Wood Preservative Solutions for Creative

And

Sustainable Bridge Design and Construction

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Summary

Wood is a remarkable fibrous material that has served the needs of mankind for centuries by being an essential source of fuel, shelter, chemicals, paper, and a host of other goods. Because of its many attributes and aesthetic benefits wood continues to be the preferred building material in a wide variety of construction applications providing a natural long life and when chemically preserved can be extended even longer. The use of wood for maintenance and construction of pedestrian bridges and highway and railway bridges over aquatic and wetland environments has long been the material of choice and when a timber bridge project is properly planned and the environmental conditions of a project site are properly evaluated the environmental risks can be minimized and managed.

Keywords: wood preservatives; decay; durability; aquatic environment; risk assessment models; best management practices; renewable resource; quality assurance

1. Introduction

Why should you use preservative wood? It is a known fact that wood degrades via non-living or living agents, or both at the same time when left unprotected from these agents resulting in a significantly shorter life expectancy. This will continue to be a significant concern when using wood and for this very concern preserved wood plays a key role in protecting wood from degradation while significantly extending the life expectancy.

Some important factors to keep in mind about wood in its natural state: *A number of non-living agents can cause degradation of wood such as: mechanical damage from handling or in-service use; weathering caused by exposure to ultraviolet light in sunlight that breaks down the lignin near the wood surface causing the wood to erode away by wind or water overtime; prolonged exposure to elevated levels of heat that break down individual wood polymers; exposure to chemicals such as strong acids and bases; and repeated wetting and drying in salt water causing surface damage to the wood as the cells absorb so much salt they literally burst.*

There are also a variety of living agents or biological agents that can degrade wood, but in all cases these organisms need four basic requirements: adequate moisture, oxygen, adequate temperature, and a food source. Some common wood destroying organisms include bacteria, fungi, insects, marine borers, and some vertebrates [1] - such as woodpeckers.

For proponents of timber bridge construction, the use of preserved wood provides an environmental and cost effective solution for protecting wood from the degradation of non-living and living agents that will significantly extend the durability and service life of a wood structure. Knowing the environmental benefits of using preserved wood is also an important factor to consider when selecting it as a construction material for a project. In a series of quantitative evaluations conducted by the organization Treated Wood Council of the environmental impacts associated with the national production, use, and disposition of various preserved wood products compared to alternative materials, they found that in 7 out of 8 key environmental impact indicators preserved wood required less total energy and less fossil fuel, had lower overall environmental impacts, and when reused for energy recovery in permitted facilities with appropriate emission controls there would be further reduction of greenhouse gas levels in the atmosphere. The evaluation was conducted using Life Cycle Assessment (LCA) methodologies and followed ISO 14044 standards, as well as being peer-reviewed. Summary information and links to the full LCA's can found by going to www.wwpinstitute.org.

Further, under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), wood preservatives containing a pesticide are fully regulated by the U.S. Environmental Protection Agency (EPA) as they are required to go through a very rigorous registration and re-registration process. The EPA considers wood preservative systems as antimicrobial pesticides and requires that the pesticides must be supported with thorough scientific review and analysis as well as show they can be used without causing undue adverse effects to human health or the environment. It is also important to be aware that under federal law preserved wood products are not considered to be a pesticide and therefore not regulated by FIFRA.

2. Five Steps to Appropriate Use of Preservative Wood

Because most types of timber bridges, such as pedestrian, auto or railway, cross some form of water body or drainage they pose varying degrees of environmental risk or required protection when constructed or maintained. For this reason it is important to have some guidance in understanding some of the science behind wood preservative systems and how to select and manage the use of preserved wood to ensure the desired performance required of a bridge project is achieved while minimizing the potential risk for any adverse environmental impacts. The process needs to begin at project conception and all the steps through installation and maintenance.

The following five basic steps are recommended when planning use of preserved wood in aquatic and wetland environments (fresh and salt water):

1. Selecting the Proper Preservative
2. Environmental Considerations and Evaluations
3. Specifying Best Management Practices
4. Requiring Quality Assurance and Certification

5. Following Basic Handling, Installation and Maintenance Guidelines

2.1 Selecting the Proper Preservative

To make sure the appropriate preserved wood product is selected it is important to fully understand how to identify and specify the appropriate wood preservative system based on the desired species and existing environment on a project site. Some good resources available that provide helpful information are the US Forest Products Lab Wood Handbook (FPL–GTR–190 – 2010) on wood preservation found at www.fpl.fs.fed.us/documnts /fpl_gtr190.pdf; Western Wood Preservers Institute guidance documents on use of preservatives in aquatic and wetland environments at www.wwpinstitute.org/aquatics.html#guidance and WWPI APP; and American Wood Protection Association (AWPA) book of standards – Use Category System Standard U1, Sections 3, 4 & 5 found at www.awpa.com or WWPI APP.

While the AWPA book of standards identifies around 27 different wood preservative systems, only seven are commonly used to preserve material designated for use in aquatic and wetland environments either in and/or over fresh and salt water. There are a few other preservative systems available, but they will not be addressed in this paper as they are not commonly used in the western regions of the United States. In addition, there are a few other proprietary formulations available that are often selected for aesthetic purposes, also not discussed.

The seven commonly available preservatives for use in aquatic and wetland environments can be broken down into two general categories – Waterborne and Oil-type systems:

2.1.1 Waterborne Preservative Systems

Waterborne systems are considered inorganic preservatives and are characterized by the fact water is the primary carrier of the preservative chemical. In these systems the chemicals are precipitated into the wood substrate and become attached to the wood cells, minimizing migration once the chemical is stabilized or fixed to the wood cells. In general all waterborne preservatives perform basically the same. They also leave a dry and paintable surface. The primary environmental concern with these preservatives is the potential environmental effect the loss of copper from each of these preservatives will have on the specific project environment when placed into service. For this reason it is critical to conduct a screening level assessment for each project site.

The four main waterborne systems or groups used in aquatic and wetland environments are:

- **Chromated Copper Arsenate (CCA)** – Since 2004 CCA has only been available for use in preserving commercial and/or industrial type wood products. While CCA preserved wood products are readily produced throughout the U.S., use near, in, or over bodies of water are largely discouraged or prohibited in many western states by permitting agencies, even though it has been demonstrated the environmental risks are minimal. This is primarily a result of perceived concerns about the toxicity of arsenic in this preservative. In addition, because coastal Douglas fir is usually the preferred wood species for many commercial and industrial applications CCA is not recommend for treating this species and other hard to treat species. The opposite is true for many other parts of the U.S., like in the southeastern states, where the preferred species is the easier to treat southern yellow pine and where CCA preserved products are considered environmentally friendly. Also, CCA is the only preservative system that has testing technology (Chromotropic Acid Test) that can determine whether fixation of the preservative has been achieved in the wood cells.

- **Ammoniacal Copper Zinc Chromate (ACZA)** – Under the trade name Chemonite®, ACZA is an ideal preservative to use for hard to treat species like the popularly used coastal Douglas fir. Because of this quality and its environmental record ACZA is normally the preservative of choice to treat coastal Douglas-fir and other western species products for such uses as piling, bulkhead and bracing that will be immersed or come into contact with fresh or salt water. Although in some local areas in the west you may find restricted use because of the perceived environmental risk associated with short term migration of the preservative from the wood or requirements for additional mitigating measures, such as wrapping or coating, to help stop or minimize the loss of preservative from the product. ACZA is also commonly used in a variety of other above water applications.

- **Alkaline Copper Quat (ACQ) and Copper Azole (CA) -** These preservatives are widely used throughout the U.S. in a variety of residential, commercial and certain agricultural applications and often thought of as “general use” preservatives. Both ACQ and CA preserved wood products perform basically the same with some minor product application differences. They are both commonly used to preserve lumber and timbers used above and in fresh water and subject to some brackish or saltwater splash. The exception is that ACQ preserved round and sawn wood piling can also be used for land and in freshwater applications. As with ACZA, there is an environmental concern by some permitting agencies over the perceived environmental effects the loss of copper from these preservatives may have on the specific project environments. However, with some exceptions, products preserved with ACQ and CA are generally viewed favorably for general use in or above freshwater or near saltwater applications.

2.1.2 Oil type Preservative Systems

Oil type preservatives are organic preservatives characterized by the fact they are 100 percent active (Creosote) or dissolved in an oil-based solvent. These mixtures fill or coat the wood cells walls during treatment.

<u>The three primary oil-type systems used in aquatic and wetland environments are:</u>

- **Creosote -** This is a coal tar-based wood preservative and when used as a preservative it can only be manufactured by the distillation of tar obtained from coal. It typically has some odor and is not paintable. Primary use is the treatment of industrial products such as railway ties, utility poles and cross-arms, piling and timbers for bridges and other transportation structures. Creosote preserved wood can be used in a variety of applications requiring in-ground contact, or in and/or over fresh and salt water. Creosote has a long history of being a very effective preservative and it is not uncommon to find marine piling and bridge structures today ranging in age from 50 - 90 years old still in good serviceable condition. Acceptance and use of creosote preserved material varies by region. For example, in Alaska and the southeastern states it is widely used for preserving a variety product, such as marine piling, dock structures, bulkheads, utility poles, and bridges.

Creosote is extensively used to treat railway ties used by our nation's railroads, which represents approximately 95% of the creosote use today. In most of the western states, other than the railways, use is typically restricted to replacement of existing structures for maintenance purposes, while in the states of New York and New Jersey all aquatic uses are prohibited. Creosote is not recommended for use in residential, industrial or commercial interiors except for laminated beams or building components that are in ground contact and where there may be frequent or prolonged contact with bare skin.

- **Pentachlorophenol (PCP)** – This preservative in a solid state is dissolved in petroleum oil either in diesel, or fuel oil grades and light hydrocarbon solvents. PCP is diluted to approximately 5% to 10% in oil in order to be used in a preservative solution. Use of PCP is popular for preserving wood utility poles and cross-arms, and solid wood and laminated timbers that are used in construction of buildings and bridges. PCP preserved material in aquatic applications are restricted to above water structures in saltwater and in or above freshwater. Like creosote, PCP is not recommended for use in residential, industrial, or commercial interiors except for laminated beams or building components that are in ground contact and where there may be exposure to frequent or prolonged contact with bare skin. PCP in light hydrocarbon solvents leaves a more natural appearance, and may be specified where stain finish is desired.

- **Copper Napthenate (CuN)** – This preservative is different than the other copper-based preservatives in that the copper is reacted with naphthenic acid, a hydrocarbon by-product of crude oil processing. The CuN concentrate is diluted with fuel oil at treating plants to make the preservative solution. Unlike the other oil-type preservatives CuN is not a restricted pesticide. When CuN is applied it is initially a light green color that diminishes over time due to weathering and often has an odor. There are odor neutralizers available that can be applied should odor be an issue. After thorough drying CuN preserved wood can be painted or stained, but a stain-blocking primer or second topcoat is recommended for finishing minimizing the CuN treatment's discoloration of the finish. CuN is used to preserve a variety of products for industrial projects such as foot and auto bridges, as well as fence rails and posts, guardrail posts, railroad ties, utility poles, piling and outdoor recreational structures. Other than being restricted from use in brackish or salt water applications CuN can be used to preserve a variety product materials for use near saltwater or in and above ground for freshwater applications.

In addition to the above referenced informational resources, many other factors will likely come into play when selecting the appropriate preservative system. Managers will likely weigh the economics, type of project, availability of wood species, aesthetics, environmental concerns, and the permitting or approval process itself. These decisions will be influenced in part or whole by the permitting authority, existing laws, personal preference, organizational policy, professional knowledge, and environmental conditions.

2.2 Environmental Considerations and Evaluation

In designing a project the characteristics of various preserved wood products should be taken into consideration in relation to the purpose of the project and the environmental conditions at the project site. Products used in a heavy industrial application, like a bridge used for motor vehicles, will likely be different from those used in a public structure, such as a foot bridge or boardwalk. Similarly, the use of a moderate amount of preserved wood in a fast flowing river or stream is likely to pose a minimal risk; whereas, the use of large amounts of preserved wood in somewhat stagnant water may pose greater risks.

Nearly any material used in aquatic environments will introduce some degree of chemical and have an environmental effect if present in large enough concentrations. When specifically using the previously described wood preservatives, a certain amount of preservative will migrate from all these preservatives, but typically for only a short period of time, and enter the water column or sediment adjacent to the project area. For this reason it is important to be able to evaluate the level of potential risk on a site specific basis to properly manage the risks. There are project situations where the use of preserved wood may be of significant environmental concern such as previously contaminated waters or very slow moving waters with no natural flushing. However, based on scientific studies and field results 95% of projects being constructed today in some type of aquatic environment should not be significantly impacted from use of preserved wood when the risks are identified and managed.

To help biologists and project proponents of preservative wood peer-reviewed risk assessment models recognized by NOAA-Fisheries as being useful in evaluating the potential environmental effects due to the conservative assumptions used in developing them are readily available to assist in determining the potential risks associated with a proposed project. A detailed discussion of the models and supporting information preservative wood can be used safely in aquatic environments when the risks are evaluated can be found in NOAA-Fisheries 2009 guide for treated wood titled - The *Use of Treated Wood Products in Aquatic Environments: Guidelines to West Coast NOAA Fisheries staff for Endangered Species Act and Essential Fish Habitat Consultations in the Alaska, Northwest and Southwest Regions*.

In addition to the risk assessment models, a companion Level One Screening Assessment tool based on the science used to develop the more robust risk assessment models has also been created to further assist in making evaluations of the environmental risks. This simplified assessment tool utilizing tables and some basic project site conditions was designed to easily make some preliminary predictions on whether a more extensive risk assessment should be undertaken, or support a conclusion there would be no significant environmental effect from using preserved wood on a project.

The risk assessment models are based on research knowledge of preservative loss rates from properly preserved wood and when coupled with site-specific project environmental data, such as water current speeds, and background levels of metals and organics in the sediment it allows users the ability to predict the environmental response to any project design when preservative wood is used in and/or over an aquatic environment, including the use of multiple wood preservatives. For those interested in a detailed discussion on the science and model assumptions used they can be found in a book published by the Forest Products Society in 2011 titled *Managing Treated Wood in Aquatic Environments.* The NOAA-Fisheries guide, risk assessment models and screening level assessment tool can all be found at www.wwpinstitute.org under the aquatic section.

Other than legacy facility sites preserved wood has a long history of safe use in aquatic environments with no published report describing any significant loss of biological integrity associated with its proper use when, again, the risks are first evaluated and the proper preservative is selected.

2.3 Specifying the Best Management Practices

Another key element available for managing risk whenever preservative wood products are planned for an aquatic environment is the specification of the Western Wood Preservers Institute's (WWPI) *Best Management Practices for Use of Preservative Wood in Aquatic and Wetland Environments (BMPs).*

The BMPs are additional wood preserving guidelines for all individual or groups of preservative systems used to preserve wood designated for use in aquatic or wetland environments. The established guidelines are intended to further minimize the amount of potential chemical migration or movement from preserved wood material during the wood preserving process.

Specification of the BMPs gives specifiers another valuable environmental protection tool to use to assure preserved material used on a project site has been preserved with the minimal level of preservative needed for protection that meets AWPA standards while reducing the amount potentially available for migration or movement in to the environment.

Along with the additional processing requirements, BMPs are separate from and in addition to the AWPA standards. There is a shared responsibility between the Specifier and Treater to assure the level of preservative system application selected will meet the goal of minimizing the migration of the preservative into the environment.

The full details on what and how BMPs work can be found by going to www.wwpinstitute.org under the aquatic section.

2.4 Providing Quality Assurance and Certification

One of the benefits of specifying wood material be preserved to the BMPs is that it will not only assure the material meets AWPA standards, but also that it meets the BMP guidelines as third-party independent inspection procedures and certification are in place to provide the needed quality assurance required by the BMPs.

CheckMark Symbol

To assure products meet the AWPA standards, it is important that the presence of a quality checkmark be present on all structural product labels or a letter of certification should labeling not be present. The presence of the **CheckMark** logo is a quick and simple way of identifying whether the product material purchased has been inspected by an approved American Lumber Standard Committee (ALSC) third-party inspection agency authorized to assure compliance with AWPA standards.

BMP Certification Mark

Additionally, to assure material has been preserved in accordance with the BMP guidelines certification should also be verified by an authorized ALSC third-party inspection agency by letter of certification or the presence of the WWPI BMP Certification Mark on the product or unit. Details on the quality assurance inspection procedures and requirements are incorporated as a separate chapter in the BMP document, which can be found under aquatics at www.wwpinstitute.org.

It is strongly recommended for the specifying agency and/or contractor and the selected supplier to review the project specifications and material requirements to assure the proper material will be produce to the desired standard and specification for the project, along with an understanding of the required quality assurance and certification. It is also advised, if practicable or customary for the wood preserving company to be directly contacted to discuss the required specifications, including the environmental concerns for the project. Past experience has shown that when a preservative product has not met the expectations of the purchaser it has typically been the result of a breakdown in communications.

2.5 Appropriate Handling, Installation and Maintenance

One of the most critical times in the life of a project using preserved wood, in terms of environmental impacts, is during and immediately following construction. While use of a U.S. EPA registered preservative treated to AWPA standards, along with specification of the BMPs will help assure minimal environmental impacts there are several other actions that can be taken to further ensure the project is constructed and maintained in an environmentally safe manner during installation or maintenance of the structure.

Some suggested additional actions are as follows:

- To degree possible framing, sawing, cutting and drilling should be specified to be done prior to preserving the wood.
- Products should be inspected when it arrives on project site.
- Use containment measures when working over water to catch and collect cutting, shavings and sawdust where necessary. Where practical conduct additional fabrication work away from water and provide for collection of waste.
- All field cuts and drill holes created on project site should be field treated. Available treatments include Copper Napthenate, Outlast Q8, and Hollow Hear CB.
- Removal of old preserved wood structures for maintenance purposes or demolition can be either be recycled for reuse, if suitable, or by federal and most all state laws can be disposed as non hazardous or exempt hazardous waste in approved landfills.
- Routine inspection and timely maintenance is critical to extending the service life of a preserved wood structure.

For further perspectives on using preserved wood in aquatic or wetland environments it is suggested you read *Guide for Minimizing the Effect of Preservative-Treated Wood on Sensitive Environments* published by the USDA Forest Service Products Laboratory.

3. Conclusion

For over a century preserved wood has played an essential role in the economic prosperity and quality of life in North America. From the rail way ties that carry our trains; to the poles that carry communications and power; to bridges that cross our rivers and valleys carrying vehicles and foot traffic; to industrial and commercial structures serving businesses and communities; and to scenic and recreational structures enjoyed by millions of visitors the use of preservative wood has been the preferred, time-proven, cost effective material of choice.

Since the awakening of environmental awareness by society in the second half of the twentieth century there have been numerous environmental laws adopted and the implementation of regulatory policies, in some cases unwritten polices, that restricted the use of some construction practices and materials in aquatic environments, like preserved wood. As result, this awakening also brought about greater scrutiny over the use of preserved wood products in aquatic and wetland environments. Because of this emerging concern the wood preserving industry undertook action to better understand the environmental effects of wood preservative systems on aquatic and wetland environments to better determine the proper applications and assure they could be environmentally safe to use. For the past two decades an effort has been in progress to conduct research and studies in partnership with various governmental agencies, universities and the wood preserving industry to better understand the environmental performance and potential effects of using preserved wood in aquatic and wetland environments.

All the information presented in this paper, and more found at www.wwpinstitute.org, represents the collective result of two decades of environmental research, case studies, and technical analysis conducted on the environmental performance of preserved wood in aquatic and wetland environments. It also represents the most authoritative and comprehensive science available critical to developing needed risk assessment tools for conservatively predicting environmental effects, as well as useful management tools to further minimize environmental risks associated with use of preserved wood in aquatic and wetland environments. Access to the science and management tools is readily available, as well as training, to assist biologists and managers better understand the science, evaluate the potential environmental effects, and manage the risks in order to make informed management decisions.

While there are no federal laws prohibiting use of preservative wood, and only a few states with limited restrictions, there is a general bias against the use of any type of preservative wood material among some regulatory agencies and individual biologist responsible for enforcing the provisions of the Magnuson-Stevens Act – Essential Fish Habitat and the Endangered Species Act due to perceived detrimental environmental effects. However, the vast majority of empirical science is contrary to this viewpoint and clearly supports the use of preserved wood in most situations. What is critical to know is that when the appropriate preservative system is selected, the potential environmental effects evaluated on a site specific basis, and the WWPI BMPs are specified the potential risks will be minimal and manageable for the environmentally safe use of preserved wood products in the majority of projects where use is proposed.

4. References

[1]. Morrell J, Brooks K, Davis C, *Managing Treated Wood in Aquatic Environments*, Forest Products Society 2011, pp. 2-3