Cold Temperature Research Results for Adhesives
LEARNING OBJECTIVES

Section 1: Understand the conditions of “cold” installation

Section 2: Understand what risks are associated

Section 3: Understand how JM conducted testing

Section 4: New installation recommendations from our learnings
Understand environmental conditions associated with a “cold” application
WHY IS THIS A CONSIDERATION?

- A wider window of installation below 40 °F provides longer roofing season
  - Early spring
  - Late fall
- Market information indicates 20% or greater of roofing systems are installed fully adhered – varies based on the membrane type
- Constrained labor market
- Competitive market pushes for added value in the offering
- Provides building owner confidence
WHAT IS COLD?

• Most roofing industry recommendations identify the transition to cold temperatures below 40ºF

• Historical language communicated acceptable installation when roof top environment met 40ºF and rising

• Dedicated formulations are now in the market touting better mixing and application characteristics in “cold” conditions
WHICH ADHESIVES ARE CONSIDERED?

- Non-exempt solvent systems
- Low VOC solvent systems

Water based systems
- No reasonable change will keep water from freezing
- 40ºF and rising
- Check the Roof TechXpert App
What risks are associated with applying solvent based adhesives below 40°F?
WHAT MAY HAPPEN?

Flash times are extended

Condensation

Installed too quickly results in:
  • Blisters
  • Decreased bonding strength
• Adhesive stored on the job site will drop in temperature
• Substrates, membrane, application equipment will pull heat out of the adhesive
• Liquids increase in viscosity as temperature drops
  • This impacts multiple areas
  • Additional work is necessary to spread the product
  • Will the adhesive pool, clump, flow?
  • Results in higher probability of the risks identified on prior slide
Understand how the adhesives were tested to quantify the critical performance
HOW DID WE TEST?

- December 22, 2016  7:00 AM-11:00 AM, Littleton, CO.
- Parking lot with building covering N exposure (no direct sunlight).
  Temp: 23°F and RH: 71%
ROUND 1 FINDINGS?

- Varied degrees of blistering/delamination observed
- Varied levels of bond quality in the adhesives
- Better environmental controls are necessary for quantitative evaluation
- Adhesive temperatures in the buckets dropped
  - Where is the temperature threshold that impacts performance?
  - Will cold substrates influence bond quality?

These samples were not rolled with a weighted roll – Did the build quality influence our results?
Johns Manville’s technical center has a cold chamber!
Conditioned all materials (ISO, membrane, …)
Conditioned adhesive
Built large scale samples for blister/delamination
Built small scale peel samples for quantitative results
Decreased the adhesive temperature under control
Rolled all builds to mimic the field installation
The temperature of the cold spray booth was set @ 25ºF. The average substrate and TPO temp ranges are from 23.4 to 27.7ºF.

<table>
<thead>
<tr>
<th>Target Adhesive Temp</th>
<th>RT (F)</th>
<th>35(F)</th>
<th>30(F)</th>
<th>25(F)</th>
<th>20(F)</th>
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</thead>
<tbody>
<tr>
<td>Actual Temp/LSB Adhesive</td>
<td>62.1</td>
<td>34.3</td>
<td>30.1</td>
<td>24.7</td>
<td>19.1</td>
</tr>
<tr>
<td>Actual Temp/LVOC Adhesive</td>
<td>61.0</td>
<td>33.9</td>
<td>29.9</td>
<td>25.4</td>
<td>18.6</td>
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</table>

- 2´x2´ ISO & TPO membrane
- 2"x6" peel samples over OSB
- Varied conditioning prior to testing
- Solvent and Low VOC adhesives evaluated
PEEL TESTING

Top view

Side view

Peel
# 2”x6” SMALL SCALE SOLVENT SAMPLES

<table>
<thead>
<tr>
<th>Sample IDs</th>
<th>SB-RT</th>
<th>SB-20F</th>
</tr>
</thead>
<tbody>
<tr>
<td>JM Adhesive</td>
<td>![Image]</td>
<td>![Image]</td>
</tr>
<tr>
<td>Adhesive 1</td>
<td>![Image]</td>
<td>![Image]</td>
</tr>
<tr>
<td>Adhesive 2</td>
<td>![Image]</td>
<td>![Image]</td>
</tr>
<tr>
<td>JM Adhesive</td>
<td>Adhesive 1</td>
<td>Adhesive 2</td>
</tr>
<tr>
<td>-------------</td>
<td>------------</td>
<td>------------</td>
</tr>
<tr>
<td><img src="image1" alt="JM Adhesive" /></td>
<td><img src="image2" alt="Adhesive 1" /></td>
<td><img src="image3" alt="Adhesive 2" /></td>
</tr>
</tbody>
</table>

**2’x2’ SOLVENT SAMPLES INSTALLED 20ºF**
SOLVENT BASED ADHESIVE FINDINGS

- Peel strength decreases as adhesive temperature drops.
- JM and adhesive 1 achieve cohesive failure in small scale testing to temperatures as low as 20°F.
- Blistering and delamination are not present in the 2’x2’.
Low VOC Adhesive Peel Test Results

- LVOC Adhesive 1
- LVOC Adhesive 2
- JM LVOC adhesive
<table>
<thead>
<tr>
<th>Sample IDs</th>
<th>Low VOC-RT</th>
<th>Low VOC-20F</th>
</tr>
</thead>
<tbody>
<tr>
<td>JM Adhesive</td>
<td><img src="image1.jpg" alt="Image" /></td>
<td><img src="image2.jpg" alt="Image" /></td>
</tr>
<tr>
<td>Adhesive 1</td>
<td><img src="image3.jpg" alt="Image" /></td>
<td><img src="image4.jpg" alt="Image" /></td>
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<tr>
<td>Adhesive 2</td>
<td><img src="image5.jpg" alt="Image" /></td>
<td><img src="image6.jpg" alt="Image" /></td>
</tr>
</tbody>
</table>

* indicates special note.
<table>
<thead>
<tr>
<th>Adhesive Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>JM Low VOC Adhesive</td>
</tr>
<tr>
<td>Low VOC Adhesive 1</td>
</tr>
<tr>
<td>Low VOC Adhesive 2</td>
</tr>
</tbody>
</table>

PICTURES OF 2”x2” SAMPLES AT 25°F
• Peel strength is more stable than the solvent based formulations
• JM and adhesive 1 achieve cohesive failure in small scale testing to temperatures as low as 25ºF
• Blistering and delamination are not present in the 2’x2’
• Adhesive 1 and Adhesive 2 will not spread evenly at 25ºF
• Adhesive 1 gels at 20ºF and could not be tested for peel performance

JM’s Low VOC rules performance at 20ºF
The old recommendations of 40 ºF and rising is more restrictive than current adhesive performance.
Cold Weather Application
Solvent and Low VOC/Solvent-Based Adhesives Cautions below 40ºF

• **JM Membrane Bonding Adhesive should NOT be applied**
  - When ambient temperatures are 25ºF (-3.8ºC) or colder.
  - Adhesive temperature is at/below 32ºF (0ºC).
  - Adhesive containers must be stored in a warming hut 60ºF – 80ºF (16ºC - 27ºC) when ambient temperatures are at or below 40ºF (4.4ºC).
  - Protect from freezing.
  - Opened adhesive being installed in cold weather applications that drops in temperature to the freezing point shall be restored to room temperature prior to continued use.
  - In high relative humidity or when the dew point is within 10 degrees of ambient temperature.
Next Efforts

- Dial in the safety factor for environmental conditions
- Update the Roof TechXpert App
- Investigate the impact of humidity
  - “Blushing phenomena”
  - Impact on bond strength
  - Flash time extended
- Monitor the feedback from the market
SUMMARY AND CONCLUSIONS

- JM’s solvent and Low VOC adhesives install and perform well when temperatures are below 40ºF.

- Proper storage and preparation of adhesive, substrate and membrane are critical.

- Adhesive must be stored in a warming hut to ensure 60ºF or greater temperature.

- Adhesive should not be applied if the bucket temperature gets below freezing.

- Substrates and environmental conditions must be 25ºF and rising.

- Proper installation technics will prevent blistering.