spruce (Picea engelmannii)	Heartwood	Slightly Durable
Black Spruce (Picea mariana)	Heartwood	Slightly Durable
Red Spruce (Picea rubens)	Heartwood	Slightly Durable
Sitka Spruce (Picea sitchensis)	Heartwood	Slightly Durable
Lodgepole Pine (Pinus contorta)	Heartwood	Slightly Durable
Jack Pine (Pinus banksiana)	Heartwood	Slightly Durable
Red Pine (Pinus resinosa)	Sapwood	Slightly Durable
Ponderosa Pine (Pinus ponderosa)	Sapwood	Slightly Durable
Western White Pine (Pinus Monticola pinaceae)	Heartwood	Slightly Durable
Eastern White Pine (Pinus strobus)	Heartwood	Slightly Durable
Amabilis Fir (Abies amabilis)	Heartwood	Slightly Durable
Alpine Fir (Abies lasiocarpa)	Heartwood	Slightly Durable
Balsam Fir (Abies balsamea)	Heartwood	Slightly Durable
Western Spruce/Pine/Fir	Heartwood	Slightly Durable
Eastern Spruce/Pine/Fir	Heartwood	Slightly Durable
Hem Fir	Heartwood	Slightly Durable

Appendix 2 – Treatment Method for Pressure Treated Wood

When wood that is not naturally decay resistant is used in an outdoors or wet application, it may be at risk for fungi decay or insect attack. In such cases, preservative-treated wood may be specified. This is lumber that has been chemically treated to make it unattractive to fungi and other pests. Chemical wood preservatives are commonly used to enhance wood durability, and if effectively applied, they can increase the life expectancy of wood by a factor of five to ten times. Not only does treating wood with the appropriate preservative increases its service life but it also helps to conserve our nation's timber resources (EC, 2002).

In Canada, use of treated wood is guided by industry standards and by building codes. The Canadian Standards Association (CSA) has produced the O80 series of standards for treated wood. The National Building Code of Canada (NBCC) is our model building code, adopted and/or modified according to the wishes of various jurisdictions across the country. It contains requirements regarding the use of treated wood in buildings (FCC and CWC, 2005b).

There are two basic methods of treating wood: with and without pressure. For the purposes of this document and because the most commonly used type of preservative-treated wood is pressure-treated, the emphasis will be put on this treatment method.

Process

The pressure treatment of wood involves a series of pressure and vacuum cycles that force the waterborne preservative deep into the wood cell structure. The treatment process is carefully monitored and controlled within an enclosed cylinder. An initial vacuum removes air from the cylinder and wood. The preservative is then introduced into the cylinder without breaking the vacuum. The following step involves the application of pressure until the specified preservative retention is obtained. A final vacuum is pulled to remove excess preservative (Arnold Lumber, date NA).

Although deeper penetration is highly desirable, the impermeable nature of dead wood cells makes it extremely difficult to achieve anything more than a thin shell of treated wood. Key results of the pressure-treating process are the amount of preservative impregnated into the wood (called retention), and the depth of penetration. These characteristics of treatment are specified in results-based standards (FCC and CWC, 2005b).

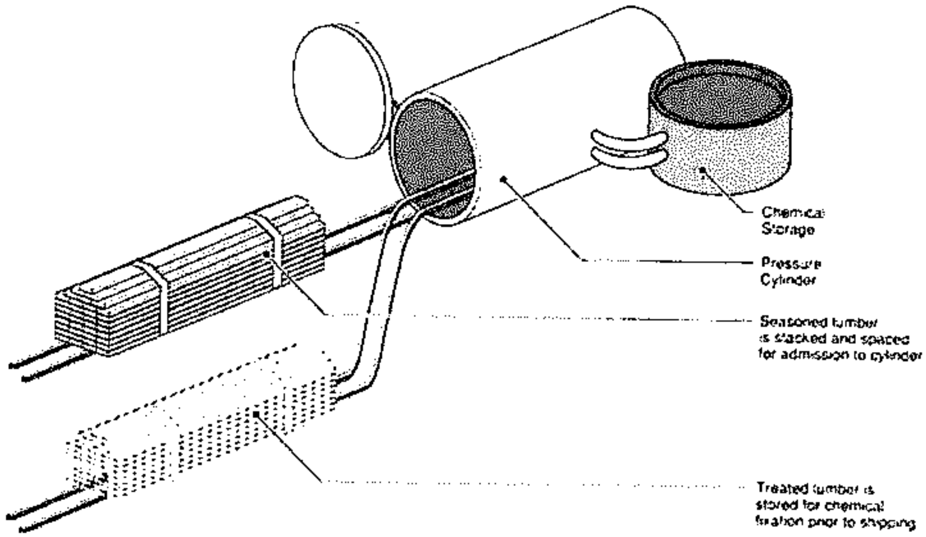

Figure A2.1 Manufacture of pressure-treated wood (CWC, 1995).

Retention of Preservative

Retention of preservatives in wood is typically expressed as kilograms of preservatives per cubic metre (kcm) of wood or pounds per cubic foot (pcf). This relates to the amount of preservatives retained in the wood after completing its treatment cycle and is also considered as a measure of the degree of protection provided (CWC, 1995). The higher the number, the harsher the conditions to which the wood may be exposed (SPC, 2005).

For example, wood preservatives penetrate more readily in plywood than in solid wood of the same species because the veneer cutting process opens the wood grain. The infinitely small fissures created by this process are difficult to detect with the naked eye but greatly enhance the penetration of preservatives under pressure (CWC, 1995).

Canadian standards for wood preservation are based on the American Wood Preservers' Association (AWPA) standards, modified for Canadian conditions. Only preservatives registered by the Canadian Pest Management Regulatory Agency (PMRA) are listed. The typical requirements for treated lumber are that 80% of samples must be penetrated to 10mm or more and the retention must be minimum of 4.0 kg/m^3 CCA (as oxides) for above ground and 6.4 kg/m^3 for ground contact in a 16mm assay zone. Utility poles require a retention of 9.6 kg/m^3 CCA and a penetration of 85% - 100% sapwood. The required penetration and the assay zone for poles vary according to the wood species (FCC and CWC, 2005a).

The CSA O80 series-97 (the current version) contains two new standards: O80.32 for residential decking with a 5mm, rather than 10mm penetration requirement, and O80.34 for borate treatment of lumber for protected applications. The 1997 standard introduced a large number of major revisions including the removal of obsolete waterborne preservatives, the addition of ammoniacal copper quat type B (ACQ-B), the addition of western spruces to the lumber standard, and a reduction of preservative retentions and cleaner processes for wood in marine applications. The current standard also requires testing of all wood products treated to CSA standards to ensure fixation before they leave the treating plant (FCC and CWC, 2005a).

Penetration of Preservative

A deeper and more thorough penetration can be achieved by driving the preservative into the wood cells with pressure. Combinations of pressure and vacuum are used to force adequate levels of chemical into the wood. Pressure-treating preservatives consist of chemicals carried in a solvent that is typically water or oil. Waterborne preservatives have become increasingly popular over the last 20 years, due to the absence of odour, the cleaner wood surface and the ability to paint or stain the wood product (FCC and CWC, 2005b).

Penetration is the depth to which a preservative is forced into the wood. It is an indication of the amount of protection provided. The amount of penetration is determined by the qualities of the wood species used and the treating process. The greater the depth of penetration, the less likely it is that the protected boundary of pressure-treated wood will be breached (CWC, 1995).

In some case, the penetration of the preservative can be improved by incising the surfaces of lumber with knives to create artificial openings through which the preservative can enter the wood (CWC, 1995).

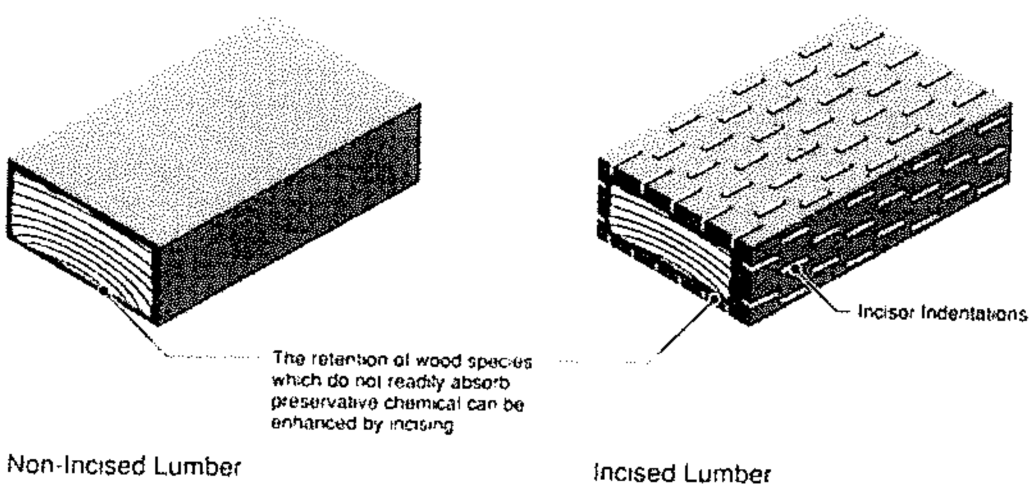

Figure A2.2 Cross section of preservative-treated lumber (CWC, 1995).

Usage of Sealant

If consumers have concerns about existing treated wood structures (e.g., decks or fences), they may consider applying a coating to the wood. Sealing involves treating the wood by applying a layer of paint or stain. Preliminary results from studies conducted by the U.S. EPA and the U.S. Consumer Product Safety Commission (USCPSC) on the effectiveness of commercially available sealants in reducing or eliminating the potential of arsenic exposure from contact with the surfaces of CCA-treated wood, indicate that application of penetrating coatings to CCA-treated structures at least once a year can reduce exposure to arsenic (Health Canada, 2005).

Wood treated with waterborne preservatives may be treated with stains to enhance its appearance or with water repellants to improve its dimensional stability. Water repellants help to prevent the splitting, warping, and twisting of treated wood, especially of horizontal structures, such as decking. Water repellants and stains are sometimes incorporated into the treatment process or may be hand-applied at the construction site. These secondary treatments appear to be beneficial for both increasing longevity and reducing leaching from the treated wood. Field application of finishes must be done with great care in sensitive environments (Hutton and Samis, 2000).

The data show that oil- or water-based sealants or stains that can readily penetrate wood surfaces are preferable to products such as paint, because paints and other film-formers can chip or flake, requiring scraping or sanding for removal, which can increase exposure to arsenic and other toxic chemicals (U.S. EPA, 2005c).