Evaluating effectiveness of window/wall interface details to manage rainwater

Selected Results from US Window Installation Practice

Research Sponsored by NRC/IRC, CMHC, PWGSC, DuPont Weatherization Systems and BDTI

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Outline

• Introduction
• Test specimens and details
• Test conditions
• Selected results & observations from testing
• Summary of results
• Acknowledgements
Wall / Window Interface can be linked to BE failures
Industry-sponsored Research Program

- Government agency / Industry consortium
- Laboratory evaluation of WWI details for management of rainwater entry subjected to range of climate loads
- Development of “standard” approach for laboratory evaluation in relation to magnitude of climate loads
Consortium Phases

Phase “A” — Interface details typical of Canadian practice
Phase “B” — Variations incorporating a drainage medium
Phase “C” — Use of flexible self adhered flashing membrane
Consortium Phases

Phase “A” — Interface details typical of Canadian practice

Further reading –


Lacasse, M.A. et al., Results on Assessing the Effectiveness of Wall-Window Interface Details to Manage Rainwater, 11th Canadian Conference on Building Science and Technology, Banff, Alberta, 2007

Consortium Phases

Phase “A” — Interface details typical of Canadian practice

Phase “B” — Variations incorporating a drainage medium

Phase “C” — Use of flexible self adhered flashing membrane

Phase “D” — Installation variations for light commercial design
Approach

• Comparative tests between sets of details subjected to simulated climate loads
  – Test specimen
  – Test protocol
• Variations in details to verify how each manages rain water
• Effects of inadvertent water entry at deficiencies
  – in cladding,
  – at interface and
  – in windows
Test Specimens

8-ft. by 8-ft. specimens / 2-ft. by 4-ft. fixed windows
# Specimen Detailing

**Phase “B”**  
Variations incorporating a drainage medium

<table>
<thead>
<tr>
<th>Specimen</th>
<th>B-side</th>
<th>V-side</th>
</tr>
</thead>
<tbody>
<tr>
<td>B-W1</td>
<td><strong>Prototype Flashing System – Type 1, with Drainage Medium, WRB installed before window</strong></td>
<td>ASTM E2112 Method A-1</td>
</tr>
<tr>
<td>B-W2</td>
<td><strong>Prototype Flashing System – Type 2, with Drainage Medium, Window installed before WRB</strong></td>
<td>ASTM E2112 Method A-1</td>
</tr>
<tr>
<td>B-W3</td>
<td><strong>Prototype Flashing System – Type 3, WRB installed before window; Foam furring strips built into WRB</strong></td>
<td><strong>Prototype Flashing System – Type 3, WRB installed after setting window; Foam furring strips built into WRB</strong></td>
</tr>
</tbody>
</table>
Objectives

Knowledge of -

• *Degree to which different approaches permit adequate drainage of subsill area*

• *Whether mounting flanges restrict rate of drainage from subsill*
Specimen B-W1
Common components to both variations

• 2-in. by 4-in. wood frame construction
• Horizontal hardboard siding over WRB membrane
• WRB membrane (PP film with microporous coating, Non-perforated)
• Fixed metal-clad wood window with flange
• Open joint (3-mm gap) between siding and window flange;
• No J-trim
• No drip cap flashing
Fabrication of B-side
Fabrication of B-side
Fabrication of V-side ASTM
Specimen B-W1
Test Conditions

Test conditions represent range of climate conditions of North America

- **Test Pressures**
  - Ranges from 0 to 700 Pa (75, 150, 200, 300, 500, 700 Pa)

- **Spray rates**
  - 0.8, 1.6 and 3.4 L/min.-m²

- **Wall system air leakage variations**
  - 0.3 to 0.8 L/s-m² at 75 Pa

- **Spray rate maintained for 15 min. intervals at each pressure level – for a given system leakage**
## Test Trials B-W1 Summary

**Phase “B”**

Variations incorporating a drainage medium

<table>
<thead>
<tr>
<th>Test Trial</th>
<th>Description / Deficiency</th>
<th>Perimeter seal</th>
<th>ABS L/s-m²</th>
<th>Spray rates L/min-m²</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>As-Is – No Deficiency</td>
<td>No</td>
<td>0.3</td>
<td>0.8, 1.6, 3.4</td>
</tr>
<tr>
<td></td>
<td>As-Is – No Deficiency</td>
<td>No</td>
<td>0.8</td>
<td>0.8, 1.6, 3.4</td>
</tr>
<tr>
<td>2</td>
<td>Perimeter sealant added between window frame and cladding – No deficiency</td>
<td>Yes</td>
<td>0.8</td>
<td>0.8, 1.6, 3.4</td>
</tr>
<tr>
<td>3</td>
<td>Deficiency in window corners</td>
<td>Yes</td>
<td>0.8</td>
<td>0.8, 1.6, 3.4</td>
</tr>
<tr>
<td>4</td>
<td>Deficiency in window corners+ sub –sill collection tray</td>
<td>Yes</td>
<td>0.8</td>
<td>0.8, 1.6, 3.4</td>
</tr>
</tbody>
</table>
Location and configuration of deficiencies

T1

T3 / T4

Deficiency at window corners
Water Collection troughs

Collection Trough W
Collection Trough T1
Collection Trough T2
Selected Results B-W1

• **T1** - Comparison of 03 and 08 ABS leakage conditions
  – Increase ABS leakage ➔ Increased entry on V-side (ASTM) as compared to B-side
  – At 08 ABS leakage ➔ higher $\Delta P$ on V vs. B-side

• **T2** - Window perimeter sealed
  – Significant reductions in rates of collection to troughs
  – Reduction in water behind cladding and to the sill

• **T3** - Window perimeter sealed; deficiencies at window corners
  – Incorporation of deficiencies - no effect on rates of collection

• **T4** - Window perimeter sealed, deficiencies at window corners + subsill collection tray
  – Confirm collection of water at sill; indicates that drainage reduced at higher pressure differential
Observations – Effects of Air Pressure Distribution

Specimen B-W1 (V-side; ASTM):
*High pressure drop ($\Delta P$) across wetted airtight external plane*

- Bead of sealant at back of window flange
- No venting or drainage at sill
- Intended interior air barrier leakier than exterior wet layers of wall specimen

$\Delta P = 302 - 55 \Rightarrow 247 \text{ Pa}$

Higher water deposition on the rough sill
Specimen B-W1 (B-side):
Lower pressure drop across wetted “vented” external plane

- No seal behind flange
- Vented and drained at the sill
- Lower water deposition on the rough sill

Exterior
302 Pa

Self-adhered membrane

Airtightness at this plane of wall assembly not as tight as Specimen A

\[ \Delta P = 117 \text{ Pa} \]

Intended assembly air barrier leaks as much as Specimen A

Observations – Effects of Air Pressure Distribution

Jamb detail (horizontal view)
Observations – Effect of Location of Plane of Airtightness

- Effect of Location of Plane of Airtightness

Airtight plane on exterior - WET

Same rate of air leakage across specimen, 2 different designs

Dry - Airtight plane on interior of joint
Location of water entry points
Selected Results B-W1

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  - Incorporation of deficiencies - no effect on rates of collection
- **T4** - Window perimeter sealed, deficiencies at window corners + subsill collection tray
  - Confirm collection of water at sill; indicates that drainage reduced at higher pressure differential
Specimen B-W3
Common components

Sloped-sill pan flashing - installed over sill flashing membrane

Weather resistive barrier: Two (2) sheets of 4-ft. wide WRB installed over entire wall surface; 6-in. overlapping

Drainage medium (‘‘built-in’’ furring strips): closed-cell foam strips (1¾-in. wide; ¼-in. thick) affixed to WRB (8-in. spacing)

Protection at rough sill of rough opening: 6-in. strip SAF membrane wrapped onto sloped sill, 2-in. on sill, 4-in. on face of WRB; 3in. strips of SAF membrane secure sill pan to jambs

Window exterior ‘‘Tie-In’’: 2 metal brackets at base of window create small gap behind window flange and support window during installation
  • Window flange at sill not taped to ensure adequate drainage
  • No caulking, J-trim between cladding and window frame (1/8-in. butt joint);
  • No drip cap head flashing

Window interior ‘‘Tie-In’’: Sheets of clear acrylic used as interior finish butted against window frame and sealed with ‘‘red tape’’
Sloped-sill pan flashing - installed over sill flashing membrane

- Sloped sill held in place by staples
- Foam strips loosened from membrane; accommodates SAF & window flange
- 6” SAF membrane wrapped over sill, 2” lap over sill; 4” over WRB
- Butyl installed to seal corners of sill pan
- Sill flashing with Butyl corners
- Installation of folded sill pan
## Test Trials B-W3 Summary

**Phase “B”**
Variations incorporating a drainage medium

<table>
<thead>
<tr>
<th>Test Trial</th>
<th>Description / Deficiency</th>
<th>ABS L/s-m²</th>
<th>Spray rates L/min-m²</th>
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<tr>
<td>1</td>
<td>As-Is – No Deficiency</td>
<td>0.3</td>
<td>0.8, 1.6, 3.4 full spray</td>
</tr>
<tr>
<td></td>
<td>As-Is – No Deficiency</td>
<td>0.8</td>
<td>0.8, 1.6, 3.4 full spray</td>
</tr>
<tr>
<td>2</td>
<td>Deficiency in window corners</td>
<td>0.3</td>
<td>0.8, 1.6, 3.4 full spray</td>
</tr>
<tr>
<td></td>
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<td>0.8</td>
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</table>
Location of deficiencies

Deficiency at window corners
**Instrumentation**

**Water collection troughs**
**Selected Results**

**B-W3**

<table>
<thead>
<tr>
<th>Test Trial</th>
<th>ABS Leakage</th>
<th>Deficiency</th>
<th>Maximum rate of water collection in respective troughs (ml/min)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>T1</td>
<td>T2</td>
</tr>
<tr>
<td>Window installed before WRB</td>
<td>WRB installed before Window</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>03ABS</td>
<td>No</td>
<td>215</td>
</tr>
<tr>
<td>08ABS</td>
<td>No</td>
<td>197</td>
<td>509</td>
</tr>
<tr>
<td>2</td>
<td>03ABS</td>
<td>With</td>
<td>120</td>
</tr>
<tr>
<td>08ABS</td>
<td>With</td>
<td>328</td>
<td>1013</td>
</tr>
</tbody>
</table>

**Diagram**

- Exterior Section
- Interior Section
- T1
- T2
- T3

**Legend**

- Exterior
- Interior
- ABS Leakage
- Deficiency
- Maximum rate of water collection in respective troughs (ml/min)
Results summary

B-W1 & B-W3

- Window installations details appear adequate to manage even most significant rainfall events in North America
- Window installation designs that cannot permit drainage from sill may be vulnerable to excessive water entry
- Critical design elements:
  - Sill pan flashing with watertight corners and integral up stand
  - Opening along interface between sill and window to permit water drainage
- Continuity of ABS at window frame to window opening interface
  - Implement towards interior of assembly
  - Well away from wetted surfaces
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- Mr. A. Jacob
- Mr. S. Nunes

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Further reading –


Lacasse, M.A. et al., Results on Assessing the Effectiveness of Wall-Window Interface Details to Manage Rainwater, 11th Canadian Conference on Building Science and Technology, Banff, Alberta, 2007


