PALLET PHYTOSANITARY PROJECT BULLETIN

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DIELETRIC HEAT TREATING OF GREEN PALLET PARTS[1] PART 2 – MECHANICAL TESTING RESULTS

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

INTRODUCTION

Part 1 of this study, as reported in Bulletin No. 5, described the evaluation of dielectric radio frequency (RF) techniques to heat treat green pallet parts in compliance with the Phytosanitary Standards as outlined in ISPM 15, "Guidelines for Regulating Wood Packaging Material in International Trade". Dielectric RF techniques were shown to be feasible for heating green pallet parts to a temperature above 56°C followed by insulated storage for 30 minutes to maintain nearly all the generated heat. In addition, negligible moisture loss accompanied by the lack of warpage was a positive outcome with respect to possible degradation of the material.

A companion study was designed to investigate the effect of the dielectric heating on the mechanical properties of pallets constructed from the heat-treated material. As part of the heat treatment research matched pairs of pallet stringers and deckboards were used. One of the pair was used for the heat treatment experiment and the other member of the pair was designated as a control, wrapped in plastic and placed in cold storage at 32°F. Following the heat treatment, the treated stringers and deckboards were fabricated into 40 x 40 inch, 2 way, non-reversible type pallets, incorporating 3 stringers and eight deckboards. Similarly, the control specimens were fabricated into pallets of identical attributes.

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Following fabrication, pallets were wrapped in plastic and transported to the Pallet and Container Research Laboratory at Virginia Tech, Blacksburg, Va for mechanical testing.

METHODOLOGY

Both the heat-treated pallets and control pallets were tested for static strength, stiffness, and resistance to rough handling. The strength and stiffness tests included simulated racking and conveyor support tests. The relative resistance to rough handling was based on the corner drop test and top deck endboard and stringer (fork tine) impact resistance tests. Testing was conducted in accordance with ASTM D1185-98, "Standard Test Methods for Pallets and Related Structures Employed in Materials Handling and Shipping". Three replications were performed for each of the following tests.

Warehouse racking strength and stiffness was evaluated according to ASTM D1185-98, Section 8.4 spanning both the pallet length (stringer) and the pallet width (deckboards) with uniform load applicator placement. The test load was 1136 kg (2,500 pounds), which is 1.25 times the rated load of 909 kg (2,000 pounds). A uniform load was applied using an airbag and deflection monitored during a 2-hour creep test. After a 60-minute relaxation period, increasing loading was applied until the pallet failed.

Conveyor support strength and stiffness evaluations were performed in accordance with ASTM 1185-98, Section 8.5, incorporating two 16 mm (5/8-inch) metal bars to simulate a two-strand chain. A uniform flexible load of 1136 kg (2,500 pounds) was applied to the top deck of the pallet using an airbag. After a 60-minute relaxation period, increasing loads were applied until the pallet failed.

Fork tine heel impact testing was on the (40-inch) top deck endboard and the fork tine tip impact test was conducted on the stringer end according to ASTM D1185-98, Section 9.4.2. Impact resistance was determined by applying 10 impacts from 6-inches with a 114 kg load, followed by an increase in the loading to 318 kg and the series of 10 impacts was repeated at distances of 12, 24, 36, and 48-inches or until endboard or stringer failure occurred. Tests continued until board failure, indicated by board breakage, joint separation, or a combination of both. For stringers, failure occurred when a minimum 3-inch split developed.

Corner drop testing was performed in accordance with ASTM D1185-98, Section 9.3. The purpose was to evaluate resistance of the pallets to impacts from dropping when empty. Each pallet was dropped from a height of 40-inches, with the length of the diagonals recorded after each drop.

RESULTS

Warehouse Rack Bending Tests – Across Length

During testing, two of the pallets failed at an unsound knot in the stringer. The pallets were a matched pair, treatment and control, and failed at similar load levels. As a result, it was not possible to draw any statistical conclusions due to the limited sample size. The two untreated pallets showed an average load at failure of 8608 kg, average deflection after 2 hours at creep load of 2.5 mm, and a residual average deflection after 1-hour recovery of 0.8 mm. The RF treated pallet results showed an average load at failure of 8148 kg, average deflection after 2 hours at creep load of 2.6 mm, and a residual average deflection after 1-hour recovery of 0.7 mm.

Warehouse Rack Bending Tests – Across Width

There was no statistical difference in the average strength and stiffness of the RF treated pallets and the untreated pallets, based on an analysis of variance at a test confidence level of 95%. The three untreated pallets showed an average load at failure of 2970 kg, average deflection after 2 hours at creep load of 28.8 mm and a residual average deflection after 1-hour recovery of 6.9 mm. The RF treated pallet results showed an average load at failure of 3038 kg, average deflection after 2 hours at creep load of 30.9 mm and a residual average deflection after 1-hour recovery of 7.2 mm.

Conveyor Support

The three untreated pallets showed an average load at failure of 2092 kg, average deflection after 2 hours at creep load of 15.6 mm, and a residual average deflection after 1-hour recovery of 502 mm. The RF treated pallet results showed an average load at failure of 2275 kg, average deflection after 2 hours at creep load of 16.1 mm, and a residual average deflection after 1-hour recovery of 4.3 mm. Statistical results, based on analysis of variance, showed no significant differences in average strength and stiffness at a test confidence level of 95%.

Corner Drop Impact Resistance

The RF treated pallets (11 percent average change in diagonal dimension) were an average 15 percent less resistant to impact that the untreated pallets (12.7 percent average change in diagonal dimension), a statistically significant result. However, the fasteners used in the pallets were well below recommended levels for both withdrawal and shear indices. A low quality fastener significantly influences pallet rigidity, and therefore, makes it difficult to conclude whether the statistical difference was attributable to a difference in treatment of the wood components.

Forktine Tip Impact Test

The average resistance of the RF treated pallets was 16.8 percent greater than that of the control specimens. However, there was no statistical significance between the two. The average maximum cumulative kinetic energy of the RF treated and control pallets were 2882 joules and 2466 joules, respectively.

Endboard Impact Resistance Test

The average resistance of the RF treated pallets was 30.4 percent greater than the control specimens. There was no statistical difference in the impact resistance of the top deck endboard between treated and untreated pallets. Because a relatively low quality nail was used in pallet construction, all failures were attributable to the fastener. As such, the test results do not accurately reflect any effect of wood component heat treatment on performance.

DISCUSSION

Standard mechanical test of the RF treated and untreated pallets showed no statistical differences in warehouse rack bending, fork tine top impact resistance and endboard resistance. The corner drop impact test did show the RF treated pallets to be statistically less resistant. However, the difference was potentially attributable to the use of a low quality fastener.

Results of this evaluation indicate that the mechanical strength of pallets appears to be largely uninfluenced by RF heat-treating of green pallet parts. And, when combined with the heat treatment results reported in Bulletin 5 it appears that the dielectric heat-treating process is a technically feasible alternative for the phytosanitary treatment of pallet lumber.