PALLET PHYTOSANITARY PROJECT BULLETIN

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MEETING CURRENT INTERNATIONAL PLANT PROTECTION COMMISSION HEAT TREATING STANDARDS WITH HOT WATER BATH TREATMENTS[1]

This bulletin summarizes the results of the above titled research project funded under the Competitive Grants Program of the Pallet Phytosanitary Project.

INTRODUCTION

The objective of this research was to evaluate a "hot water bath" procedure to sanitize wood pallet components as an alternative treatment to the current accepted treatments: methyl bromide fumigation and heat treatment utilizing dry heat or steam. Treatments investigated included submersion of test specimens using hot water as the heat transfer medium and a combination treatment using a borate/hot water solution. Results included information on the time it takes to meet the IPPC (International Plant Protection Convention) standard for both hot water bath and borate/hot water bath; treatment effects on mechanical properties of the pallet parts treated; treatment effects on fastener holding capacity; and penetration and retention results from a 17 percent borate/hot water solution.

METHODOLOGY

Test specimens included green stringers (1.75" x 3.5" x 35") and deckboards (5/8" x 3.5" x 35") of three different species: yellow-poplar, red oak, and white oak. Samples from each species were subjected to three treatment options: control, hot water bath, and borate/hot water bath. All treatments were conducted in a treatment cylinder. Heating of treatment solutions was

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accomplished with electric heaters. Individual charges consisted of 20 stringers or 30 deckboards, all of the same species per charge.

For each species, 120 stringers were treated with the borate solution (6 charges). Four stringers from each of the first five charges were used for borate penetration/retention analysis. The test specimens from the sixth charge were used for mechanical testing samples. For borate treated deckboards, an additional 12 boards were treated for retention/penetration analysis.

Each charge had four thermocouples distributed throughout the charge as the basis for determining the amount of time to achieve the ISPM 15 standard of 56°C and to ensure temperature was maintained for 30 minutes.

In order to simulate a worse case scenario, the test specimens were started treatment in a frozen condition. The initial water temperature of the treatment was 100°C. With these conditions the temperature in the treatment cylinder dropped to approximately 60°C. Core temperature of the test specimens was then recorded for 30 additional minutes in order to document that the temperature remained at or above the target temperature of 56°C.

RESULTS

Heating Time

The mean rate of internal temperature increase for frozen stringers was 0.78°C per minute, while the frozen deckboards had a mean temperature increase of 6.7°C per minute. Mean time to an internal temperature of 56°C for the stringers and deckboards was 96.25 minutes and 12 minutes, respectively. The temperature of the test specimens at the beginning of treatment had an impact on the time to reach 56°C. Results showed that yellow-poplar and red oak stringers, statistically, took about the same amount of time to reach 56°C, while white oak reached 56°C faster than red oak.

Over all species, borate treated boards took a significantly longer time to reach 56°C than those treated with hot water alone. A more detailed statistical analysis of the interaction between treatment type and species, showed that yellow-poplar explained most of the difference in the borate versus hot water only treatments. That is, yellow-poplar stringers treated with borate took significantly longer to heat to 56° C than for the hot water bath treatment alone.

A regression model was developed to estimate time to 56°C for hardwood stringers:

$$Y = 53.135 - 1.0744X$$

where,

Y = predicted time to 56°C
X = stringer starting temperature

The model was statistically significant and amount of variation explained by the model was 86 percent (i.e., $r^2 = 0.86$)

Mechanical Property Testing

Three mechanical properties of the pallet parts were evaluated: modulus of elasticity (MOE), modulus of rupture (MOR), and nail holding capacity. MOE and MOR were evaluated simultaneously by three-point static bending according to ASTM D143, except for specimen size and quality (i.e., full-size stringers and deckboards, with inherent defects were used).

Statistical analysis, by species (red oak, white oak, and yellow-poplar), type of board (stringer or deckboard), and type of treatment (control, hot water bath, hot water/borate bath), showed 7 of 18 pairwise comparisons to be significant. That is, some statisitically significant effect was evident due to treatment type. However, the authors note that theoretically, the strength and stiffness of a material are independent of the size of the specimen. Therefore, the same (if any) treatment effects should be observed on stringers and deckboards within a species. The lack of any statistical trend in the data allows for only one explanation: the natural variability of saw logs is manifested in different mean values and standard deviations. Batches of deckboards and stringers may be sawn from a single log or from several different logs, so that the statistical parameters of the batches do not represent the true population parameters. The researchers conclude with reasonable certainty that in practical terms, the treatments had no significant effect on MOE and MOR.

Nail withdrawal testing procedures followed a combination of ASTM D1761 and accepted modifications of that procedure as they have been applied to pallet nails in the past by other researchers. Nail withdrawal tests were conducted using 2.25-inch long, helically threaded bulk (uncollated) pallet nails, with an average wire diameter 0.120-inches, average thread diameter of 0.135-inches, 4 flutes, 69-degree thread angle, and 1.50-inches thread length. Nails were driven to a penetration depth of 1.25 inches. One hundred nails were tested in each species and treatment combination (control, hot water, and hot water/borate).

The nail withdrawal tests of the stringers, comparing nail withdrawal by species and treatment showed only one pairwise comparison to be statistically significant (the borate/hot water treated white oak demonstrated somewhat less fastener holding capacity compared to the control treatment). Based on the earlier discussion of variation in the properties of test materials, the researchers conclude that the treatments did not significantly affect nail withdrawal capacity.

Borate Penetration and Retention

Ninety-six samples of each species (red oak, white oak, and yellow-poplar) (20 stringers and 12 deckboards) were analyzed for borate penetration and retention following a 24-hour diffusion period. A two-step procedure, as suggested by Borax, was used. The procedure is titled "*Procedure for Determining Penetration of Timbor Preservative in Wood Using Curcumin*

Reagent". Retention was determined by a two-step analysis according to a modified American Wood Preserver's Standard protocol A2.

The test specimens showed 100 percent retention within 24 hours for stringers and 16 hours for deckboards. Retention was considerably above the AWPA standard of 0.17 pounds per cubic foot for southern pine and hem-fir for "Lumber Used Out of Contact with the Ground and Continuously Protected From Liquid Water". Mean retention for red oak, white oak, and yellow-poplar was 1.60, 1.27, and 1.24 pounds per cubic foot, respectively.

DISCUSSION

Based on the project results, the researchers believe that the hot water bath procedure can be used to effectively and efficiently sanitize wood packaging material to meet the current IPPC standard of 56° C for 30 minutes at the core of the piece.

The hot water bath was tested under worst-case condition (i.e., frozen wood) and reached 56° C faster than conventional methods, suggesting potential technical and economic advantages for hot water bath treatment over the current IPPC approved heat treatment procedure. Further, no practical differences in mechanical properties of treated material were evident between treated and untreated samples, although the treated samples became a darker color as additional treatment cycles were conducted with the same solution.

The very positive borate penetration and retention results suggest the potential for better long-term protection against infestation of treated materials than the IPPC approved heat treatment method.

Although no protocols are currently in place to approve alternative treatments under IPPC auspices, the results of this study provide baseline information to begin the process of developing an approved alternative treatment using a hot water or borate/hot water bath treatment.

Finally, the researchers propose that some additional work is necessary to determine the minimum concentration of borate solution that will provide 100 percent penetration and minimum retention levels.