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Use the following learning objectives to focus your study while reading this month's ARCHITECTURAL RECORD / AIA Continuing Education article.

Learning Objective:  
After reading this article, you will be able to:

1. Understand the various causes of wood rot.
  2. Become aware of alternate treatment practices, the history of wood preventatives, and the long-term benefits of preventative treatment.
  3. Develop an understanding of a new highly effective wood treatment process.
- warranty coverage.

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To receive AIA/CES credit, you are required to read the <http://www.fpl.fs.fed.us/ahrc/moldqa.htm>. The quiz [questions](#) include information from this online reading. To receive a faxed copy of the material, contact Joyce Richter, (888) 535-3936 or email [joycer@jeld-wen.com](mailto:joycer@jeld-wen.com).

John and Shirley Reynolds custom-built their two-story home in early 1991. Windows are wood, manufactured in accordance with the Window & Door Manufacturer's Association (WDMA) IS-4 Industry Standard for Water Repellent Preservative Non-Pressure Treatment for Millwork. The windows are painted. The roof design includes minimal overhang. The automatic sprinkler system sits directly beneath lower level windows.

In winter, the Reynolds' home is subject to near-constant rainfall.

In summer, windows are kept moist by the sprinklers. The home is still in relatively good repair, and the Reynolds did not find it necessary to repaint the exterior.

They recently sold the home, however, and new owners contend that lower level windows show evidence of wood decay. A call to the manufacturer reveals that, despite representations when sold that the windows would not experience defects for "at least" 10 years, there is no





Because most common wood species have little resistance to decay, some form of chemical preservative is necessary to protect lumber from rot and from the attack of insects and fungi.

Window and door manufacturers for a half-century have employed various chemicals and a variety of methods to treat window and door components to repel insects, fungi and moisture.

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A search for a more effective solution with lessened environmental impact has led an Oregon manufacturer to a new process that 1) treats wood under pressure and using vacuum techniques—allowing nearly complete saturation (most processes rely on a surface coat to repel moisture and insects) and 2) uses a relatively new chemical formulation in place of solutions common to the industry.

The pioneering venture, in concert with a chemical company specializing in wood-treating systems, replaces the “dip” common to the industry. Preliminary test data, says the manufacturer, suggests the process is highly effective. In addition, full-penetration treatment reduces the possibility that the “envelope of protection” afforded by the treatment will be broken in assembling and installing the woodwork, says a manufacturer’s representative.



Left: Three unpainted L-joints in our greenhouse after 29 months exposure. The middle one is treated with the new process (machined from treated stock), with an untreated to the left (one of 3 of 10 that had not already failed), and on the right (fungus growing out) is a IPBC dip treated L-joint. Right: L-joints and window units in Hilo.

Treated wood typically has eight times the useful lifespan of untreated wood, according to calculations by the American Wood Preservers’ Institute (AWPI).

Most of us are familiar with the most common forms of wood treatment: creosote, the black or brownish oil made by distilling coal tar is widely evident as the

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preservative for railroad ties and, frequently, utility poles. Contemporary outdoor construction nearly always is done with pressure-treated lumber characterized by a green cast and the incisor marks of the treatment process.

We are most likely, however, unfamiliar with less apparent forms of treatment. It may be surprising to some to find that most millwork used in wood windows are subject to some form of preservation technique.

Globally, wood preservation is a \$10 billion industry and is a science of intense interest worldwide. A “Google” web search of the subject results in a half-million hits. Annual North American production of treated lumber is estimated to be in the range of 6-to-7 billion board feet.

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The 300-member, Stockholm-based International Research Group on Wood Preservation this year will disseminate roughly 150 technical documents on subjects as arcane as “Effects of methylene bistiocyanate on morphology and ultra-structure of a sapstain fungus,” and as topical as “Environmental Impacts of CCA (chromated copper arsenate) Treated Wood.” In February, 2004, the Florida Interdisciplinary Center for Environmentally Sound Solutions (FICCESS), under the sponsorship of the National Science Foundation, will host several thousand attendees to the “Environmental Impacts of Preservative-Treated Wood Conference in Orlando.”

Because environmental restrictions are creating changes in the wood preservation landscape, and because of the emergence of new treatment technologies, this continuing education piece will look at wood preservation—from the perspective of the U.S. millwork industry—and discuss water-based processes which, though they have been around for nearly a half century, are likely to become industry standards in this era of environmental sensitivity. It will look at alternative treatment methods that have become standard throughout the industry standards and describe the new water-based process which soon will replace existing treatment methods for all of the product line of the manufacturer.



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Top: L-joints during exposure in Hilo with differences in mold on paint. Bottom: Greenhouse setup of L-joints for artificial spraying of water.



Treatment methods generally differ by wood species, but, in general, the replacement cost of treated wood over its lifetime is much lower than that of untreated wood, which has a shorter useful life, says the American Wood Preservers Association (AWPA).

Although not used in millwork, chromated copper arsenate (CCA), which serves as a fungicide and insecticide (and which gives the green cast to outdoor decks, picnic tables and playground equipment) is topical because the U.S. Environmental Protection Agency (EPA) has announced a ban of its use. Fearful of the effects of arsenic exposure, the U.S. will ban CCA products for residential use after January 2004. The European Commission has announced a partial prohibition on the use of CCA-treated timber, to take effect after June 2004. The reasoning: scientific studies suggest that, over time, arsenic slowly leaches from CCA-treated wood products, the rate dependent upon rainfall, soil PH and the age of the structure. EPA Administrator Christie Whitman announced in February 2002 a “voluntary” decision by the lumber products industry to move from arsenic-based preservation techniques to alternative wood preservatives. The EPA is not recommending, however, that existing structures or surrounding soils be removed or replaced.

As is the case with outdoor lumber manufacture, millwork preservation incorporates water repellants, fungicides and insecticides in the manufacturing process. In most millwork preserving systems “active ingredients” are carried into the wood by petroleum-based solvents, most typically applied today through a “dip” method, no more complicated than it sounds, in which untreated lumber is dipped into a tank of preservative to make the wood resistant to decay and insect infestation.

Effective water repellent preservatives retard the impact of moisture on wood and, thereby, help reduce dimensional changes in the wood.



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## Fungi and Insects Feast on Wood

The two principal organisms responsible for destroying wood are fungi and insects.

Fungi are microscopic organisms that consist of threadlike structures and depend on organic matter for food. There are three types of wood fungi:

- Mold: grows on the surface of wood, consuming sugars and other carbohydrates. It gives the wood a 'woolly' or powdery appearance but does not affect timber strength.
- Sapstain: these fungi are pigmented and discolor or stain infected timber. Sapstain fungi don't affect timber strength but do make small holes in cell walls and membranes, making it more susceptible to rot.
- Decay: is the most destructive form of fungal attack. Three types occur: brown, white and soft rots. These utilize the cellulose and lignin in cell walls, quickly weakening timber strength.

Insects involved with wood destruction are, generally, either termites or beetles. However, wood wasps, moths and carpenter ants are problems in some areas. Insects feed on wood, damaging it by chewing and boring into it. Some insects do negligible structural damage while others, such as termites, can leave only a thin outer shell of wood, the inside being completely hollow.

In 1931, a Defense was Mounted

Chlorinated phenols, principally pentachlorophenol (penta or PCP), were one of the earliest preservatives used in protecting millwork from decay. This solvent-based system was introduced to the millwork industry in about 1931. Chlorinated phenols were highly effective, but for environmental reasons, the EPA in 1986 restricted the use of PCP.

Today, hundreds of sites across the country, like that of the former Penta Wood Products treatment facility south of Duluth, Minn., are under remediation. A 1987 investigation of the Penta site disclosed that groundwater at the site was contaminated with PCP. About 4,800 tons of arsenic-contaminated soil (from related ammonia copper arsenate use) have been excavated and a groundwater treatment program, expected to last up to 30 years, was begun this summer.

One brand name that became synonymous with penta was "Woodlife." In 1984,

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due to pending EPA restrictions, 3-iodo-2-propynyl butyl carbamate, commonly referred to as IPBC, replaced penta as the fungicide in Woodlife, and is still used today by many in the millwork industry. IPBC is not an effective insecticide, however. An insecticide, “chlopyrifos,” is commonly added to Woodlife for pest control. The newest version of Woodlife uses a petroleum solvent as a carrier for the active ingredients. It is commonly applied using the dip system.

Penta was a very effective decay preventative, and since its ban, manufacturers say that they have seen a “creeping” increase in incidents of wood decay.

Another treatment product, Pilt, which used Tri-N-Butyltin Oxide (TBTO), became available in 1976. Pilt is an acronym for preservative in-line treatment. Like Woodlife, it uses a solvent-based dip system. In 1990, IPBC largely replaced TBTO.

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## The New Process

In 1998, a major Oregon-based window and door manufacturer began investigating new alternatives in wood preservation technology for millwork. The objective was to find a reasonably priced system that increased decay resistance and diminished environmental impact.

Water replaces petroleum-based solvents as the carrier for the active ingredients—tebuconazole as the fungicide. Tebuconazole is an organic triazole biocide, that is stable and leach resistant in wood, effective against wood decay fungi, but of uncertain effectiveness as an insecticide. Therefore, a proven insecticide—imidacloprid—is blended into the solution. Both tebuconazole and imidacloprid are among ingredients certified by the Window and Door Manufacturers Association's Hallmark Certification Program. The repellent is a proprietary emulsion that differs from paraffin-based repellants commonly used throughout the industry.



“From an environmental standpoint, this system results in a 97 percent reduction in VOCs (volatile organic compounds). That, alone, is a huge benefit,” says the manufacturer’s technical director. “The water-soluble process produces little or no wastewater, unlike oil-based processes that produce both significant quantities of process wastewater and metal-containing sludge.” In addition, pressure treatment

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permits manufacturers to use solutions with considerably lower chemical concentrations to achieve comparable effect.

The process, referred to as “full-cell,” is this:

- Treating chemicals are delivered and stored in holding tanks.
- Chemicals and water are mixed in a treating solution.
- A charge of wood is sealed into an 84-ft.-long pressure vessel and a vacuum is applied to remove air from the chamber—and, as much as possible, from the wood.
- The vacuum is released, flooding the containment vessel with chemical solution, and 150 psi pressure is applied until the wood will take no more preservative.
- Pressure is released, the solution drained from the chamber, and a final vacuum is applied to recover solution.
- The vacuum is released, the pressure vessel opened, and wood removed. The process takes about two hours, and up to 10,000 board feet can be treated in a single charge. The system now produces up to 500,000 board feet of treated lumber per week.
- Wood is transferred to a computer-controlled dehumidification kiln.



Boards are immersed in the solution in the process, not merely surface-treated. The result is that the solution penetrates the wood, not merely coats it.

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## Other Treatment Alternatives

Alternative lumber treatments are available. These alternatives are free of arsenic, chromium, and other preservatives classified by the EPA as hazardous. However, they may contain ingredients that are synthetic or that are not yet evaluated by the National Organic Standards Board (NOSB).

Borates (boric acids and borax) have long been used for alternative wood protection and are used in all types of lumber, logs, and plywood. Boric acid is a synthetic substance allowed for use in organic crop production as a “structural pest control, [not in] direct contact with organic food or crops.”

Borate wood treatments will penetrate to the center of the wood when the wood is dipped, especially when the wood is freshly cut, or when seasoned wood is re-wetted. However, because borates are water soluble, they will leach from the wood when in contact with water in the soil, leaving the wood unprotected. Thus, borate-treated lumber is commonly used only in locations that are at least six inches above the ground and protected from excessive rain. 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.



Ammoniacal Copper Citrate (CC) is a recently developed wood preservative that has 62.3% copper as copper oxide and 35.8% citric acid dissolved in a solution of

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ammonia in water. The treated wood initially will have a slight ammonia odor, but the odor dissipates soon after treatment. The copper protects against decay and insects, and the citric acid helps distribute the copper inside the wood.

Copper azole (CBA) is a wood preservative with active ingredients of copper, boric acid, and tebuconazole (azole), a synthetic organic carbon product used in fungicides. Copper azole has 49% copper as CU, 49% boron as boric acid, and 2% azole as tebuconazole dissolved in a solution of ethanolamine in water. CBA lumber use must be discussed with your certifying agents before any application and use, and written into your Organic System Plan. The EPA has not yet established use and handling precautions for wood treated with copper azole.

Alkaline Copper Quaternary Ammonium (ACQ®) is a wood preservative—containing copper and quaternary ammonium compound (quat) as active ingredients—that protects against rot, decay, and termite attack. It is the most common CCA replacement. Quat is a product commonly used in commercial disinfectants and cleaners. It acts as a co-biocide. Some copper does leach from ACQ-treated lumber, making it unsafe for garden use. And because copper is highly toxic to marine life, ACQ is not recommended for aquatic environments.

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## A Preservation Chemical Glossary

Timber preservation works by treating wood to make it unsuitable for attacking organisms. This is generally achieved by impregnating wood with toxic chemicals that poison or make it unpalatable. The main wood preservative chemicals are:

- Creosote: is produced by the high-temperature distillation of bituminous coal. The distillate consists of solid aromatic hydrocarbons, and tar acids and bases. Creosote is toxic to fungi and insects, is relatively insoluble in water, and is generally low cost. The pungent odor, oily finish and it's propensity to leak and stain surrounding material makes it less desirable in some situations. Creosote is used where timbers are in contact with the ground or in buildings that have a high decay hazard such as railway sleepers. Fence palings and battens. It is also effective in marine structures.
- PCP: or pentachlorophenol (C<sub>6</sub>Cl<sub>5</sub>OH) was used for many years as a fungicide. It also affords good protection from insects when dissolved in heavy oil. It is ineffective against marine borers. Many countries have banned the use of organochlorines such as PCP, because of their broad toxicity and persistence in the environment.
- TBTO (Tri-N-Butyltin Oxide (C<sub>24</sub>H<sub>54</sub>OSn<sub>2</sub>): is another oil-soluble chemical like PCP. It is generally used with the addition of an insecticide (eg, dieldrin or lindane) to treat exterior joinery. While it leaves the surface clean for finishing work, it does break down in UV light.
- CCA: or copper-chrome-arsenate is a broad spectrum preservative that has no major limitations. The copper and arsenic are the fungicide and insecticide respectively, while the chromium fixes the chemical to the wood. The chemical penetrates wood well, is odorless, and surfaces can be painted once dried. CCA treatment is the most common for outdoor or ground contact uses. The chemical can be used in both terrestrial and marine environments.
- Boron: salts are another broad spectrum preservative, effective against fungi and most insects with low toxicity. The main problem with boron treatment is that it is water-soluble and doesn't chemically bond to the wood. It can therefore be leached out and can only be used in low hazard environments such as house framing.



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## Preservation Processes

There are a number of types of treatment techniques utilized in wood preservation:

Pressure Impregnation uses vacuum and pressure to obtain chemical penetration of permeable timbers, while controlling the amount of preservative retained. The timber must be free of stain and be less than 30% moisture. Many treatment schedules are used, the pressure fluctuations and timing being distinctive in each.

The Bethell process is the most important of the treatment processes and achieves about 90% of the theoretical maximum uptake in radiata pine. The Lowry treatment is designed to achieve maximum penetration with a low retention of preservative. Retention is around the 60% of theoretical maximum. The Rueping process is used principally with preservative suspended in hot oil such as creosote and PCP where a low net retention is desired for some hazard categories. Net retention here is as low as 40-50%. The Alternating Pressure method utilizes repeat applications of pressure and vacuum to force preservative into green wood.

Vapour Phase utilizes the fact that some Boron esters boil at low temperatures. The liberated gas can be drawn into timber where it reacts with water and condenses. For this reason, timber must be very dry (less than 5-6 percent moisture content) or only low penetration is achieved. Treatment of framing timber in the drying kiln is possible and can offer considerable cost savings.

Vacuum treatments utilize volatile organic solvents to transport the preservative into the wood. It is designed to treat dry profiled or machined wood. TBTO is typically used, being introduced to the timber by either a double vacuum or low-pressure cycle. The advantage of this technique is that there is no dimensional swelling as associated aqueous treatments and wood can be painted within a couple of days of treatment.

Diffusion is used to introduce boron salts to green timber. The timber is sprayed or dipped in the preservative solution and block stacked (without fillets). The wood is then tightly wrapped and left for a number of weeks during which the boron salts diffuse into the wood. Thicker timber may require a second dip to top up the salt levels. For this technique to be successful the timber must have a moisture content over 50 percent. If the timber surface dries out, the process may not work at all, or be uneconomically slow. Another method using the diffusion process is called double diffusion. This works in the same manner except two

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successive chemical treatments are used. The second chemical treatment (Na<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub>/Na<sub>2</sub>CrO<sub>4</sub> and Na<sub>2</sub>HasO<sub>4</sub>) precipitates with the first (CuSO<sub>4</sub>) to form a non-leachable preservative.

The Reynolds learned from their window manufacturer: that despite common preservation techniques, wood decay can occur, and that preventing “overexposure” to moisture must include these steps:

- Eliminating exposure of the product to excessive wind and water loads.
- Adding gutters or water breaks, awnings or barriers (natural or artificial).
- Eliminating exposure of the product to irrigation and sprinkling.
- Eliminating building design features that allow water to pool at window (fenestration) openings or to come in contact with the end grain of the wood like pop-outs, improperly sloped sills, contact with brick, masonry, or stucco, insect nests, or incorrectly installed flashings.

Homeowners, they are told, may find it possible to repair doors or windows that have not been “structurally” damaged.

A professional wood restorer using the proper equipment, processes and materials MAY be able to repair at a cost significantly less than the cost of replacing the product. If the homeowner chooses to replace the product, he/she is advised to choose products that are certified as treated to the most current version of the WDMA IS-4 standard. Homeowners are further advised to properly maintain window products by:

- Painting with a high-quality exterior trim paint and regularly maintaining the paint finish. Prior to painting, all wood-to-wood joints where water can penetrate should be sealed using a high quality sealant.
- Inspecting products at least twice a year, immediately touching up any breaks in the sealant or paint film and contacting the manufacturer at the first sign of any softness or discoloration in the product.

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The quiz [questions](#) include information from this online reading. To receive a faxed copy of the material, contact Joyce Richter, (888) 535-3936 or email [joycer@jeld-wen.com](mailto:joycer@jeld-wen.com).



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- Complete the questions below, then fill in your answers .
- Fill out and submit the AIA/CES education reporting form in the magazine or [print](#) the form to receive one AIA learning unit.

Questions:

LU: 1 HS: 1

- According to the American Wood Preservers' Institute, the life span of treated wood is typically how many times the useful lifespan of untreated wood?
  - Two
  - Four
  - Six
  - Eight
- What common form of wood treatment is the black or brownish oil made by distilling coal tar and widely evident as the preservative for railroad ties?
  - Creosote
  - Sapstain
  - Boron
  - PCP
- Wood preservation is a \_\_\_\_\_ industry.
  - \$5 billion
  - \$10 billion
  - \$15 billion
- Which treatment technique is used to introduce boron salts to green timber?
  - Pressure Impregnation
  - Vapour Phase
  - Vacuum Treatments
  - Diffusion
- Which wood preservative chemical is appropriate for marine structures?
  - ACQ
  - Creosote
  - PCP

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