NFRC 401 Ventilation Rating Update

March 2020
Why have we decided to rate Fenestration Ventilation?
- to expand NFRC reach (open vs sealed shut products)
- to standardize measures across the industry
- Allow NFRC to be a Green Ventilation contributor
- to allow comparison for consumers
- to give manufacturers more to sell
- to fill a demand for information to regulators
- to keep window ratings in the industry
Current status;

Testing has been completed on the Velux high aspect ratio units as well as multiple aspect ratio casement and awning units.

A calculation method for VA has been created that accounts for aspect ratio and represents actual test results.
Ventilation Research Device

- Fan: creates flow through the test window
- Data Collection: 600 data points each minute per iteration up to 25 Pa pressure drop
- Test Window: Different windows with 5-10 iterations to each variance of the window
Schematic of Ventilation Device

- Flow Diverter Wall: is added to straighten air flow into the orifice
- Fan speed is set to create pressure differential between atmospheric pressure (P1) and internal box pressure (P3).
- Pressure differential between static pressure pitot tube (P2) above orifice and (P3) is data logged and used to determine volumetric air flow
60 Tests and 18,000 data points later…
Testing proves screen effect is minimal, even with different mesh. Recommendation is 0.9 screen factor.

Peak flow @ 75 Pa in this test is at 68 degrees, at 25 Pa projected peak flow is at lower angles.
Projected products: Triangular contribution

21 x 54 7/16 Skylight, Aspect Ratio: 2.6

16x48 Awning, Aspect Ratio: 3

46% Triangular Area Flow Contribution

50% Triangular Area Flow Contribution
Projected products: Triangular contribution

Test Data shows a 1/3 triangular area contribution – covers all Aspect Ratios, including skylights
Key Findings

• For Projected products, effects of triangular areas on total air flow depends on aspect ratios.

• Test data has shown projected products triangular area needs adjustment and consideration. Analysis leads us to propose a 1/3 triangular area adder to all projected products.

• New calculation considers angle and aspect ratio to better represent any opening angle or size.

• The ventilation area is capped by frame opening area.

• Since peak flow happens before 90 degrees, sash width reduction is not required.
Proposed Method for Projecting Products:

4.3.2 Projecting Products

For all projecting products, the Ventilation Area (VA) expressed in square meters (square feet) shall be calculated at the selected opening angle (θ), as follows:

\[ VA = \left( 2 \cdot OPH \cdot OOH \cdot \sin \left( \frac{\theta}{2} \right) \right) \cdot \left( \frac{AR}{3} + 1 \right) \]

Where,

- \( \theta \) is Angle of Window Opening
- OPH is Opening Perpendicular to Hinge, shown in Figure 4-2
- OOH is Opening Opposite to Hinge, shown in Figure 4-2

- Screen frame intrusion into the vent opening, as indicated in red in Figure 4-2, shall reduce OPH and OOH accordingly.
- Intermediate screen frame braces, if used, shall not be included in the VA calculation.

\[ Aspect \ Ratio \ (AR) = \frac{OPH}{OOH} \]

Ventilation Area shall not exceed (Opening Perpendicular to Hinge × Opening Opposite to Hinge).

\[ VA \leq (OPH \cdot OOH) \]
Why OOH & OPH?

• Previously used Ventilation Opening Width (VOW) and Ventilation Opening Height (VOH) were inadequate
  • These parameters are confusing when calculating for awning, casement, or skylight

• Opening Opposite Hinge (OOH) and Opening Perpendicular Hinge (OPH) is unambiguous no matter the product type.

• OOH and OPH are measured at the smallest opening point, such as screen opening.
  • No extra measurement required for frame opening or screen intrusion
  • Using OOH and OPH we can correctly calculate the aspect ratio for all units
Why 1/3 Triangular Contribution Angle?

• Testing has shown projected product aspect ratio directly affects the window’s triangular area contribution
  • With tall, narrow casement windows triangular area is small and has little impact on total flow
  • In awnings and skylights that create long triangle areas compared with the opposite hinge area, the triangular flow area is a significant part of the total flow

• By blocking the triangular area in different aspect ratio products:
  • Determined the airflow contribution of the Opposite Hinge Area vs Triangular Area
  • Comparing results has shown 1/3 of the triangular contributes to flow for all aspect ratios
Why $VA \leq (OPH \cdot OOH)$?

- Opposite hinge area and 1/3 triangular area have been included into the total VA calculation
- If VA was not limited, a calculated VA would overestimate potential ventilation
- Testing supports maximum airflow is limited by the $OPH \times OOH$ area
  - Peak airflow happens before 90 degrees
Examples

► Case #1 - Casement 23 3/4” X 59” @ 26°
  - OPH = 23 3/4”
  - OOH = 59”
  - VA = 7.03 sq. ft.
  - Aspect Ratio (AR) = 22/57.5 = 0.4
  - \[ VA = \left( 2 \cdot OPH \cdot OOH \cdot \sin\left(\frac{\theta}{2}\right)\right) \cdot \left(\frac{AR}{3} + 1\right) \]
  - \[ = 4.97\text{sq. ft.} \]

► Case #2 - Skylight/Awning 21” X 54 7/16” @ 26°
  - OPH = 54 7/16”
  - OOH = 21”
  - OPH•OOH = 7.94 sq. ft.
  - Aspect Ratio (AR) = 54.4375/21 = 2.6
  - \[ VA = \left( 2 \cdot 54 7/16 \cdot 21 \cdot \sin\left(\frac{13}{2}\right)\right) \cdot \left(\frac{2.5}{3} + 1\right) \]
  - \[ = 6.66\text{sq. ft.} \]

► Case #3 - Skylight/Awning 21” X 54 7/16” @ 13°
  - OPH = 54 7/16”
  - OOH = 21”
  - OPH•OOH = 7.94 sq. ft.
  - Aspect Ratio (AR) = 54.4375/21 = 2.6
  - \[ VA = \left( 2 \cdot 54 7/16 \cdot 21 \cdot \sin\left(\frac{13}{2}\right)\right) \cdot \left(\frac{2.5}{3} + 1\right) \]
  - \[ = 3.35\text{sq. ft.} \]
401 Document revisions

4.3.2 Projecting Products
For all projecting products, the Ventilation Area (VA) expressed in square meters (square feet) shall be calculated at the selected opening angle (θ), as follows:

\[ VA = \left( 3 \times \frac{\text{OPH} \times \text{ODH}}{2} \right) + \frac{\text{AR}}{2} + 1 \]

Where,

- θ is Angle of Window Opening
- OPH is Opening Perpendicular to Hinge, shown in Figure 4-2
- ODH is Opening Opposite to Hinge, shown in Figure 4-2

- Screen frame intrusion into the vent opening, as indicated in red in Figure 4-2, shall reduce OPH and ODH accordingly.
- Intermediate screen frame braces, if used, shall not be included in the VA calculation.

4.3.3 Dual-Action Products
For dual-action products, such as lift-turn windows or doors, the Ventilation Area (VA) shall be calculated and reported based on the mode of operation that yields the greatest Ventilation Area. Utilize appropriate equations as discussed in either 4.3.1 or 4.3.2.

4.3.4.1 Optional Calculations
Optionally, at the manufacturer’s discretion, the Ventilation Area (VA) may also be calculated and reported based on both modes of operation.

4.4 Screen Mesh Factor
Screen Mesh Factor (SMF) shall be 0.9 for all types and designs of screen mesh.
Excel based calculator is provided to determine VA by size and angle.

### NFRC 401 Ventilation Area Calculator Spreadsheet for section 4.3.2 & 4.3.3 only

To Calculate VA only in NFRC 401 section 4.3.2 & 4.3.3:

1. All determines the effect of triangular area in ventilation
   AR (Aspect Ratio) = \( \frac{\text{OFL}}{\text{OII}} \)

2. To find projected distance, plot a perpendicular to the middle of PD and use trigonometry with OPH
   PD (Projected Distance) = 2 × OPH × Sin \( \frac{\theta}{2} \)

3. To find rectangular area:
   OVA (Opposite Hinge Area) = PD × OII

4. Total VA = Triangular area + Rectangular area

   VA = \( \left( \frac{AB}{2} \right) \times \text{OFL} + \text{OII} \)
   VA = OHA + \( \left( \frac{AB}{2} + 1 \right) \)

3. Substituting:
   VA = \( 2 \times \text{OPH} \times \text{OII} \times \text{Sin} \left( \frac{\theta}{2} \right) \) / \( \left( \frac{AB}{2} + 1 \right) \)

<table>
<thead>
<tr>
<th>Opened Degree</th>
<th>Calculated Opposite Hinge Area (OHA)</th>
<th>Triangle Contribution Area</th>
<th>Calculated VA</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>0.12</td>
<td>0.10</td>
<td>0.22</td>
</tr>
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<td>0.12</td>
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<td>0.22</td>
</tr>
</tbody>
</table>

[Graph showing calculated data]
Excel Based Calculator Graph

Calculated VA caps at max OOH x OPH value
<table>
<thead>
<tr>
<th>Unit Type</th>
<th>width, mm (in)</th>
<th>height, mm (in)</th>
<th>OPH, mm (in)</th>
<th>OOH, mm (in)</th>
<th>VA, m² (sf)</th>
<th>Screen Mesh Factor (SMF)</th>
<th>Example Adjusted Ventilation Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Projecting Products - (at AR 0.33 &amp; 22°), Typical Casement Window</td>
<td>600 (24)</td>
<td>1500 (59)</td>
<td>432 (17)</td>
<td>1321 (52)</td>
<td>0.24 (2.60)</td>
<td>0.9</td>
<td>0.22 (2.34)</td>
</tr>
<tr>
<td>Projecting Products (at AR 3.06 &amp; 8°), Typical Awning Window</td>
<td>1500 (59)</td>
<td>600 (24)</td>
<td>1321 (52)</td>
<td>432 (17)</td>
<td>0.16 (1.73)</td>
<td>0.9</td>
<td>0.14 (1.56)</td>
</tr>
<tr>
<td>Skylight (at AR 1 &amp; 24°)</td>
<td>1200 (47)</td>
<td>1200 (47)</td>
<td>1016 (40)</td>
<td>1016 (40)</td>
<td>0.57 (6.16)</td>
<td>0.9</td>
<td>0.51 (5.54)</td>
</tr>
<tr>
<td>Single Hung (4.3.1)</td>
<td>1200 (47)</td>
<td>1500 (59)</td>
<td>1067 (42)</td>
<td>635 (25)</td>
<td>0.68 (7.29)</td>
<td>0.9</td>
<td>0.61 (6.56)</td>
</tr>
<tr>
<td>Double Hung (4.3.1)</td>
<td>1200 (47)</td>
<td>1500 (59)</td>
<td>1067 (42)</td>
<td>635 (25)</td>
<td>0.68 (7.29)</td>
<td>0.9</td>
<td>0.61 (6.56)</td>
</tr>
<tr>
<td>Horizontal Slider (4.3.1)</td>
<td>1500 (59)</td>
<td>1200 (47)</td>
<td>660 (26)</td>
<td>1067 (42)</td>
<td>0.70 (7.58)</td>
<td>0.9</td>
<td>0.63 (6.83)</td>
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<tr>
<td>Sliding Door (4.3.1)</td>
<td>2000 (79)</td>
<td>2000 (79)</td>
<td>991 (39)</td>
<td>1930 (76)</td>
<td>1.91 (20.58)</td>
<td>0.9</td>
<td>1.72 (18.53)</td>
</tr>
<tr>
<td>Swinging Doors (xx, Double Swinging Door)</td>
<td>1920 (75.5)</td>
<td>2090 (82.375)</td>
<td>1664 (65.51)</td>
<td>1946 (76.61)</td>
<td>3.24 (34.85)</td>
<td>0.9</td>
<td>2.914 (31.37)</td>
</tr>
</tbody>
</table>
Next steps;

- Task group is evaluating new calculations now
- Ballot rewrite to TG
- Refine ballot
- Final Ballot for Fall meeting
- Approval and use late Fall 2020
- Celebration!
Thank you! - Questions?