Tales from the Trenches: Passive House Ventilation Commissioning Roadblocks

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Curated by Bart Bales

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Learning Objectives

1. Discuss **common passive house ventilation system designs**, layouts, and components pertaining to the performance and field installations.

2. Demonstrate through examples **common problem areas** related to implementing high-performance ventilation systems.

3. Recommend ways to **design for best ventilation performance** based upon lessons learned.

4. Describe the **Passive House certification criteria** and the actual performance necessary for ventilation systems to be within compliance.
Overview of Presentation

1. Passive House Basics and Relevance
2. Cx Process & Relevance in PH Buildings
3. TAB, Shop Dwg, System leakage
4. ERV/HRV Controls & Interlocks
5. Operations & Maintenance
6. Conclusion
Passive House Basics & Relevance
Passive House In the News

Passive House Required for Multi-family equal to or greater than 12,000 square feet:

- Effective Jan 1, 2023: Passive House required for buildings up to 5 stories
- Effective Jan 1, 2024: Passive House required for buildings 6 stories and above

- Over 6,500 Passive House Units in Development in MA
- Passive house Growth: 6+ unit multi-family currently over 6,500 units in the Mass Save® incentive program pipeline versus less than 20 in 2017.
- 133 MA firms have Certified Passivehouse consultants, $1.7m for Mass Save training of 3,600 people in 2022-2024.
- Significant Mass Save incentives available for design/feasibility and construction up to $3,000 per unit.

https://phmass.org/buildingcode/
Ventilation: Unitized vs. Central vs. Semi-Central

Credit: Handel Architects
Introduction – Ventilation Recommendations and Requirements

Energy Efficiency:
- Recommend ERV HRV fan motors consume 0.765 W/cfm or less at the highest power setting
  - Verify ERV/HRV wattage at final

Balancing Requirements:
- Supply and exhaust flows are within 10% of each other (at the unit)
- A targeted air change rate between 0.30 and 0.50 air changes per hour (ACH)
- Minimum flow rates must be met in apartments
- Supply and exhaust flows are +/- 15% or 15 CFM of design values (in apartments)
- Third-party (certified air balancing professional e.g. NEBB, AABC)
- Required pre-meeting with TAB contractor to discuss expectations
Cx Process & Relevance in PH Buildings
Energy Code Commissioning (Cx)

**Exceptions:** The following systems are exempt:

1. Mechanical systems and service water heater systems in buildings where the total mechanical equipment capacity is less than 480,000 Btu/h (140.7 kW) cooling capacity and 600,000 Btu/h (175.8 kW) combined service water-heating and space-heating capacity.
2. Systems included in Section C403.3 that serve individual *dwelling units* and *sleeping units*.
**Cx Impact**

<table>
<thead>
<tr>
<th>Low Cost</th>
<th>Rapidly Increasing Cost</th>
<th>High Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Major Influence</td>
<td>Rapidly Decreasing Influence</td>
<td>Low Influence</td>
</tr>
</tbody>
</table>

**Figure 1.** Cost of Change vs. Opportunity to Influence, Edith Cherry, FAIA, ASLA.

**Table:**

<table>
<thead>
<tr>
<th>Planning and Programming</th>
<th>Schematic Design</th>
<th>Design Development</th>
<th>Construction Documents</th>
<th>Construction</th>
</tr>
</thead>
</table>

**Benefits of Commissioning:**

- Improved occupant comfort and satisfaction resulting in higher productivity
- Increased building system life
- Improved documentation of the operational processes
- Efficient and optimal performance from the systems leading to lower complaints
- Increase in the asset and expected rental value associated with a building, etc.
TAB, Shop Drawings and System Leakage
Testing and Balancing - Process

Measure flow at the ventilation unit

Pitot tube traverse

Measure and adjust flow rates in apartments
“Extensive laboratory tests and several field tests show…Their RMS errors are typically in the 20% to 30% range compared to accuracies of 10% or better required for most distribution system diagnostics. In particular, they are inadequate for use in estimating duct leakage, air handler flow and individual register flows for room load and comfort.”

“The laboratory results for the reference active flow hood show an RMS error of only 2%.”
# Testing and Balancing - Reporting

<table>
<thead>
<tr>
<th>Drawing</th>
<th>Area</th>
<th>Supply/Return</th>
<th>Type</th>
<th>Size</th>
<th>CFM Design</th>
<th>CFM Actual</th>
</tr>
</thead>
<tbody>
<tr>
<td>27</td>
<td>Apt 6C</td>
<td>ERV Supply</td>
<td>SWR</td>
<td>6x4</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>28</td>
<td>Apt 6C</td>
<td>ERV Supply</td>
<td>SWR</td>
<td>6x4</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>30</td>
<td>Apt 6C</td>
<td>ERV Supply</td>
<td>SWR</td>
<td>6x4</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>32</td>
<td>Apt 6C</td>
<td>X</td>
<td>SWG</td>
<td>6x6</td>
<td>25</td>
<td>25</td>
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<tr>
<td>33</td>
<td>Apt 6C</td>
<td>TX</td>
<td>CG</td>
<td>6x6</td>
<td>20</td>
<td>20</td>
</tr>
</tbody>
</table>
Let’s talk about shops…
Shop Drawings – Review Physical Access

- For flow traverses, sometimes the space is there and sometimes not
Design Detailed Shop Drawings As-Built
System Leakage Examples

**Duct Leakage**

**Accessory Leakage**

**Equipment Leakage**
Duct Sealing using Aerosolized Sealant

- Seals ducts from the inside
- Pressurized aerosolized particles are forced through the duct systems and build up at leak locations.
- Can seal leaks up to ½” size
## Aerosolized Sealant – Volumetric VS SMACNA Duct leakage Standard

<table>
<thead>
<tr>
<th></th>
<th>ERV-Unit 1</th>
<th></th>
<th>ERV-Unit 2</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Supply</td>
<td>Exhaust</td>
<td>Supply</td>
<td>Exhaust</td>
</tr>
<tr>
<td>Design Flow Rate (CFM):</td>
<td>450</td>
<td>450</td>
<td>465</td>
<td>465</td>
</tr>
<tr>
<td>3% Volumetric Leakage %</td>
<td>3%</td>
<td>3%</td>
<td>3%</td>
<td>3%</td>
</tr>
<tr>
<td>(SMACNA CL 8) % Leakage of design flow</td>
<td>32%</td>
<td>19%</td>
<td>18%</td>
<td>31%</td>
</tr>
<tr>
<td>(SMACNA CL 2) % Leakage of design flow</td>
<td>8%</td>
<td>5%</td>
<td>4%</td>
<td>8%</td>
</tr>
</tbody>
</table>

Recommended 3% Fractional Leakage Method
Leakage Impacts on PHIUS WUFI Energy Model

+ 2.5 Site EUI Due to high duct leakage and fan power
## Duct Leakage – Cx Example

<table>
<thead>
<tr>
<th></th>
<th>ERV-1</th>
<th>ERV-2</th>
<th>ERV-3</th>
<th>ERV-4</th>
<th>ERV-5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design Flow Rate (CFM):</td>
<td>795</td>
<td>795</td>
<td>450</td>
<td>450</td>
<td>465</td>
</tr>
<tr>
<td>Round 1 T&amp;B % System Leakage:</td>
<td>12%</td>
<td>15%</td>
<td>3%</td>
<td>3%</td>
<td>12%</td>
</tr>
<tr>
<td><strong>Average System Leakage Before Cx:</strong></td>
<td>14%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Final Commissioned TAB % System Leakage:</td>
<td>15%</td>
<td>15%</td>
<td>3%</td>
<td>3%</td>
<td>0%</td>
</tr>
<tr>
<td><strong>Average System Leakage After Cx:</strong></td>
<td>5%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

9% Leakage reduction from early Cx engagement
ERV/HRV Controls & Interlocks
ERV Sequences & Controls

- Constant Flow vs Variable Flow
- Key Setpoints:
  - Airflow
  - Static pressure
  - Supply Air Temperature
- Other Setpoints:
  - CO2 concentration
  - Schedules
Example 1 – Fictitious TAB reports

- Is the relevant sensor installed?
- Is the controller setup correctly?
Example 1 (cont.) – Proper reporting

Design airflow in the system data sheets reflect the sum of all diffuser design ratings. These ratings were provided in the mechanical drawings.

Static pressure setpoint: 0.51"
Example 2 – Lighting ctrls. & Ventilation ctrls.

C. BASE BUILDING/AMENITY ENERGY RECOVERY VENTILATOR (ERV) SEQUENCE:

1) ENERGY RECOVERY VENTILATOR SHALL RUN CONTINUOUSLY.

2) VARIABLE FREQUENCY DRIVE ON SUPPLY AND EXHAUST FAN SHALL MODULATE TO MAINTAIN A CONSTANT PRESSURE AS SENSED BY DUCT MOUNTED PRESSURE SENSORS.

3) DURING A FIRE EMERGENCY CONDITION, THE SUPPLY FAN SHALL SHUT OFF, THE SUPPLY SIDE MOTORIZED DAMPER SHALL CLOSE, AND THE EXHAUST FAN SHALL RUN CONTINUOUSLY.
Example 1 (cont.) – The way it should go

Minimum Damper closes

Maximum Damper opens
Example 3 – Complicated controls?
ERV Controls – Heat Pump Interlocks

• Who is responsible for setting these up?
ERV Controls – Heat Pump Interlocks
How could we avoid these issues?

• Clear & realistic sequences of operation
  • Early Design Reviews.
• Clearly defined roles
  • Installer + Supplier + Manufacturer + CxA
• Clear expectations
  • The job is done when…
  • Warranty periods
Operations & Maintenance
O&M and Ongoing Cx

- Proper training
  - Training requirements come from the spec
- Ongoing Cx
  - Test plans templates
- Central ERVs w/ DX
  - 3 or more days for tuning

Live-in Building Superintendent
Operations and Maintenance
Conclusion
Conclusion

• Traditional and typical specifications for duct leakage may not be enough for high-performance buildings

• Communicate design AND construction expectations through specifications reinforced with on-site training

• Communicate project nuances and PH requirements early and often

• Engage CxA early in the design phase

• Push for clear and realistic sequences of operation

• Consider operations and operators during the design phase

Trust but Verify
Bridging the Gap - Design - Construction - Operation
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Questions?

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