DRYING CHARACTERISTICS OF SPRAY-APPLIED CELLULOSE FIBER INSULATION

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Presentation overview

• Installation and field practice
• Objective and approach
• Analysis and Results
• Interim conclusions
• Is there a risk of damage?
• Analysis of field conditions
• Recommendations
Installation and industry recommendations

Manufacturer recommendations

- Max MC 35-40%
- At closing 25%
- Drying time
- 24-48 hours
- Test MC in the mid-depth
- No precautions for cold climate
- No vapor barrier
Cold climate: When does built-in moisture dry out?

- High initial MC can lead to interstitial condensation, dimensional changes in sheathing, mold growth and poor IAQ
- MC often exceed 40%, 24-48 hour “normal” drying time may be too short
- MC measured at the center of the cavity
- Are vapor barriers required to provide long-term performance?
Drying of spray-applied CFI

Objective and approach

- Both experiments and computer simulation
- Determine storage and transport properties
- Perform drying experiments
- Simulate for different climates
- Provide field verification (test huts)
Cold climate: Factors affecting moisture movement

Outdoor/Indoor: temperature, RH,
CFI properties: sorption, WV permeability
Initial moisture content
WV permeability of adjacent materials

- Thermal gradient drives moisture to the exterior, yet with a low permeance sheathing, most of the drying occurs from the interior
Laboratory experiments

Graph showing relative humidity (% RH) over time (days) for various positions and courses.
Field test – CFI Installed in test hut

Test hut in Georgia

CFI installed in January

Walls instrumented with T/RH/MC sensors
**MC when CFI installed in the hut**

MC (% by weight) and dry density. Samples taken at the beginning, mid-time and end of the spraying.

<table>
<thead>
<tr>
<th>Installed as ‘Normal’</th>
<th>MC %-%-weight</th>
<th>Installed as ‘Wet’</th>
<th>MC %-%-weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Samples 1, 2, 3</td>
<td>66, 67, 71 %</td>
<td>Samples 1, 2, 3</td>
<td>86, 100, 112 %</td>
</tr>
<tr>
<td>Average dry density</td>
<td>56 kg/m³ (3.5 lb/ft³)</td>
<td>Average dry density</td>
<td>71 kg/m³ (4.5 lb/ft³)</td>
</tr>
</tbody>
</table>
Installed dry density vs the installation MC

- Installed Dry Density, lb/cf
- Installed Initial Moisture Content, %-weight

Graph shows a linear relationship between installed dry density and initial moisture content.
1-D WUFI Pro Hygrothermal Model
• No drywall - to dry better to interior
• No cladding - to dry better to exterior
• Outdoor climate: Detroit, MI and San Antonio, TX (warm and humid)
• Interior conditions: ASHRAE 160
Computer simulation show the effect of liquid transfer on drying rate
Simulated and measured RH in CFI

![Graph showing simulated and measured RH (Relative Humidity) over time for interior and exterior surfaces from 1/1/09 to 6/30/09.](image)

- **Interior surface**
- **Exterior surface**

24 per. Mov. Avg. (RH1 Measured)
24 per. Mov. Avg. (RH1 Simulated)
24 per. Mov. Avg. (RH2 Measured)
24 per. Mov. Avg. (RH2 Simulated)
Simulated and measured MC in OSB

Simulated init. MC 70%

Simulated init. MC 40%

Measured (oven dry)

100 days
Simulated Performance with Initial Moisture Content 40% by weight in CFI

CFI installed at the beginning of each month (Jan, Feb, ...)

Cold Climate (Detroit, MI)
Time Series Plot of Jan, Feb, Mar, Apr, May, Jun, Jul, Aug, ...

MC in inner half of CFI
Moisture Content in Outer Half of CFI

<table>
<thead>
<tr>
<th>Time after installation, hour</th>
<th>1</th>
<th>168</th>
<th>336</th>
<th>504</th>
<th>672</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture Content of CFI, % by weight</td>
<td>45</td>
<td>40</td>
<td>35</td>
<td>30</td>
<td>25</td>
</tr>
</tbody>
</table>

- Oct - Feb
- May - Sept

MC in outer half of CFI

28 days
Time Series Plot of Jan, Feb, Mar, Apr, May, Jun, Jul, Aug, ...

Moisture Content of OSB, % by weight

Oct - March

MC in the OSB sheathing

Time after installation, hour

28 days
High MC can cause dimensional changes, structural problems.

**Installation in**
- **November**
- **September**
Hot/Humid Climate (San Antonio, TX)

Simulated Performance with Initial Moisture Content 40% by weight in CFI

CFI installed at the beginning of each month (Jan, Feb, ...)
Time Series Plot of Jan, Feb, Mar, Apr, May, Jun, Jul, Aug, ...

MC in the inner half of CFI

Variable
- Jan
- Feb
- Mar
- Apr
- May
- Jun
- Jul
- Aug
- Sep
- Oct
- Nov
- Dec
MC in the outer half of CFI

Time Series Plot of Jan, Feb, Mar, Apr, May, Jun, Jul, Aug, ...

Moisture Content of CFI, % by weight

Time after installation, hour

28 days
Time Series Plot of Jan, Feb, Mar, Apr, May, Jun, Jul, Aug, ...

Moisture Content of OSB, % by weight

Variable
- Jan
- Feb
- Mar
- Apr
- May
- Jun
- Jul
- Aug
- Sep
- Oct
- Nov
- Dec

Time after installation, hour

28 days
Interim conclusions

- Industry recommendations are based on lab work that does not describe the field performance.
- In cold climate installation in October – March may keep outer layer of CFI with MC >20% for 1 month.
- The worst case scenario installation in Dec, shown here for in Detroit, will bring MC of OSB to above 15% wt in February.
Do we have a risk of damages and if so how to avoid it?

1. To close or not close is the question
2. Redistribution of moisture from CFI to wood frame, OSB and drywall
3. Criteria for mold: level A/B; 80/90% RH 
   OSB 15-18% & CFI 13-16% by weight
4. OSB and moisture = swelling
5. Effect of outdoor temperature
6. Ventilation – space occupied or not
7. Recommendations
MC in CFI one week after installation at 40% MC in relation to average ambient temperature for the week.
To close or not close is the question in any climate

- A week in $T > 15$ deg C is a realistic time to the closure not 1-2 days
- Is this realistic for a small builder – yes; for a large builder – probably not
- If the builder closes wall before a week, moisture related problems may occur
Effect of temperature and ventilation on average MC in OSB sheathing

![Graph showing the effect of different ventilation rates (0.5 ACH, 1 ACH, 2 ACH) on moisture content (MC) over time. The graph plots moisture content (% weight) against time from the beginning (hours). Each line represents a different ventilation rate, with distinct colors and markers for easy identification.](image)
Conclusions

This presentation, based on previously published research analyzed the data and identified conditions of CFI spray application that require additional care:

1. Installation in cold climates during Oct - Feb
2. Installation in humid climate
3. In both cases when space is not immediately inhabited we require ventilation, and in cold climate both ventilation and heating, to maintain conditions of rapid drying of the built-in moisture.