Closer Look at Conditioning and Stress Relief

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Stress Relief
12. Equalization and Conditioning

“Conditioning”
- Stress removal
- MC uniformity within

Stress Relief
### 12. Equalization and Conditioning

#### T3-D2

<table>
<thead>
<tr>
<th>Step</th>
<th>% Moisture Content</th>
<th>Dry-bulb</th>
<th>Wet-bulb</th>
<th>Depression</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Above 50</td>
<td>110</td>
<td>106</td>
<td>4</td>
</tr>
<tr>
<td>2</td>
<td>50 to 40</td>
<td>110</td>
<td>105</td>
<td>5</td>
</tr>
<tr>
<td>3</td>
<td>40 to 35</td>
<td>110</td>
<td>102</td>
<td>8</td>
</tr>
<tr>
<td>4</td>
<td>35 to 30</td>
<td>110</td>
<td>96</td>
<td>14</td>
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<tr>
<td>5</td>
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<td>120</td>
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<tr>
<td>6</td>
<td>25 to 20</td>
<td>130</td>
<td>90</td>
<td>40</td>
</tr>
<tr>
<td>7</td>
<td>20 to 15</td>
<td>140</td>
<td>95</td>
<td>45</td>
</tr>
<tr>
<td>8</td>
<td>15 to Final</td>
<td>160</td>
<td>115</td>
<td>45</td>
</tr>
</tbody>
</table>

Equalize and Condition as necessary

#### EQUALIZATION

Brings about moisture uniformity between boards

![Equalization Diagram](image)
Equalization “By the book!”

1. Begin when the driest sample is 2% below the target moisture content
2. Set wet bulb and dry bulb temperatures in kiln to give an EMC in kiln that is 2% below target
3. Continue until the wettest sample reaches the target moisture content

Why are we talking about Equalization? Conditioning?

Conditioning: “By the book”

1. Begin when the wettest sample reaches the target MC
2. Set the kiln to an EMC of 4% above target MC
   • Hardwoods
3. Dry bulb temperature the highest allowed in the schedule

   8% target
   EMC = 12%
   Highest Temperature used 170 F
12. Equalization and Conditioning

8% target
EMC = 12%
Highest Temperature used 170 F
Wet-bulb should be 161-162 F

Continue conditioning until the stresses are relieved as shown by the stress test (prong test)
How does this it work?

$\uparrow$ WBT $\uparrow$ % RH

$\uparrow$ temperature $\uparrow$ increased moisture = plasticization

**Stress Relaxation**

the loss in stress when it is held at a constant strain over a period of time

4/4 and 5/4 lumber cut the prongs one-fourth the thickness of the lumber
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Interpreting Stresses

How many of you:
Cut stress test and read immediately?
Cut stress test and let cool before interpreting?
Cut prong test and microwave 15-20 seconds?
Look for moisture content increase of 1-1.5%?

“The time of cutting the prongs, whether immediately following removal from the kiln or delayed for 1 week, had no substantial effect on prong response” - Fuller and Hart 1994
12. Equalization and Conditioning
Factors Influencing Conditioning Time

4 hours or 2 days?
• Drying stress
• Density
• Thickness
• Properly equalized
• Temperature
• Relative humidity

Temperature

Critical factor
• Alone has been shown to able to relive stresses – Churchill, 1954
  • Strength reducing and plasticizing qualities
  • Thermal expansion
Lumber Thickness

Thicker lumber =
• longer conditioning times
• longer subsequent cooling times
  • to eliminate moisture gradients

Equalization

Properly equalized?
MC uniformity within charge = Better/Uniform Conditioning
Relative Humidity

Alone RH will not reduce case hardening!

- Time to reach proper depression
  - Influences overall time!
- Too low
  - Poor conditioning
- Too severe
  - Reverse case hardening

Conditioning
Why override?

• Enthalpy Change
  • Live steam injected into kiln pressure drops to atmospheric pressure and steam temperature goes to 212.

• Sensible Heat
  • When live steam at 212 cools to the kiln temperature

• Heat of Condensation
  • When steam condenses on wood, vapor to liquid

• Heat of wetting
  • Chemical bonding of water molecules to molecules in wood

Hart, 1990

Avoiding Dry-bulb Over-ride 1

• Turn off heating coils
• Raise the wet-bulb temperature to set point
• The steam spray will raise the wet-bulb temperature and the heat in the steam will raise the dry-bulb
• Raise the dry-bulb temperature to set point and open one heating coil
• Open additional coils only if needed to hold heat
Avoiding Dry-bulb Over-ride 2

- After equalizing, cool the kiln for several hours
  - Open the doors/vents
  - Leave fans on
- Close kiln
- Turn on steam spray to reach set-point
  - Leave dry-bulb off
  - Moisture will condense on surface more easily
- Watch closely to avoid stress-reversal

Avoiding Dry-bulb Over-ride 3

Use high pressure water vapor
Longitudinal Stress

• Use higher temperatures (over 160°F)
• Reaching setpoint quickly
• Proper conditioning time
Summary

Variables:
• Temperature (higher better)
• Relative Humidity (increase and get there quickly)
• Also influenced by thickness, density, prior stress, equalization