Tales from the Trenches: Passive House Ventilation Commissioning Best Practices

Luis Aragon and Michael Schmidt, Steven Winter Associates, Inc.

Curated by Lea Keating (Parity) and Sara Bayer (MAP)

Northeast Sustainable Energy Association (NESEA)
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Learning Objectives

1. Analyze 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 the implementation and operation of 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 Context
2. Cx Process & Relevance in PH Buildings
3. TAB, Shop Dwg, System leakage
4. ERV/HRV Controls & Interlocks
5. Operations & Maintenance
Passive House Basics & Relevance
NYC buildings prepare to drastically reduce emissions to avoid penalties

By Emily Notiko
Published Jan. 16, 2020, 3:31 p.m. ET
ELEMENTS OF A LARGE MULTIFAMILY PASSIVE HOUSE BUILDING

CONTINUOUS INSULATION & THERMAL BRIDGE-FREE CONSTRUCTION

HIGH PERFORMANCE WINDOWS & DOORS

ARTIGHT ENVELOPE

ENERGY RECOVERY VENTILATION

FRESH AIR

EXHAUST AIR

DOMESTIC HOT WATER

EFFICIENT LIGHTS & APPLIANCES
Ventilation: Unitized vs. Central vs. Semi-Central

- Exhaust Air
- Fresh Air
- ERV

Credit: Handel Architects
Introduction – Ventilation Recommendations and Requirements

Energy Efficiency:
- Recommend ERV/HRV fan motors consume 0.76 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
Project Flow

Modeling and Design
- Project Kickoff
- Review Feasibility, 100 DD, 50 CD, and 100 CD
- Model performance and provide reports
- Develop Cx specs, Create Cx plan

Pre-Construction
- Develop construction checklists
- Construction kickoff meeting with client
- Define training requirements
- Clarify roles & responsibilities for Cx scope

Construction Phase
- Contractor Training
- Ongoing site inspections
- Submittal review
- Interim testing

Construction Completion
- Verify proper installation of MEP systems
- MEP Startups & Functional Testing
- Testing and Balancing (TAB)
- Ventilation system readings (Post-TAB verification)

Closeout Phase
- O&M & As-Built Documentation
- Submission to a certifying body
- Warranty review
- Seasonal testing

O&M & As-Built Documentation
- Submission to a certifying body
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TAB, Shop Drawings and System Leakage
Testing and Balancing - Process

Measure flow at the ventilation unit

Measure and adjust flow rates in apartments

Pitot tube traverse
Key Findings of LBNL Report - 47382

“Extensive laboratory tests and several field tests show…errors are typically in the 20% to 30% range. 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>Grille</th>
<th>CFM</th>
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<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>
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<td>X</td>
<td>SWG</td>
<td>6x6</td>
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<td>T</td>
<td>CG</td>
<td>6x6</td>
<td>20</td>
<td>20</td>
</tr>
</tbody>
</table>

**Image:**
- Picture of a digital device showing CFM reading.
- Picture of a thermostat with temperature setting.

**Text:**
- Manufacturer: [redacted]
- Model: [redacted]
- Location: Apt 6C Closet

**Table:**
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<tr>
<th>Drawing</th>
<th>Area</th>
<th>Supply/Return</th>
<th>Type</th>
<th>Size</th>
<th>Design</th>
<th>Actual</th>
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<td>SWR</td>
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Let’s talk about shops…
Detailed Shop Drawings

Design

As-Built
Retrofit Detailed Shop Drawings
Coordination Between Trades
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>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Design Flow Rate (CFM):</strong></td>
<td>Supply 450, Exhaust 450</td>
</tr>
<tr>
<td>3% Volumetric Leakage %</td>
<td>3%, 3%</td>
</tr>
<tr>
<td>(SMACNA CL 8) % Leakage of design flow</td>
<td>32%, 19%</td>
</tr>
<tr>
<td>(SMACNA CL 2) % Leakage of design flow</td>
<td>8%, 5%</td>
</tr>
</tbody>
</table>

**9% Leakage reduction from early Cx engagement**

**Recommended 3% Fractional Leakage Method**
Is SMACNA Duct Leakage Class Outdated?

38-year-old Standard Specification
Leakage Impacts on PHIUS WUFI Energy Model

+ 2.5 Site EUI Due to high duct leakage and fan power
+ ~$ 3,500 / year increased energy
Comparing Predicted V.S. Verified Fan Energy

Can you spot projects with high duct leakage?

Predicted V.S. Verified W/CFM

- A: 0.76 W/CFM
- B: 0.36 W/CFM (Exhaust Only)

W/CFM

Can you spot projects with high duct leakage?

W/CFM (design) W/CFM (actual)
Conclusion

• Traditional and **typical specifications for duct leakage are not adequate** for high-performance buildings

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

• Emphasize the need for coordination between trades, **require shop drawings**, and ensure they match as-built conditions

• Communicate **project nuances** and PH requirements early and often

• Engage **CxA early** in the design phase and ASAP after start-ups

**Trust but Verify**
Controls and Sequences of Operations

K.I.S.S.
ERV Sequences & Controls

- Constant Flow vs Variable Flow
- Key Setpoints:
  - Airflow
  - Static pressure
  - Supply Air Temperature
  - RH% (Dew Point Temp)
- Other Setpoints:
  - CO2 concentration
  - Schedules
Variable Air Volume – Keep It Super Simple

Minimum Damper closes

Maximum Damper opens
Example – Complicated controls?
Example – ERV & Heat Pump Interlocks (Bldg X & Mfr X)

• Who is responsible for setting these up?
**ERV Controls – Heat Pump Interlocks (Bldg Y & Mfr Y)**

- DIP Switches in OFF position (from Factory) – 6+ months after startup

<table>
<thead>
<tr>
<th>SW Name</th>
<th>No</th>
<th>Item</th>
<th>Setting</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>SW1</td>
<td>1</td>
<td>ODU Type</td>
<td>ON</td>
<td>Single Comm. Using Single Split outdoor unit</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>OFF</td>
<td>Comm. Using outdoor unit</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Control Type</td>
<td>ON</td>
<td>Communication Controlled by DDC Modbus or remote controllers &amp; central controllers</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>OFF</td>
<td>Contact signal            Controlled by DDC through Contact signal Central controller can only monitor status)</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>DO Type</td>
<td>ON</td>
<td>Fan Speed DO1 : High, DO2 : Middle, DO3 : Low (DO changes according to fan speed setting value)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>OFF</td>
<td>Status DO1 : ON/OFF, DO2 : Defrost, DO3 : Alarm</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>Fan Speed (available when SW1-3 ‘ON’)</td>
<td>ON</td>
<td>Fixed The fan will always be running as set fan speed except defrost. (During defrost, the fan speed will change as low fan speed.)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>OFF</td>
<td>Change The fan speed will be changed according to TH on/off For more detail please check ‘Digital Output – Fan Speed’</td>
</tr>
</tbody>
</table>
ERV Controls – Heat Pump Interlocks (Bldg Y & Mfr Y)
What’s the effect of all this?
What about in the apartments?
How could we avoid these issues?

- Clear & **realistic** sequences of operation
  - Early Design Reviews.
- Don’t reinvent the wheel
  - ERV & VRF **separate**
- **Clearly defined roles**
  - Installer + Supplier + Manufacturer + CxA
- Clear expectations
  - The job is done when…
    - 3 or more days for **tuning (over multiple seasons)** with building staff
  - Warranty periods
Operations & Maintenance
O&M and Ongoing Cx

- Proper training
  - Training requirements come from the spec
- Ongoing Cx
  - Test plans templates
Conclusion
Key takeaways

• Developers/Property Managers – Commissioning is an ongoing process and it takes more than 1 day of functional testing

• Designers – Include clear sequences and performance requirements for installers to complete the job.

• Construction Managers / Contractors – interlocked ERVs with Heat Pumps need a lot of tuning. Diligence and Patience are key

• Manufacturers and Reps – Continue developing and improving documentation for your systems.

• Push for clear and realistic sequences of operation

• If interlocking multiple manufacturers, it’s Not ONE and DONE

• Consider operations and operators during the design phase
Bridging the Gap

Design - Construction - Operation
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Questions?

Luis Aragon: laragon@swinter.com

Michael Schmidt: mschmidt@swinter.com