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Western Juniper Drying Project Summaries, 1993-96

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Abstract

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Drying tests and trials for western juniper (*Juniperus occidentalis* Hook.) were conducted between 1993 and 1996 to (1) test and refine existing dry kiln schedules; (2) develop moisture meter correction factors; (3) test dry western juniper in different types of kilns, both by itself and with ponderosa pine (*Pinus ponderosa* Dougl. ex Laws.); (4) explore alternative drying techniques to minimize splitting and warping caused by inherent growth stresses; and (5) test a “saw-dry-rip” program currently used in the hardwood industry to reduce splitting and cracking. Test results over a 3-year period revealed that checking and splitting in juniper can be reduced by (1) careful selection of logs to minimize large knots, spiral grain, and excessive taper; (2) careful treatment of logs after harvest, such as end-coating and sawing logs as soon as possible after felling; (3) minimizing material with large knots (over one-half inch) and pith; (4) drying thinner and shorter boards; (5) using moderate kiln schedules (lower initial temperatures, higher initial relative humidities, and longer times); and (6) finger jointing and emphasizing products that require shorter and thinner lumber than that commonly produced in the Pacific Northwest.

Keywords: Western juniper, drying, kiln drying, moisture loss.

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Introduction

The purpose of this project was to confront the common perception in the wood industry that western juniper (*Juniperus occidentalis* Hook.) is difficult to dry. During trials conducted by the Western Juniper Commercialization Project in 1993 and 1994, it became apparent that years of anecdotes about how difficult it is to dry juniper were hindering the willingness of manufacturers to conduct manufacturing trials and test market value-added western juniper products. Drying tests and trials were conducted between 1993 and 1996 to:

- Test and refine previously published western juniper dry kiln schedules (Boone and others 1993)
- Develop moisture meter correction factors
- Test dry western juniper in different types of kilns, both by itself and with other tree species
- Explore alternative drying technologies to minimize splitting[1] and warping caused by inherent growth stresses, based on available industry infrastructure and capabilities
- Test a “saw-dry-rip” program currently used in the hardwood industry to reduce warping (Hallock and Bulgrin 1978, Maeglen and Boone 1986)

Another project objective was to expose a broad cross section of manufacturers to western juniper and its manufacturing characteristics, and promote product trials in niche markets.

Methods and Techniques

Most standing western juniper (about 80 to 90 percent) is unsuitable for sawing into lumber because of large and numerous limbs, spiral grain, rapid taper, bark seams, and rot[2] (Swan 1998). Finished product recovery from the few logs suitable for sawing is sometimes low because of warping and splitting encountered during remanufacturing. Juniper manufacturing always will be economically marginal unless methods are developed to maximize recovery.

Warp and splitting often are called “drying defects” because they are linked to moisture loss. One method to reduce warp and splitting, and improve recovery is to refine kiln schedules (for example, amount of time in the kiln, range of temperatures and relative humidities, and pretreatments such as steaming) for various products. Another method is to change the condition and dimensions of the material going into the kiln. Both methods were tested for this project. Several drying techniques used in other species with high growth stress also were suggested by industry sources and tested.

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[1] The terms "splitting" and "checking" often are used interchangeably. A check is defined as "a lengthwise separation of the wood that usually extends across the rings of annual growth and parallel to the wood rays" (Dry Kiln Operator's Manual 1991), whereas splitting often results from the extension of a check and extends across the full thickness of the piece. Warp is a broad term that encompasses any distortion in the "shape" of a board and includes bow, crook, twist, cup, and diamonding.

[2] Juniper pocket rot *(Pyrofomes demidoffii [Fomes juniperinus])* (Scharpf 1993), also referred to as white trunk rot, attacks a large percentage of living trees. There is also an unidentified brown cubicle rot (Dealy 1990).

Table 1—Moisture meter correction factors for western juniper[a]

Meter reading	Resistance-type meter ("pin")	Dielectric-type meter ("pinless")
6	+1.3	+1.8
8	+1.4	+2.1
10	+1.5	+2.4
12	+1.6	+2.4
14	+1.7	+3.0
16	+1.7	+3.3
18	+1.8	+3.6
20	+1.9	+3.9
22	+2.0	+4.3
24	+2.1	+4.6
26	+2.1	+4.9
28	+2.2	+5.2

[a] Add the factor given to the meter reading to get the true moisture content.

Source: Milota and Swan 1995.

Regardless of how well a drying schedule or technique works in an experimental situation, implementation with industry-standard equipment and training will require adjustments. For that reason, juniper was dried in various kilns and kiln sizes. Moisture meter correction factors (see table 1) also were needed so kiln operators could ensure they were drying juniper to customer specifications. Finally, to realistically test and evaluate dried material, properly dried material had to be remanufactured and used in various products and markets.

Prior Work

This project built on prior work by (1) testing and refining kiln schedules developed by Boone and others (1993) and Kozlik (1976) for products besides “distressed” paneling; (2) testing the schedules derived in different kilns, including radiofrequency (RF), dehumidification, and vacuum kilns; (3) developing moisture meter correction factors; and (4) testing methods such as high temperatures and steam, and presteaming, to reduce warping causd by inherent growth stresses in the wood. Flexibility was maintained throughout the project so that preliminary results provided direction for work that followed.[3]

Current Practices

Most manufacturers who primarily manufacture juniper have low-volume operations (less than 50 thousand board feet per year) and air-dry their material. Air-drying, if done properly, can dry material slowly and gently, and minimize stresses that can lead to warping and checking. There are, however, several potential drawbacks to air-drying juniper lumber:

[3] For example, growth stresses were discovered early on to be the major factor affecting warp in juniper lumber. Lab trials therefore were conducted on methods used for other species with this problem to determine if they should be attempted on a commercial scale.

- **Woodborers**—Woodborers can be a problem in air-dried juniper lumber. Woodborers have been reported emerging from furniture made of air-dried juniper a year or two after processing (Swan 1996) . It is difficult to attain and maintain the temperatures necessary to kill insects and their larvae (for 4/4 stock, 130 ˚F for at least 12 hours) if no supplemental heat source or heating technique exists.

- **Weather and ambient temperatures**—During much of the year, ambient temperatures and humidities may not allow wood to dry to moisture contents low enough for remanufactured products, such as finger-jointed/edge-glued panels, flooring, or paneling. Some manufacturers want 6 to 8 percent moisture content. It is hypothesized, however, that because of low shrink-swell ratios, manufacturers may be safe with 8 to 10 percent moisture content (Burke 1994).

- **Casehardening**—Air-drying does not provide the ability to condition lumber and relieve casehardening, an internal stress in dried lumber that results in warping during resawing or molding. This stress, however, may not be severe in slowly air-dried lumber, especially if techniques are used to slow dry (for example, use of fabric cloth and protection from direct sunlight).

Several juniper manufacturers have contracted their drying with mills that operate conventional steam kilns. Most kilns are large (50 to 200 thousand board feet capacity) and either require customers to completely fill a kiln with juniper or request that small volumes be dried with other species (primarily pine or fir in eastern Oregon), using the kiln schedule of other species.

Partially filling a kiln and drying juniper with other species has its drawbacks. In trials where juniper was dried with pine to a target moisture content of 8 to 10 percent, moisture content of juniper came out at 10 to 12 percent on average. Experience at another mill indicates that pulling the juniper out earlier in the conditioning cycle (end of the drying cycle where moisture is added back into the wood to reduce drying stresses) may result in failure to adequately relieve the drying stresses in the juniper. In addition, it will interrupt airflow within the kiln (Swan 1998). Milota (1996) cites other potential problems with mixing juniper and ponderosa pine (*Pinus ponderosa* Dougl. ex Laws.) in a dry kiln. If dried with pine heartwood, juniper is likely to dry too quickly, thereby resulting in excessive checking and warp. If dried with pine sapwood, juniper may become too dry, again resulting in increased checking. Milota (1996) mentions these things merely to encourage caution, and states that only experience will indicate if juniper can be kiln dried properly if mixed with pine.

Results

Summary Discussions of Individual Drying Research Project Components

Dry kiln schedules—According to Milota (1998),[4] the western juniper kiln schedules found in Boone and others (1993; see table 2) should work well if adjusted for kiln type. The final drying trial was a full kiln charge (about 40,000 board feet) in a standard commercial kiln. Although the kiln operator expressed some anxiety about what would happen, and in fact pulled the charge about 24 hours sooner than recommended, no problems were encountered. Target moisture content of 8 to 10 percent probably would have been achieved, rather than 10 to 12 percent, if the recommended schedule had been followed.

[4] Michael Milota is professor of forest products at Oregon State University, Forest Research Laboratory, Corvallis, OR 97331.

Table 2—Suggested dry kiln schedule of western juniper—all grades and thicknesses

Step	Time	Dry bulb	Wet bulb	Equilibrium moisture content	Relative humidity
	Hours	*Degrees*	*Farenheit*	--------- *Percent* ---------	
1	0-24	130	123	14.3	81
2	24-48	135	125	12.0	74
3	48-72	140	125	9.6	64
4	72-96	150	135	9.5	66
5	96-120	155	135	8.0	58
6	120-144	160	135	6.8	51
7	144-168 [a]	180	140	4.5	36
8	Equalize and condition as necessary [b]				

[a] Or until dry.

[b] This step applies to all columns.

Source: Boone and others 1993.

Moisture meter correction factors—Moisture meter correction factors (see table 1) for western juniper are small but significant. At 10 to 12 percent, true moisture content averages almost 2 percent above what resistance- and capacitance-type meters would read if calibrated or set for pine.

Different kiln: single species and mixed—Juniper was dried in three different steam kilns, a radiofrequency drier, a dehumidification kiln, and a vacuum kiln.

Air-drying—Juniper air-dried more quickly than expected. Although all material sawn was green, after just 4 days stacked on the green chain, sapwood moisture content was about 30 percent and heartwood was 22 percent. After 3 weeks, both heartwood and sapwood equalized to around 12 to 14 percent moisture content. Conditions were reported ideal for the air-dried material: temperatures were in the 70s ºF, and winds were light and constant. No excessive shrinkage, cracking, or warp was noticed.

Steam kilns—No problems were encountered in any of the steam kilns when juniper lumber was dried by itself. Drying time varied from 87 hours (commercial kiln where material was removed about 24 hours sooner than recommended) to 168 hours (Boone and others [1993] recommended schedule). Moisture content targets, however, were consistently exceeded by about 2 percent when juniper was kiln dried with ponderosa pine (for example, if target moisture content was 8 to 10 percent, juniper would average 10 to 12 percent). Dried lumber was tested and found free from drying stresses, thereby indicating that juniper may be conditioned successfully.

Dehumidification kiln—As with air-drying, juniper lumber dried faster than expected in a dehumidification kiln. Because of several power outages, however, an exact kiln schedule was not obtainable. Average moisture content of the juniper when removed from the kiln was 8 to 10 percent. Shrinkage was minimal. Boards were visually inspected, and no severe warp or drying defects were noticed. Any warping observed appeared reduced for shorter and narrower boards. According to the kiln operator, probably less than 2 to 3 percent of the sample warped to any extent, and most of this was due to spiral grain. Drying defects were common to all species with high heartwood to sapwood ratios.

Radiofrequency drier—The radiofrequency drier was used to dry 1/16-inch sliced veneer. Challenges were encountered because of large knots and mixtures of heartwood and sapwood. Western juniper veneer required two passes through the drier and even then, the final moisture content ranged from 3 to 12 percent. Veneer dried slightly wavy, and small checks developed in pin knots (Swan 1993). Further refinement of schedules would be necessary before full production (Swan 1998).

Vacuum kiln—Two charges of 4/4-juniper lumber were dried to about 9 to 10 percent moisture content. Total drying time was 6 days per charge. Material in the first charge appeared to dry satisfactorily without any noticeable degrade. Some bow and slight crook were evident in the second charge, as well as surface cracking on the jacket boards. One unanswered question is why the rubber seal on the kiln, which had just been replaced, had to be replaced again immediately after the first charge of juniper; the seal appeared deteriorated and full of cuts. This problem did not reoccur with the second charge of juniper.

Alternative drying techniques—Two alternative drying techniques were tested to evaluate their potential to relieve growth stress in juniper: high temperatures and steam (Milota 1995b), and presteaming (Milota 1995a). Based on previous tests and trials, growth stress is considered the primary cause of the warp encountered during remanufacturing. Neither technique tested showed potential for reducing warp. Full-scale trials were not conducted.

Saw-dry-rip program—Tests were conducted to determine if juniper would warp less if ripped after drying rather than before. Results support previous research and experience with hardwoods: less warpage will occur if kiln-dried lumber is properly conditioned and ripped after rather than before drying (Milota 1996).

About 10 secondary manufacturers were asked to test the juniper dried during the course of this project in various phases of their remanufacturing processes, as well as market products made from juniper. Reactions were mixed. Those manufacturers already working with different species and niche markets were open to further trials with juniper, especially if there was assistance in finding and exploring new market niches. Those that had experience and established markets for a limited number of species were not normally pleased with the results, especially recovery and potential price of raw material.

Recommendations

Several recommendations under various categories can help smooth the drying process of western juniper. The categories are choice of raw material, treatment of logs, kiln schedules, primary and secondary processing, air-drying, moisture meter correction factors, drying juniper with other species such as pine, and use of green juniper fencing stock.

Drying Process Categories

Choice of raw material—The biggest factor in reducing cracks and splits is raw material quality (Milota 1997). As with other species, the more material there is with small knots (under one-half inch) and the less material there is with pith, the fewer the cracks and splits. This is a challenge in juniper.

Treatment of logs—A correlation seems to exist between how long logs are stored and an increased amount of cracking and splitting. Cracking and splitting can be reduced by processing logs as soon as possible after harvest and using end coating (Leavengood and Swan 1996). Experience with other species suggests that water spray or storage likely are highly effective in reducing end splitting; it is unlikely, however, that western juniper manufacturers will use these techniques because of high capital investment and maintenance requirements, as well as increasing environmental restrictions.

Kiln schedules—The western juniper kiln schedules (Boone and others 1993) should work well, if adjusted for kiln type (see table 1).

Primary and secondary processing—Warping and checking are common problems with western juniper, and the techniques to minimize these problems can be contradictory. Sawing to shorter lengths (8 feet or less) and using saw dry-rip techniques (drying wider boards then ripping) will minimize warp. Drying narrower and thinner boards will reduce checking and splitting. Perhaps the best practice to follow with western juniper is, where possible, dry shorter (8-feet or less), thinner, and relatively wide pieces, and rip after drying. Increased checking and splitting is a risk with wider boards; however, if end coating is used and knots larger than one-half inch are avoided, as mentioned previously, checking will be lessened. As with other species, larger components such as panels should be constructed by finger jointing and edge gluing. Edge-glued and finger-jointed western juniper panels have been constructed, and warping and checking were minimal.

Air-drying—Western juniper air-dries well. Because of woodborers, however, air-dried material should be carefully prepared before stickering. Two methods to reduce the potential for woodborers are to (1) saw logs as soon after harvest as possible and eliminate wane and (2) treat green lumber with one of the commercially available borax products, such as Bora Care®[5] or Tim-bor®. A combination of the two methods would be optimal. Commonly accepted techniques for predrying hardwoods also should be implemented: use of filter cloth (or a substitute such as burlap), protection from direct sunlight, and top weighting.

[5] The use of trade or firm names in this publication is for reader information and does not imply endorsement by the U.S. Department of Agriculture of any product or service.

Moisture meter correction factors—Understanding moisture meter correction factors is essential to drying juniper (see table 1). These factors are especially important for higher value-added products where moisture content can be a critical factor.

Drying juniper with other species, such as pine—Although juniper seems to be "forgiving" during the drying process, Milota (1996) advises caution in putting juniper in kiln charges composed mainly of other species, such as pine. He states that most drying defects are related to how fast wood is dried early in the schedule, and pine is often dried fast to avoid brown stain (which is not a problem for juniper). He recommends starting at a 7˚F wet-bulb depression and 130 ˚F equilibrium moisture content (EMC) of 14 percent. This is compared to pine schedules, which often start with a 15 to 20˚F wet-bulb depression, and at 130 to 160˚F (EMC of 8 to 10 percent). Additionally, he recommends adjusting the pine schedule so that EMC never goes below 6 to 7 percent (about a 22 to 28˚F wet-bulb depression). By doing this, juniper will not dry to less than 6 to 7 percent moisture content, no matter how long it takes to dry the pine. Milota (1996) also states that juniper should never be placed on top of the charge, where temperatures and drying rates tend to be greater, and load-weight is low and ineffective in reducing warp.

Use of green juniper fencing stock—Based on observations made during the green juniper fencing trials, including an additional horizontal brace in each fencing panel, midway between the top and bottom horizontal braces, is recommended. Using screws instead of nails also is recommended.

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