Title: Report on Western Juniper Doors Equalized at 8% and 2.5% Moisture Content for Connolly Wood Products, Bend, OR. December, 1997

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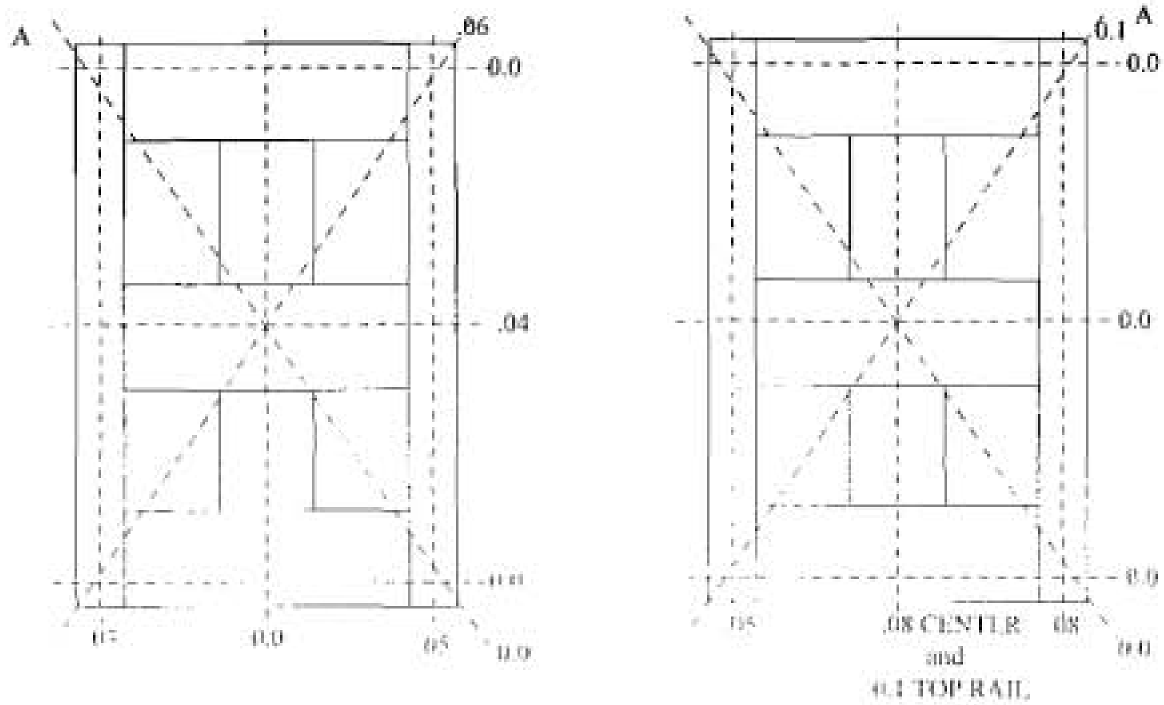
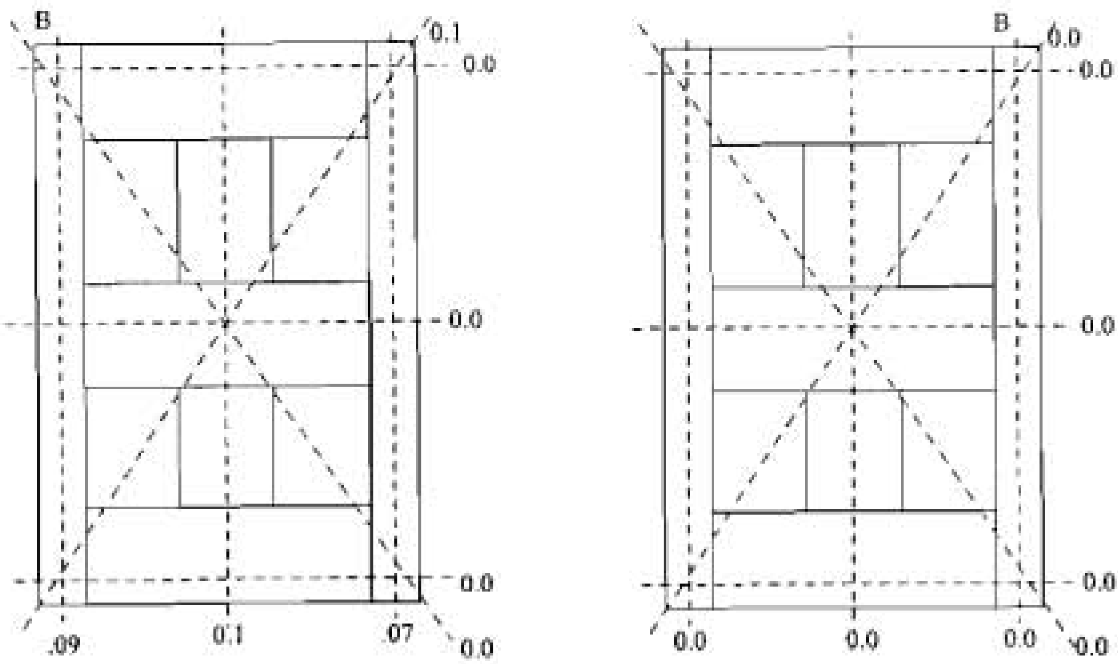
Mike Connolly, Connolly Wood Products, asked us to look at two doors that were put in use in Montana (probably a low humidity environment) but returned to Connolly Wood Products due to excess warping. When we received the doors in Corvallis it was difficult to see the out-of-plane deviation although very slight bowing was apparent in the finished door (along one stile).

Two Western Juniper exterior doors, one unfinished and one finished, were placed in a room at the Forest Research Laboratory, Oregon State University, and allowed to equilibrate to an approximate moisture content of 8%. Both doors were constructed using 3-ply for stiles and rails with floating panels. The unfinished door had a thick interior ply (about 1 1/4") with thinner exterior ply (front and back ply each about 1/4"). The finished door had thinner interior ply (about 3/8") and a little thicker exterior ply (front and back ply each about 5/8"). Measurements from the flat plane were taken in different directions across the surface and on both sides of the doors. Deviation from the flat plane were recorded for the finished door (Figures 1a and 1b) and the unfinished door (Figures 2a and 2b).

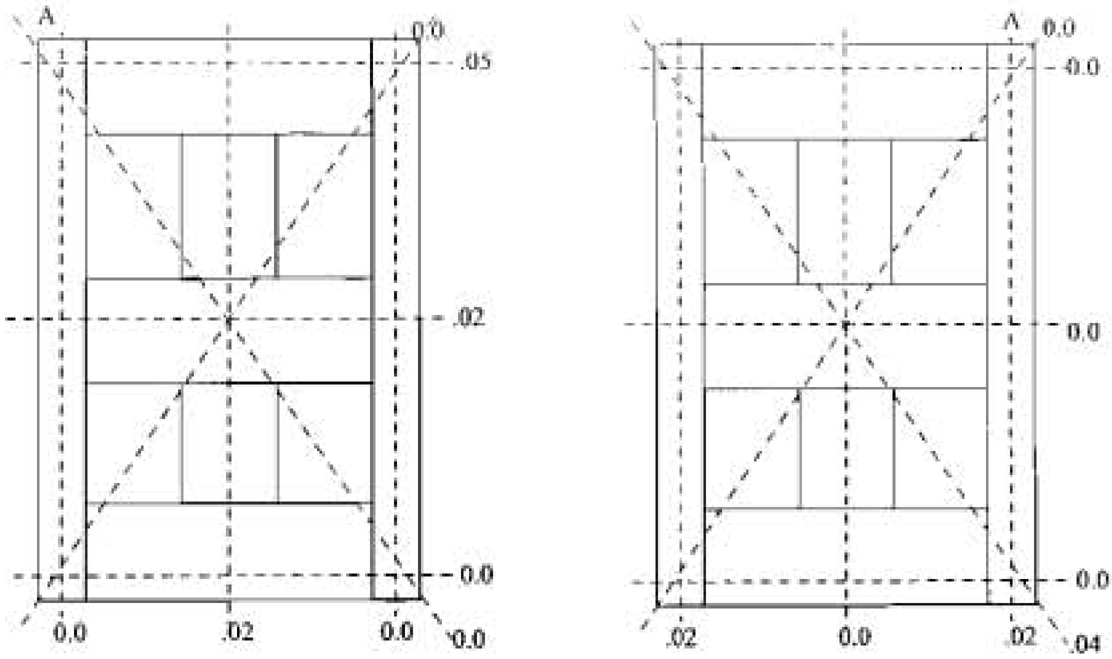


Figures 1a and 1b. Simplified drawing of finished door (8% MC). Dashed lines represent stretched wire. Values are measured maximum deviation under the wire. "A" represents same top corner.

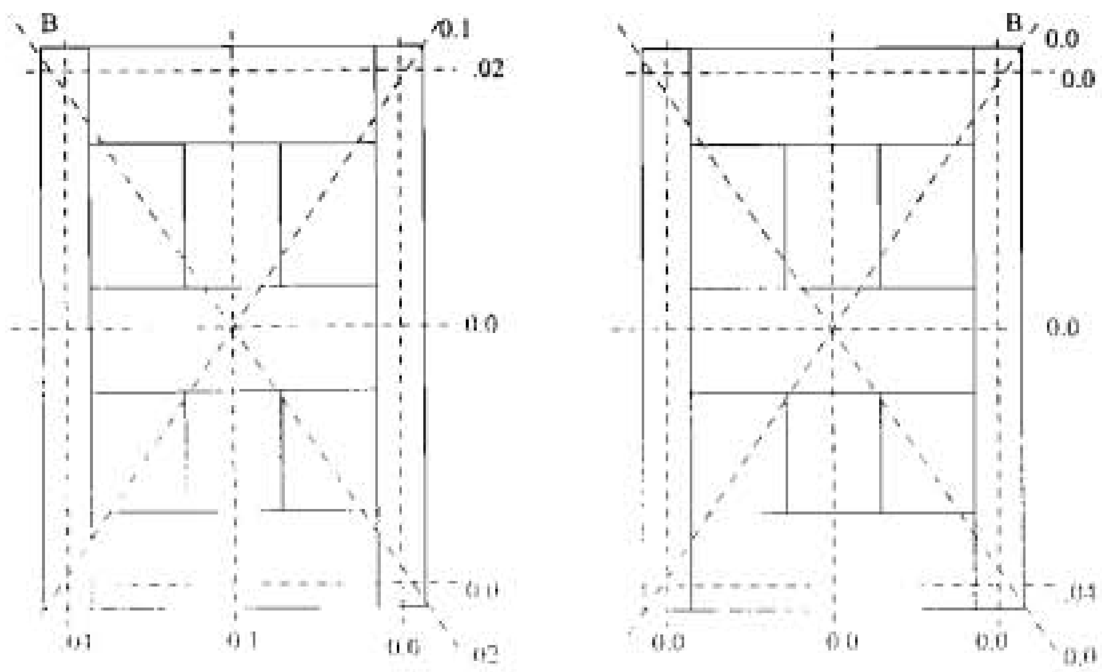


Figures 2a and 2b. Simplified drawings of unfinished door (8% MC). Dashed lines represent stretched wire. Values are measured maximum deviation under the wire. "B" represents same top corner.

The doors were put into a controlled chamber and allowed to equilibrate to an approximate moisture content of 2.5%. Measurements were repeated for both doors to determine what effect the lowering of the MC had on the deviation from the flat plane. Deviation from the flat plane were recorded for the finished door (Figures 3a and 3b) and for the unfinished door (Figures 4a and 4b).



Figures 3a and 3b. Simplified drawings of finished door (2.5% MC). Dashed lines represent stretched wire. Values are measured maximum deviation under the wire. "A" represents same top corner.



Figures 4a and 4b. Simplified drawings of unfinished door (2.5% MC). Dashed lines represent stretched wire. Values are measured maximum deviation under the wire. "B" represents same top corner.

Discussion

Measurements were taken by stretching a wire cross the surface. Indirect lighting was used so a shadow would appear if the wire was off the surface of the door. However, in case of a concave surface, the reported deviation would be 0. Therefore, convex surfaces and those twisted out of plane were the surfaces that could be measured using this technique. Measurements below .04" were difficult to measure accurately and difficult to see without the indirect lighting. Measurements of .01 to .04" were very small deviations from the flat plane. Deviations from .05 to 0.1" could be seen very easily.

Initially, we thought the doors probably warped because the wood was exposed to a dryer environment than that in which the doors had been constructed, warp due to the wood losing moisture and shrinking across the grain. However, observation and measurements showed that the finished door relaxed somewhat in the low EMC (equilibrium moisture content) conditions. Except for the stiles (.07 to 0 and .09 to .04, Figures 2a and 4a), the unfinished door did not change much from 8% MC to 2.5% MC. Does this mean that the doors (particularly the finished door) were manufactured in extremely low EMC conditions? If the doors were built with wood conditioned in Bend at a low humidity (2 - 3% EMC would not be unreasonable in heated winter conditions), then sent to a dry site in Montana, the dry site could still have EMC conditions greater than 5% above those from the manufacturing facility. For example, a relative humidity range of 10 - 15% and temperature range of 60 - 90 degrees F would equate to EMC conditions ranging from about 2.3% to 3.6%.

A tactile examination of the knots displayed only one knot obviously protruding above the surface of the dried doors. If the wood was manufactured at the same moisture content and the product was dried to a low MC, knots would be expected to shrink less (wood shrinks less longitudinally than across the grain) then the surrounding wood. But all knots, except one edge knot (see picture) felt smooth when running a finger across the surface of the wood. This might indicate that the wood was at a low moisture content (about 2 - 3%) when the doors were assembled. However, a 6% reduction in MC might not result in enough of a difference to feel. Losing moisture from 8% to 2.5%, one would expect about 20% of the total shrinkage that would occur from green to oven-dry. One large edge knot (finished door) was the only knot on either door that significantly detached from the surrounding grain and was raised above the surrounding grain.

Joints opened and were exposed (photographs) and this would argue against the wood being at 2-3% MC when assembled. Some unfinished wood was also exposed on floating panels of the finished door indicating shrinkage below that when the door was finished. If the wood was assembled at this moisture content then one wouldn't expect the gaps between the joints to be as large, or the finished panels unfinished surface to be exposed, after reducing the MC from 8% to 2.5%. Again referring to the photographs, most large knots checked and there were many splits along the grain after conditioning to 2.5% MC.

Upon delivery to the Forest Research Lab, the finished door did have some bow along one stile. Mike Milota, Drying Specialist at the FRL, noted that there were a significantly higher number of knots on the concave side of the bow. Even though the design of the doors was balanced, by having many more knots on one face than the other can cause an unbalanced design due to excess shrinkage on the face with more knots.

Recommendations

Recommendations are to use wood conditioned to the MC where the doors will be put into use. Shipping and handling are very important to insure the products do not get wet or are left in a low humidity (heated in winter) environment before being put in use. Use a balanced design that includes balancing the number and size of knots from one side of the door to the other. Clearer (fewer knots, bark pockets), straighter grained wood could also help reduce the occurrence of warp. Enclosed, find a summary of a report from the Forest Products Laboratory, Madison WI on the moisture exclusion efficiency (MEE) capabilities of several paints and stains. Although none can completely impede the moisture movement in and out of wood, some are much better at doing this than others. For doors you would want to finish with a stain or paint that had a high MEE. Of course, in highly decorative doors such as Western Juniper, you want a light finish with a high MEE. Two sources that could give advice on finishes are the Forest Products Lab, Madison WI (608-231-9200) or the National Paint & Coatings Association (202-462-6272).

Any questions or comments about this report can be directed to Jim Reeb, 105 Forest Research Laboratory, Corvallis, OR 97331-7402, Phone: 541-737-4233, Fax: 541-737-3385, email: reebj@frl.orst.edu.

MOISTURE-EXCLUDING EFFECTIVENESS (MEE) OF WOOD FINISHES

(3 coats after 14 days at 90% relative humidity)

FINISH	MEE
Melted paraffin wax (1-coat dipped)	95
Two-component epoxy/polyamide gloss paint	87
Aluminum-pigmented polyurethane gloss varnish	84
Soya-tung alkyd satin enamel	80
Pigmented flat shellac	73
Two-component polyurethane wood sealer	63
Orange or white shellac	46
Phenolic/tung floor sealer	35
Paste wax	1
Linseed oil	0

Source: U.S. Forest Service Forest Products Laboratory