Boron Wood Preservatives And Their Application To Historic Wooden Vessels At San Francisco Maritime N.H.P.

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This paper will present an overview of the remedial and preventive boron treatment program at San Francisco Maritime National Historical Park.

Wooden vessel decay has long been studied and is known to be caused by a number of factors including weathering, insects, marine borers and crustaceans, bacteria and wood decaying fungi. In the past, the study of wood rot was dominated by the maritime industries. Navies and merchant shipowners had a keen interest in preventing the decay of their vessels, and hundreds of preservative systems have been employed for that purpose. During the past 150 years, research into decay and development of treatment methods has been dominated by the railroads, electric power, and telecommunications industries. We have adapted to this change and adopted many of their methods and materials with mixed results.

In 1985, San Francisco Maritime initiated a search for alternative wood decay treatment methods and materials. This search was due in part to increased governmental regulation of commonly utilized wood preservatives and the known health consequences to the applicator. In addition, it was becoming all too clear that in spite of all of their toxic properties, both modern and traditional wood preservatives were largely ineffectual at treating or preventing deterioration of our vessels.

The inventory of vessels in our collection includes both wooden ships and steel hulled vessels having wooden components. These components are highly prone to fungal decay in a marine environment. Douglas fir is by far the largest single species of wood utilized in these vessels. Douglas fir heartwood is only moderately naturally resistant to decay fungi. Under controlled laboratory conditions, advanced decay (>40% weight loss) of Douglas fir can be achieved in four weeks time. In environments such as those upon our vessels, advanced decay could be anticipated after about six years of exposure in the most vulnerable of locations.

The 1985 Historic Structure Report undertaken by Tri-Coastal Marine for the steam schooner *Wapama* clearly documented the dire condition of that vessel in part due to fungal wood decay. With the assistance of the Forest Products Laboratory at the University of California at Berkeley a thorough review of suitable preservatives was undertaken and the U.S. Borax product TimBor was selected for testing.

TimBor or sodium octaborate tetrahydrate, commonly referred to as boron, is a water soluble wood preservative that is absorbed by the wood surface and then penetrates by diffusion. TimBor is highly toxic to wood decay fungi yet is low in toxicity to mammals and fish. Treatment of the vessel's hull was undertaken utilizing a semi-automated spray system from May 1988 through June 1989. The success of the project was documented by comparing wood samples taken before and after treatment. Diffusion of the preservative was documented by sampling and testing for both boron content and fungal viability. These tests indicated that diffusion was successful even in the largest of treated timbers and fungal growth was arrested.

The success of the experimental treatment of *Wapama* provided encouragement to extend the program of remedial treatment to other vessels and vessel components. In addition, the documented success of preventive treatment in the wood preservation industry encouraged our expansion of the use of borates to include pretreatment of new wood replacements. The integration of wood preservatives, specifically borates, into all repair and replacement projects has been a major emphasis of our preservation program since 1990.

As a part of both large and small repair and replacement projects evaluation of existing decay or potential for decay has provided direction for the application of borate preservatives in various forms and formulations. The foremost means of application remains the water based solutions of from 10 - 15 % TimBor applied by spray, brush, roller or dipping. Absorption and diffusion of the preservative following application has been encouraged when possible by covering with plastic sheeting. The results obtained have been highly successful. With sufficient chemical loading, high wood moisture content and time, diffusion can fully protect even the largest of timbers. Boron

solutions are clear in color, which has many advantages when working with historic fabric. Colorants are sometimes added to the solution as an aid to insuring full coverage when treating new wood.

Our efforts to preserve historic vessel fabric when possible often allows contamination of new materials by old. Scarfing or abutting new material with old provides the opportunity for fungal colonization. In the case of *Wapama*'s repair in 1959 used timber, acquired from a wrecker, was installed as a cost saving measure. Not only should used material be considered suspect, new materials that have been mishandled and contaminated during harvest , processing or storage can be equally infected with a variety of wood deteriorating fungi.

To provide some insight into the process of deterioration let us look at the acquisition in 1958 of new masts for *Wapama*: In December of 1958 two Douglas fir trees were carefully selected and felled in Washington State's Snoqualmie National Forest. They were old growth, more than 300 years old. In the forest they were limbed and loaded for transport, then hauled for debarking and shaping. They then were trucked to a railyard for transfer to a railcar and transport to Oakland where *Wapama* was undergoing repairs. They laid side by side on the dock alongside the ship. On July 13, 1959 the first protective coating was applied. During this six month seasoning period the wood was unprotected from fungal attack. The masts were exposed to environments with high levels of fungal activity, beginning in the forest where fungal growth occurs during the natural decay of forest debris and logging slash and ending alongside a vessel undergoing repair for extensive fungal deteroration. These masts were almost certainly colonized by wood decay fungi before they were ever lifted aboard the ship.

Wapama's masts have once again been removed due to decay. Could early application of borates have extended their lives? We think so. We are specifying diffusion treatment of all new masts and hope to undertake remedial treatment of existing wooden spars whenever possible.

The installation of fused boron rods into large timber replacements such as deck beams on the ferryboat *Eureka* has provided long term protection of these vulnerable elements. Rod placement is planned to maximize coverage and provide treatment of areas with high decay potential. When internal timber moisture levels rise, boron is released from the rods and diffuses to provide protection. High quality paint coatings will insure that boron is retained by each wood element.

Most recently, pressure treatment with borate preservatives of Douglas fir decking replacements on *Balcutha* has been specified. With fir, pressure treatment with borates is no more successful at immediate penetration than other preservative compounds. Due to a closed network of capillary pathways Douglas fir is relatively difficult to effectively pressure treat. Treatment with borates can however, establish a reservoir of preservative from which diffusion can later take place. Studies have shown that boron diffusion will progress slowly in Douglas fir with as low a moisture content as 25%. When moisture content remains under 25%, diffusion ceases and borates are held until moisture levels increase and diffusion can once again proceed.

In 1995 we acquired several large sections of the Clipper Ship *Snow Squall* from the Spring Point Museum in South Portland, Maine. Portions of this important vessel were retrieved from the Falkland Islands in 1987 and maintained wet, first with salt water, and then upon arrival in Maine with fresh water. The six foot wide hull cross-section that was transported to San Francisco consists of more than 10 species of wood with a wet weight of more than 7000 lbs. It was treated with a 10% solution of TimBor over a period of several months. Approximately 50 lbs of TimBor was diffused throughout the wet wood. Condition of the ships iron fastenings permitted easy removal of ceiling planks which made direct spray application of borates to all components possible. Once tests of core samples utilizing circumin indicator confirmed completion of diffusion controlled drying was begun. At the present time drying is complete in all but the largest timbers. The *Snow Squall*, built almost entirely of wood species without natural decay resistance was not constructed for a long career. We believe our treatment can help insure the preservation of its remains.

While boron diffusion permits eventual protection in even the largest of timbers, the issue of leachability remains one of much concern. Leaching takes place at an intermittently or constantly wetted surface. Leaching will not take place in high humidity situations unless liquid water is present. While leaching can eventually reduce boron content below effective levels, careful monitoring and replenishment can provide continuing protection. When properly protected by paint or varnish, boron loss can be limited.

Due to the complexity of vessel construction the application of preservatives can be difficult. We are currently testing commercially available foam and mist application equipment. Both show promise. The mist equipment for example has been shown to effectively deliver a concentrated borate solution to both vertical and horizontal surfaces between the ceiling and hull planking of the *C A Thayer*. Droplet size permits the mist to move like a concentrated fog, depositing fungicidal droplets on wood surfaces as the fog passes. The mist has been shown to travel more than twenty feet. The foaming equipment produces a highly concentrated borate-foam mixture that adheres well to most surfaces. Low runoff and increased wetting times encourages boron penetration of surfaces. The ability to force the foam under pressure between wood joints and into recesses allows

treatment in some of the most inaccessible areas of the vessels.

Boron wood preservatives offer a number of benefits to historic vessels in addition to their antifungal properties. Boron preservatives produce few visual or structural changes in wood. Boron is a highly effective insecticide against termites, anobiid & lyctid beetles, and most other pests common to wood. Boron compounds are also effective flame retardants.

Our experience with boron treatments has proven to us that diffusion of this preservative can provide an increased level of protection to our vessels. Our question is not whether the treatment can be effective, but how best can the application be undertaken and maintained. We look forward to answering those questions in the near future and sharing the answers with you.

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