Drying Wood for the Woodturner

Curt Van Weelden

9-11-2017

Bowl VS Board Properties

We are going to be using kiln schedules for boards, so let's look at a comparison

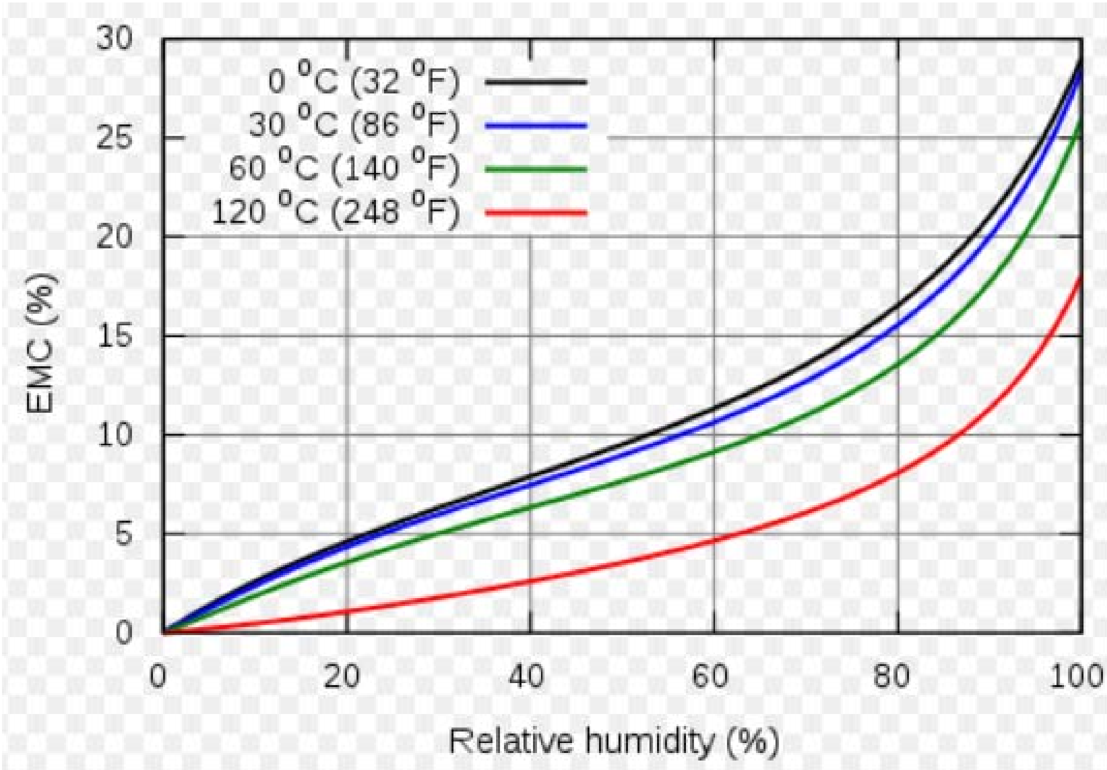
	14" x 6" Bowl	2"x6" x 8' board
Area	494	1536
Volume	305	1152
End Grain Area	144	24
Area/Volume	1.61	1.33
End Grain Area/Area (end grain was any area where the surface was with in 45 degrees of the grain direction)	29%	2%

Clearly there are some big differences between drying a bowl and a board

Terminology

- Relative humidity: the percentage of water vapor in air relative to what the air can hold at that temperature
- Dry bulb temperature: the normal temperature you read with a thermometer
- Wet bulb temperature: kind of like wind chill but with respect to dampness. WB = DB at 100% RH
- Wet bulb depression: DB – WB temp, a measure of air dryness, related to RH

Equilibrium Moisture Content of Wood



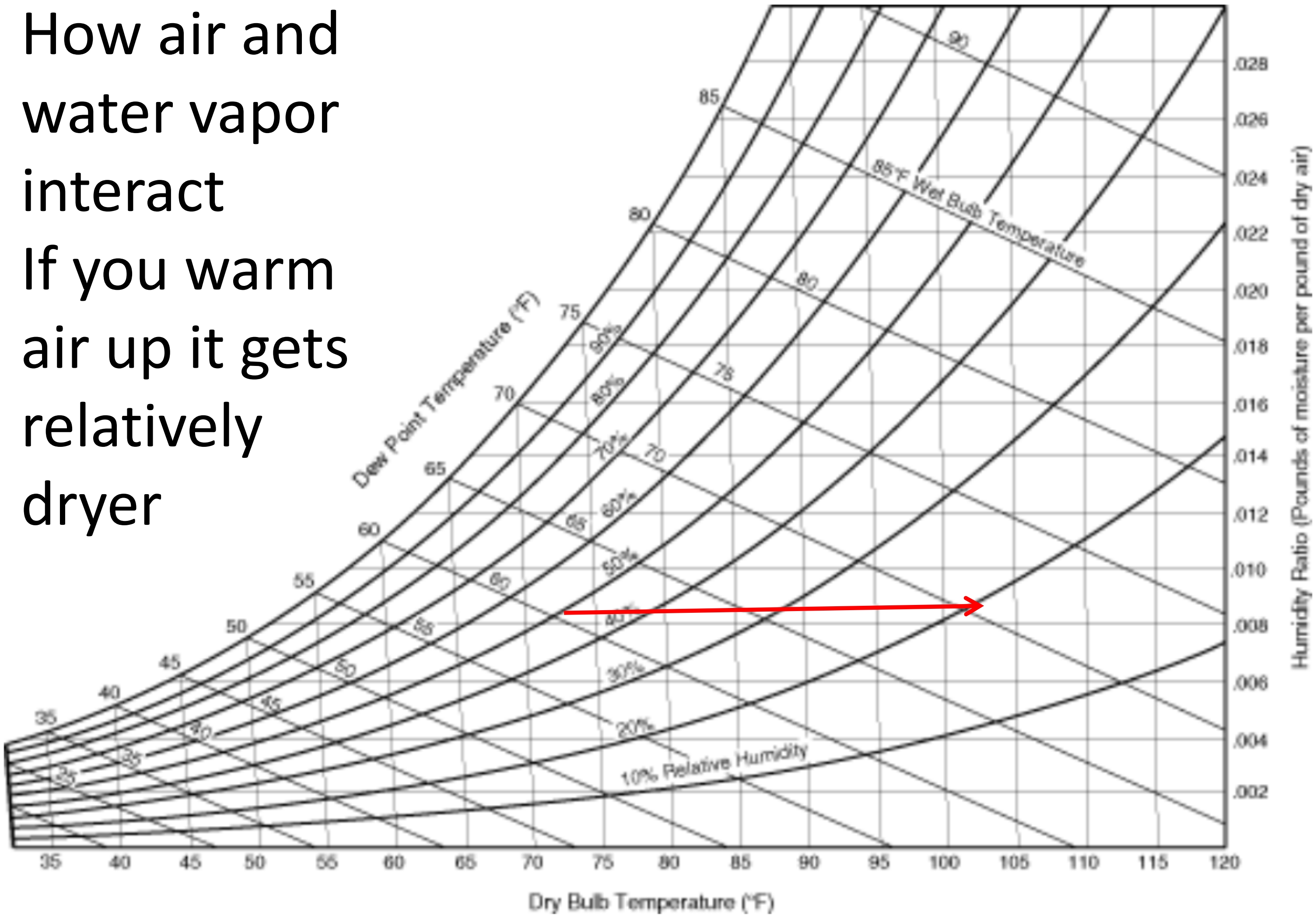
Observations:

- The curve is steep at the wet end
- The EMC is relatively insensitive to temperature
- Note that the EMC starts at ~28%

EMC= 100% x wet weight/ oven dry weight
When the wood is at EMC, it is balanced with the air and will not pick up or lose moisture

Psychometric Chart

- How air and water vapor interact
- If you warm air up it gets relatively dryer



Kiln Schedules

- https://www.fpl.fs.fed.us/documnts/fplgtr/fplgtr57.pdf
- There are published kiln schedules for most species and thicknesses and a wealth of other info at Forest Product Laboratory
- Google kiln schedules and you will find it
- Table 20 is for 8/4 Walnut

Table 20 **T3-D3 (Modified)**

Step	Moisture content	Temperature Dry-bulb	Temperature Wet-bulb	Equilibrium moisture content	Relative humidity	Temperature Dry-bulb	Temperature Wet-bulb
	pct	°F	°F	pct	pct	°C	°C
1	Above 50	110	105	16.3	84	43.5	40.5
2	50 to 40	110	103	14.2	78	43.5	39.5
3	40 to 35	110	99	11.6	68	43.5	37.0
4	35 to 30	110	91	7.9	48	43.5	32.5
5	30 to 25	120	90	5.5	32	49.0	32.0
6	25 to 20	130	90	4.0	22	54.5	32.0
7	20 to 15	140	90	2.9	15	60.0	32.0
8	15 to Final	160	110	3.4	21	71.0	43.5

Equalize and condition as necessary (see appendix A).

How to Read the Kiln Schedules

Table 20 T3-D3 (Modified)

Step	Moisture content	Temperature Dry-bulb	Temperature Wet-bulb	Equilibrium moisture content	Relative humidity	Temperature Dry-bulb	Temperature Wet-bulb
	pct	- - - - - - *°F* - - - - - -		- - - - - - *pct* - - - - - -		- - - - - - *°C* - - - - - -	
1	Above 50	110	105	16.3	84	43.5	40.5
2	50 to 40	110	103	14.2	78	43.5	39.5
3	40 to 35	110	99	11.6	68	43.5	37.0
4	35 to 30	110	91	7.9	48	43.5	32.5
5	30 to 25	120	90	5.5	32	49.0	32.0
6	25 to 20	130	90	4.0	22	54.5	32.0
7	20 to 15	140	90	2.9	15	60.0	32.0
8	15 to Final	160	110	3.4	21	71.0	43.5

Equalize and condition as necessary (see appendix A).

- Moisture Content: wetness of your wood
- Dry Bulb: Temperature of the kiln air
- Wet bulb: another way to state RH - ignore
- Eq. M. C.: the effective MC of the kiln air if it were wood
- Relative Humidity: **this is the main parameter you want to control**

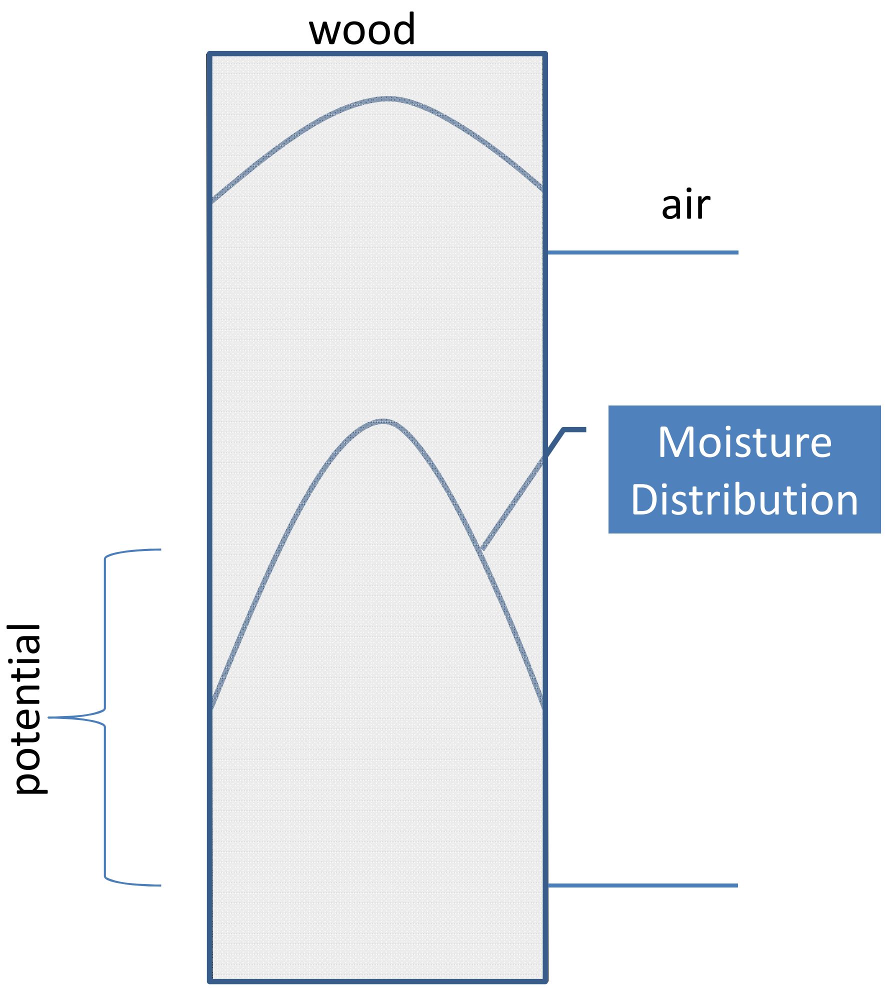
The mechanism of wood drying

- When the inside of a wood piece is wetter than it's environment, drying happens
- The "potential" depends on the water vapor pressure inside the wood versus the vapor pressure of the water in the air
- The resistance is the length of travel over permeability of the wood
- Flow out = (Pv inside – Pv outside)/(Length/Permeability)

The mechanism of wood drying (con’d)

- Thicker wall = more resistance
- Dense wood = more resistance
- Tight grained wood = more resistance
- Heart wood= more resistance
- The higher the resistance and the greater the potential, the greater the moister gradient within the wood.
- Gradients are good because it means moisture is leaving
- Gradients are bad because it means the outside is dryer than the inside, which leads to shrinkage at the outside and cracking (tensile stresses in the wood)

Moisture Gradient



Low Gradient

- moist air
- Low air flow
- Low temperature
- Soft or porous wood

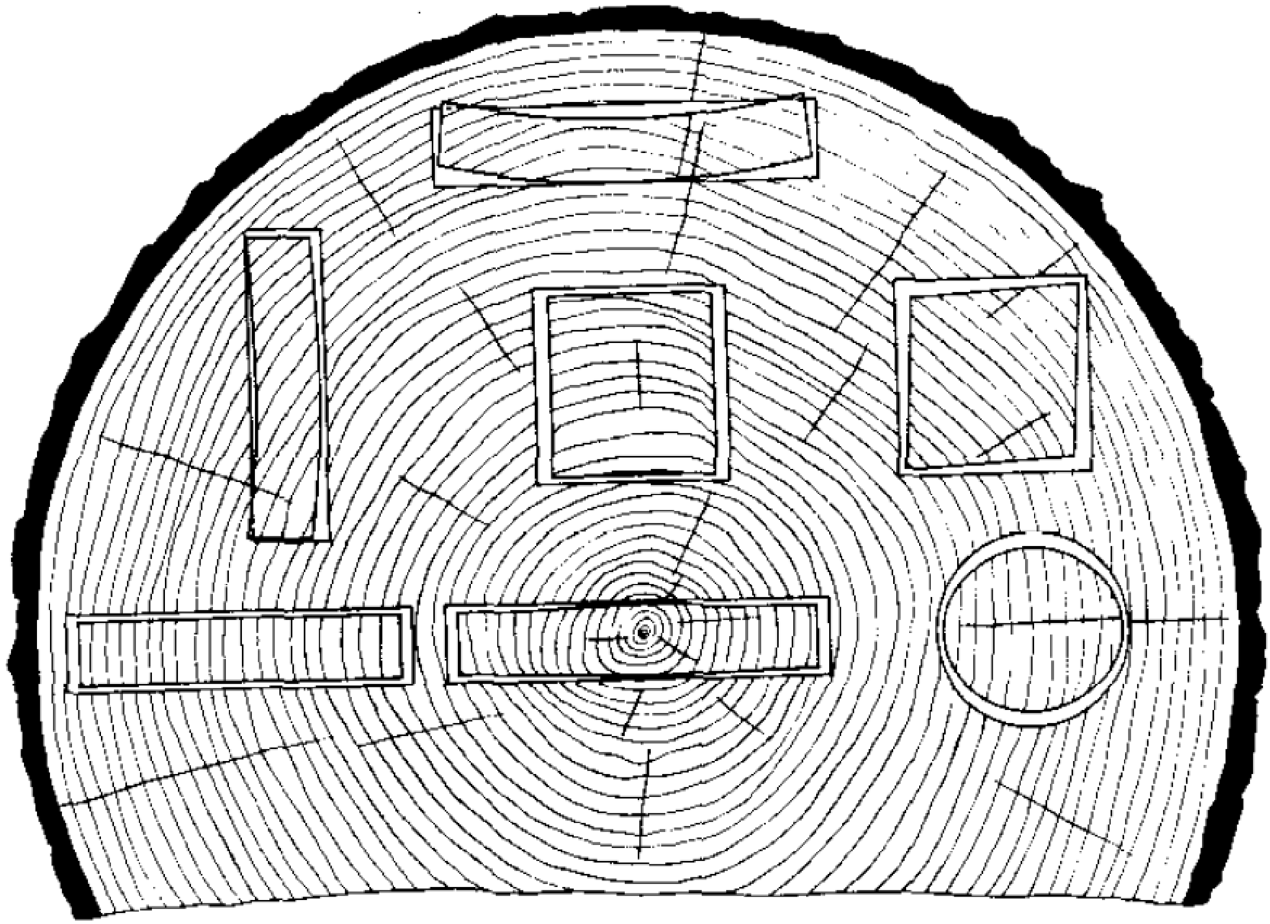
High Gradient

- dry air
- high air flow
- high temperature
- Hard dense wood

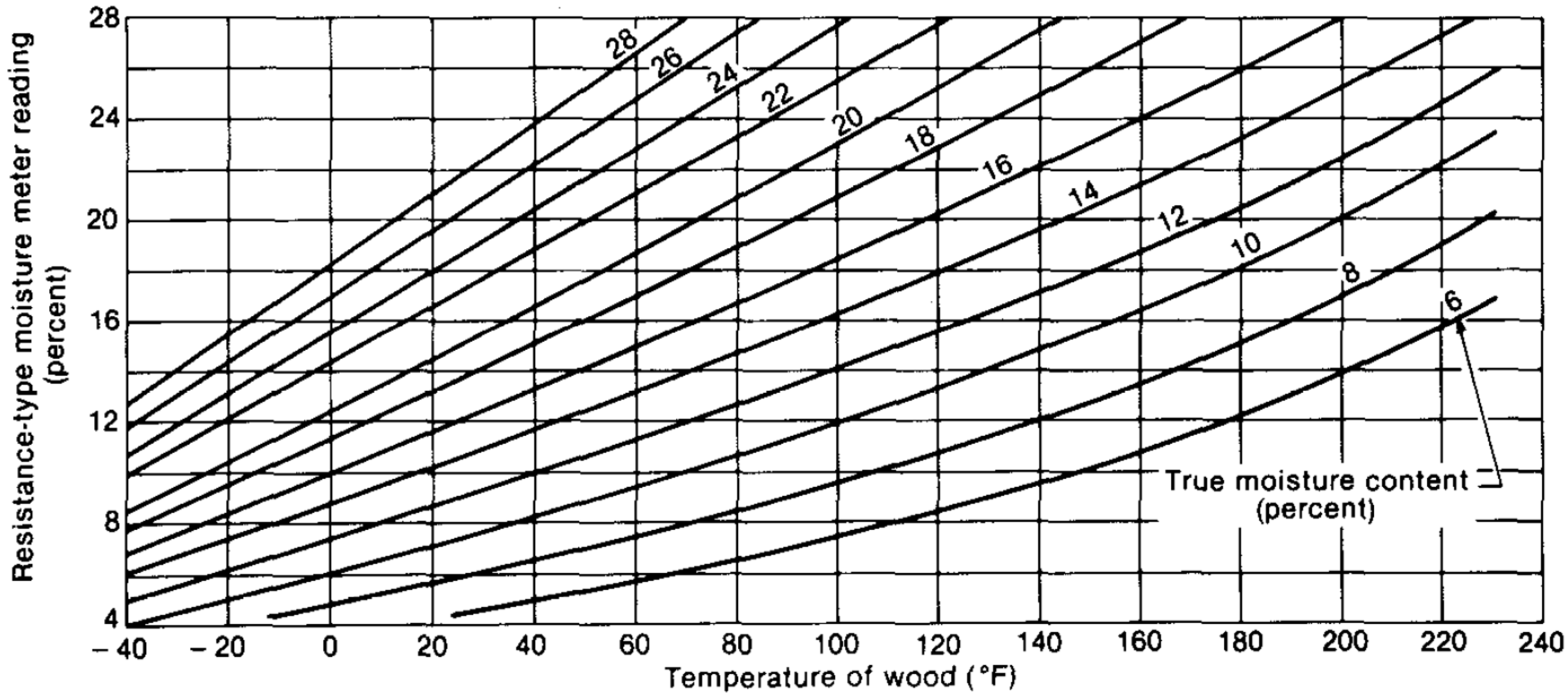
Let’s review some wood properties

- Free water: between the cells
- Bound water: inside the cells
- The MC of wood can be greater than 100%
- Wood does not start shrinking until you get below the Fiber Saturation Point ~28%
- Diffusion along the grain is 10 to 15 times higher than across the grain, and slightly higher radial versus tangential
- Double the thickness= 3-4 times slower drying
- **Most drying defects happen above 20% MC, so the first part of the drying process is critical**

Wood Shrinkage versus grain



Resistance Moisture meters are temperature sensitive, beware



- At colder temps, the meter reads low
- At warmer temps, the meter reads high
- Best to measure with pins parallel to the grain

How Fast to Dry?

- Too slow
  - Have to wait
  - Mold/Staining
  - You may die first
- Too fast
  - Cracks
  - Case hardening/ internal stresses
  - Honey comb
  - Fire (ok that's way to fast)

SPECIES	MAXIMUM RATE OF MC LOSS PER DAY (%)	
	1" Thick	*2" Thick*
Ash, White	10.4	4.1
Beech	4.5	1.8
Birch, Yellow	6.1	2.4
Cherry	5.8	2.3
Elm, American	10.4	4.1
Gum, Red	5.3	2.1
Maple, Hard	6.5	2.6
Maple, Soft (Sapwood)	13.8	5.5
Oak, Red Lowland	1.0 - 2.5	-
Oak, Red Upland	3.8	1.5
Oak, White Upland	2.5	1.0
Poplar, Yellow	13.8	5.5
Tupelo (Black Gum)	10.9	4.3
Walnut	8.2	5.5

Figure 7: Safe Drying Rates for North American Hardwoods.

A large bowl or hollow form can be dried to final MC in 1 to 3 weeks with no drying defects with the right methods

Pith In Drying

- The pith is the area in the very center of the growth rings (not usually the center of the log)
- The pith wood is weak and very porous
- This causes the pith to dry out quickly and shrink
- Since it is weak wood it cracks easily
- The cracks from the pith tend to spread into the rest of the log
- Since the pith wood is so porous, decay often starts there as well
- I have had some luck with soaking the pith with thin CA glue. This both slows the drying and strengthens the wood. It may also reduce shrinking.

Measurement based drying process

1.	Seal end grain on outside		
2.	Measure MC of fresh rough out	M1	35%
3.	Measure weight of blank	W	4800
4.	Calculate Dry weight	DW=W/(1+M1/100)	
5.	Determine desired final MC	M2	8%
6.	Calculate target weight	TW=DW*(1+M2/100)	3840
7.	Find Table for species and thickness	Walnut , 8/4	20
8.	Determine starting step based on MC	S	3
9.	Determine starting RH	RH1	68
10.	Determine weight for next step	W1= DW*(1+m/100)	4600

Measurement based drying process

11. Measure weight and log Mx
12. When Mx drops below the step range, reset chamber to next step
13. When Mx drops to desired (6-8%), hold at 50% RH for 1 day

Moisture Content %= (Current Weight/Oven Dry Weight) x 100%

Equalize and Condition

- Equalize= get all the boards to the same MC
  - Hold at a RH of about 40% (8% EMC)
  - The wetter pieces will continue to dry, drier pieces will pick up moisture
- Condition= add some moisture back in to even out MC though the thickness and reduce case hardening
  - increase RH to maybe 55% to level the MC through the thickness
  - Or put it in your shop for a week or so

Equipment

- Scale
- Moisture meter
- End Grain Sealer
- Thermometer
- Hygrometer (measures RH)
- Hot Plate and pan, Hot Pot, Crock Pot, wall paper steamer
- Heater
- Fan
- Controller
- Chamber
  - Box, cooler, old freezer, old frig, etc

Equipment - cont

- Your equipment requirements will depend on the chamber and how well and how often you want to control the process
- I have to add moisture because my chamber is not well sealed and it is in the house (dry)
- If the chamber is outside, and well sealed, you may not have to add moisture

Control Methods

- RH too low?
  - Boil water or add steam
  - Reduce temperature
  - Close vents
  - Add wet towels, shavings, etc
- RH too high
  - Increase temperature
  - Add more ambient air, vent chamber

So what about the well published light bulb method?

- It doesn’t account for a lot of variables:
  - Weather
  - Season
  - Region
  - Wood Species
  - Thickness/Size
  - Starting MC
  - Number of pieces
  - Size of chamber