



Tales From The Trenches
Passive House Ventilation Construction
Issues And How To Curb Them



Learning Objectives



- Discuss common Passive House ventilation system designs, layouts, and components pertaining to the performance and field installations.
- Demonstrate through examples common problem areas related to the implementation of high-performance ventilation systems.
- Identify ways to curb potential project shortfalls and recommendations based on lessons learned.
- Understand the Passive House certification criteria and the actual performance necessary for ventilation systems to be within compliance.

High Performance Ventilation Systems

Critical Design Aspects & Goals

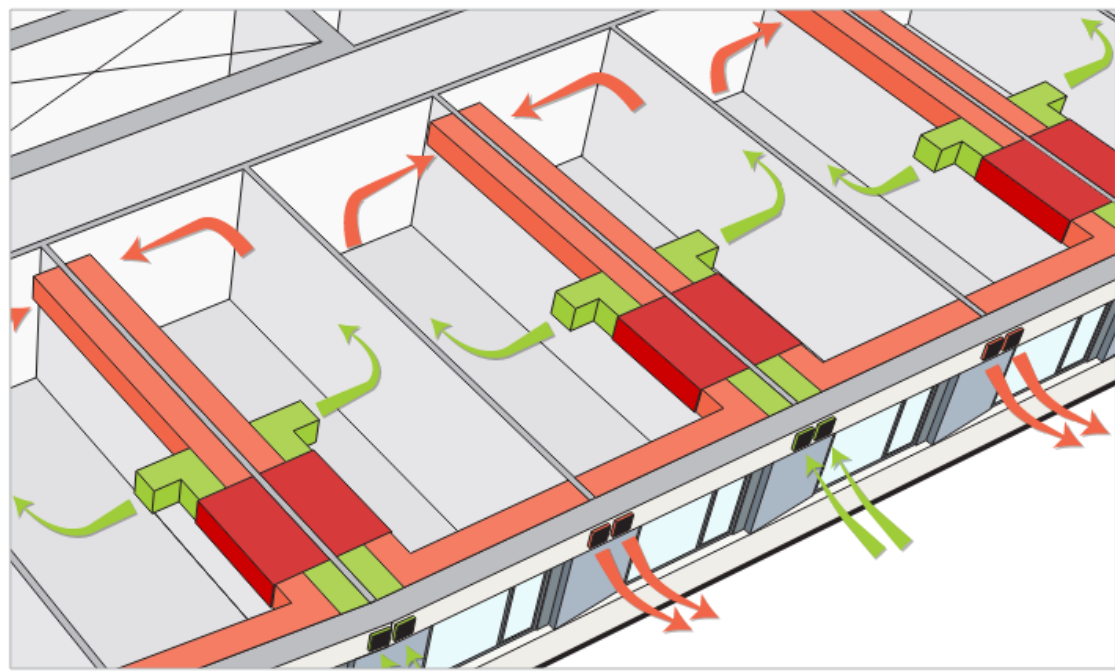
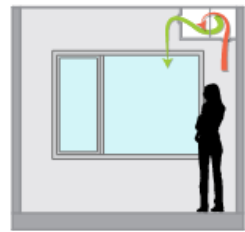
- Balanced ventilation ERV/HRV
- Indoor Air Quality (IAQ)
 - Occupant comfort
- System leakage
- Flow control and balancing
- Performance
 - Energy consumption
 - Delivery of air flow

Ventilation: Unitized vs. Central vs. Semi-Central

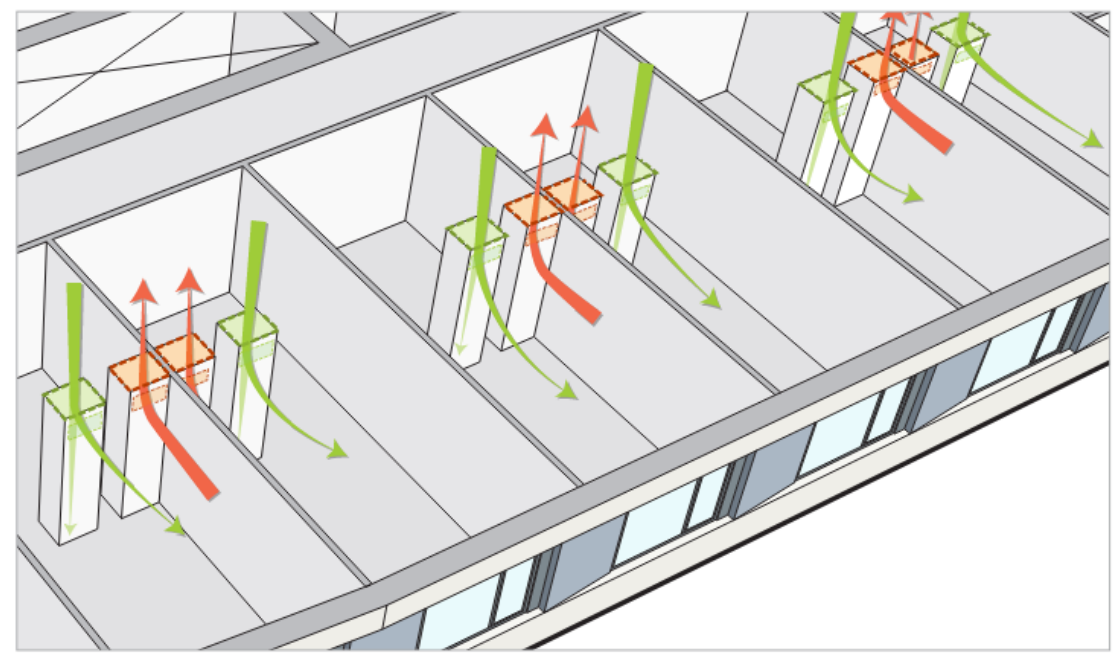
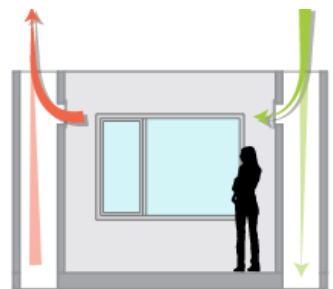


- Exhaust Air
- Fresh Air
- ERV

Unitized

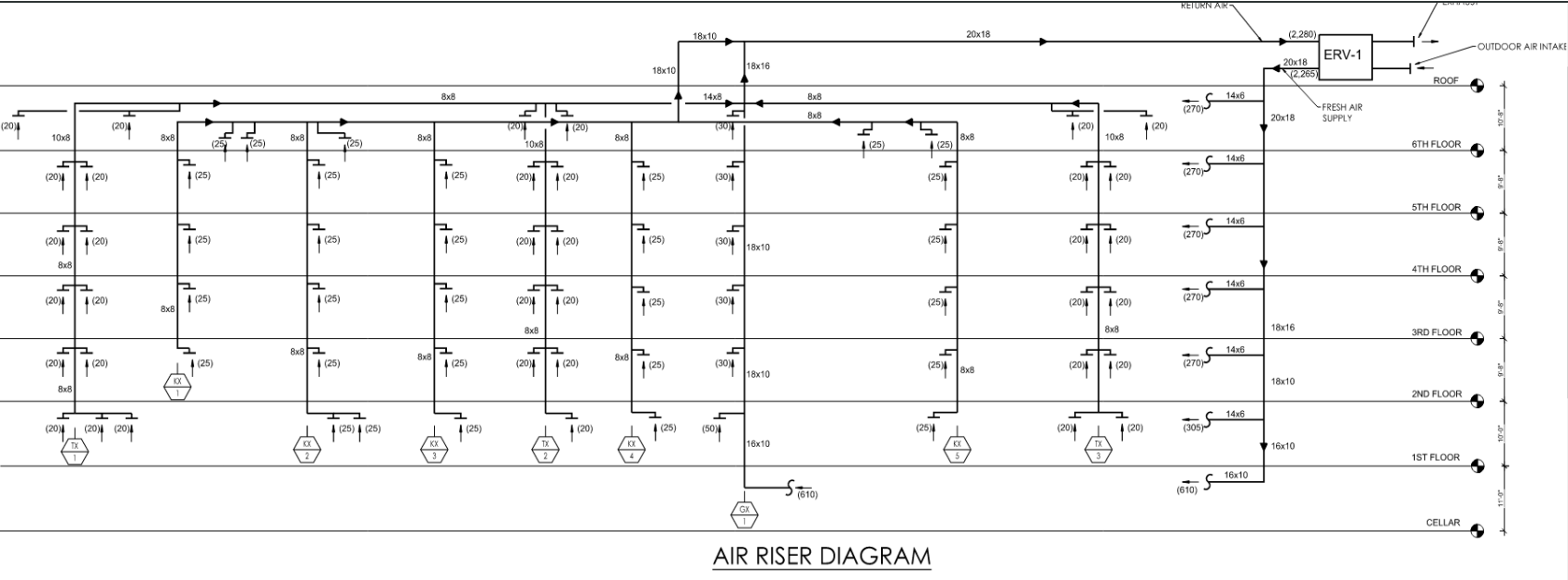


Central

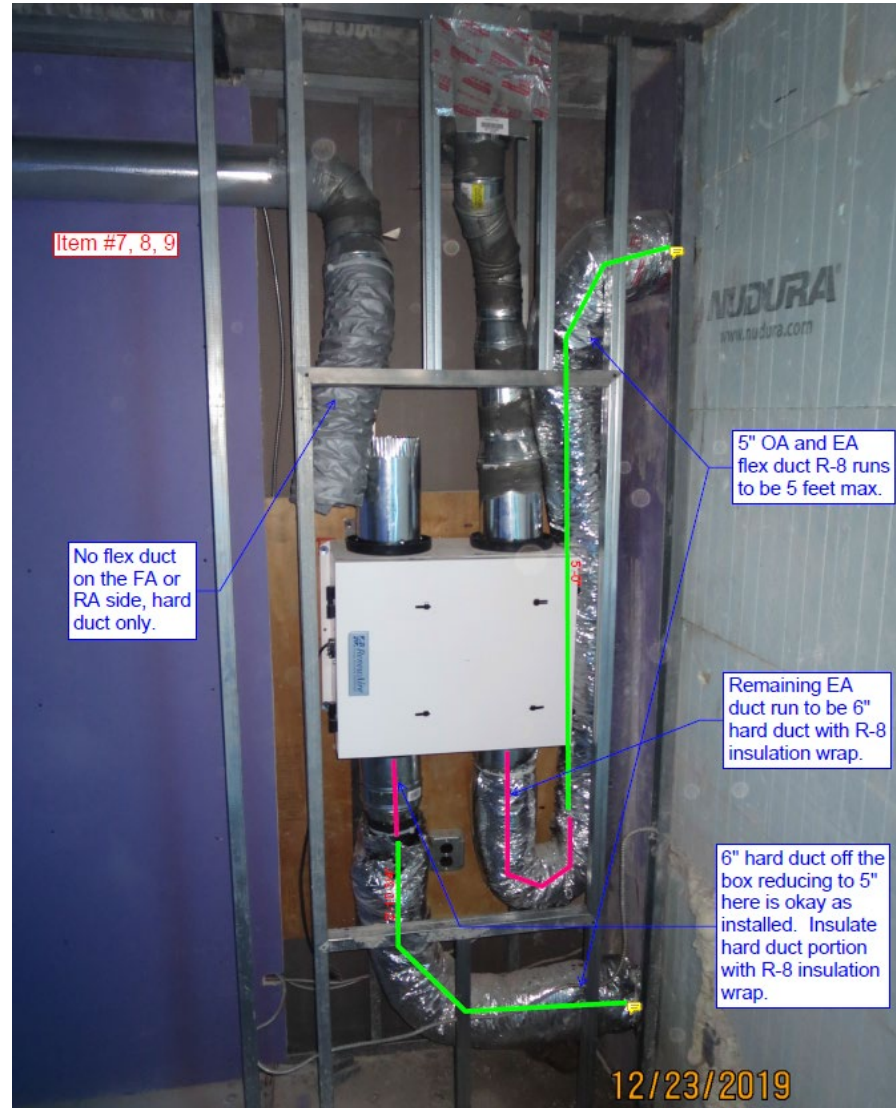
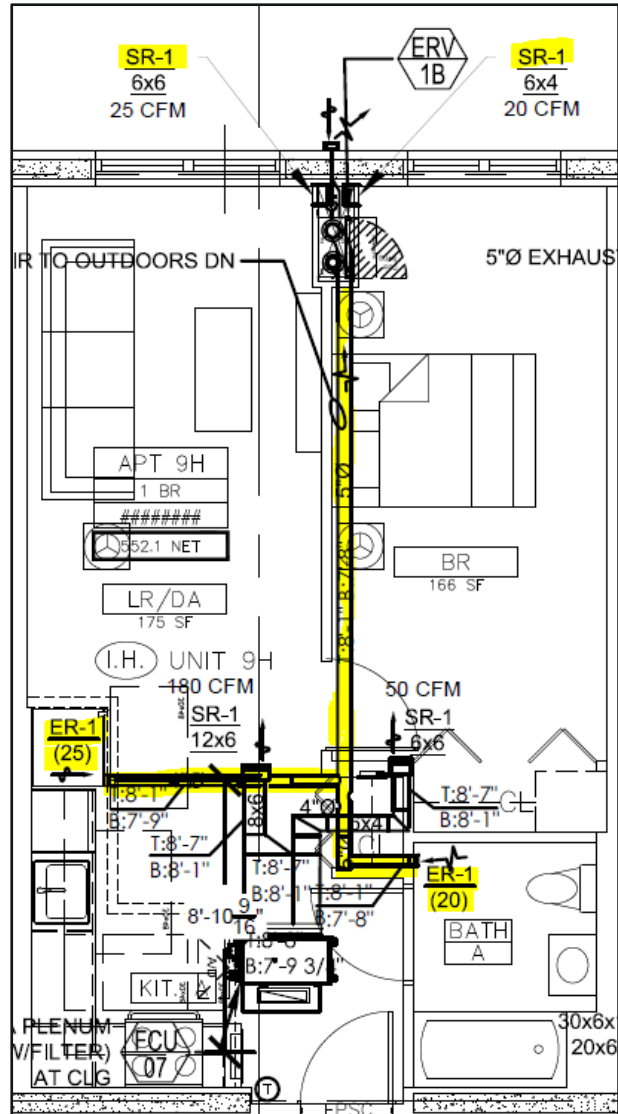


Credit: Handel Architects

Ventilation – Central



Ventilation – Unitized



General Recommendations and Requirements



Energy Efficiency:

- ERV/HRV fan motors recommended to consume ≤ 0.765 W/cfm at the highest power setting
 - Wattage of ERVs verified at final

Balance:

- Typical 24/7 operation total supply and exhaust flows are +/- 15% or 15 CFM of design values and within 10% of each other (at the ERV).
 - Minimum flow rates must be met in apartments (tolerance is -0 CFM/+10% CFM), especially on the exhaust side.
- TAB Requirements
 - Third party (certified air balancing professional e.g. NEBB, AABC)
 - Recommend pre-meeting with TAB contractor to discuss expectations



Duct and System Leakage

What Could Go Wrong?

Defining Leakage



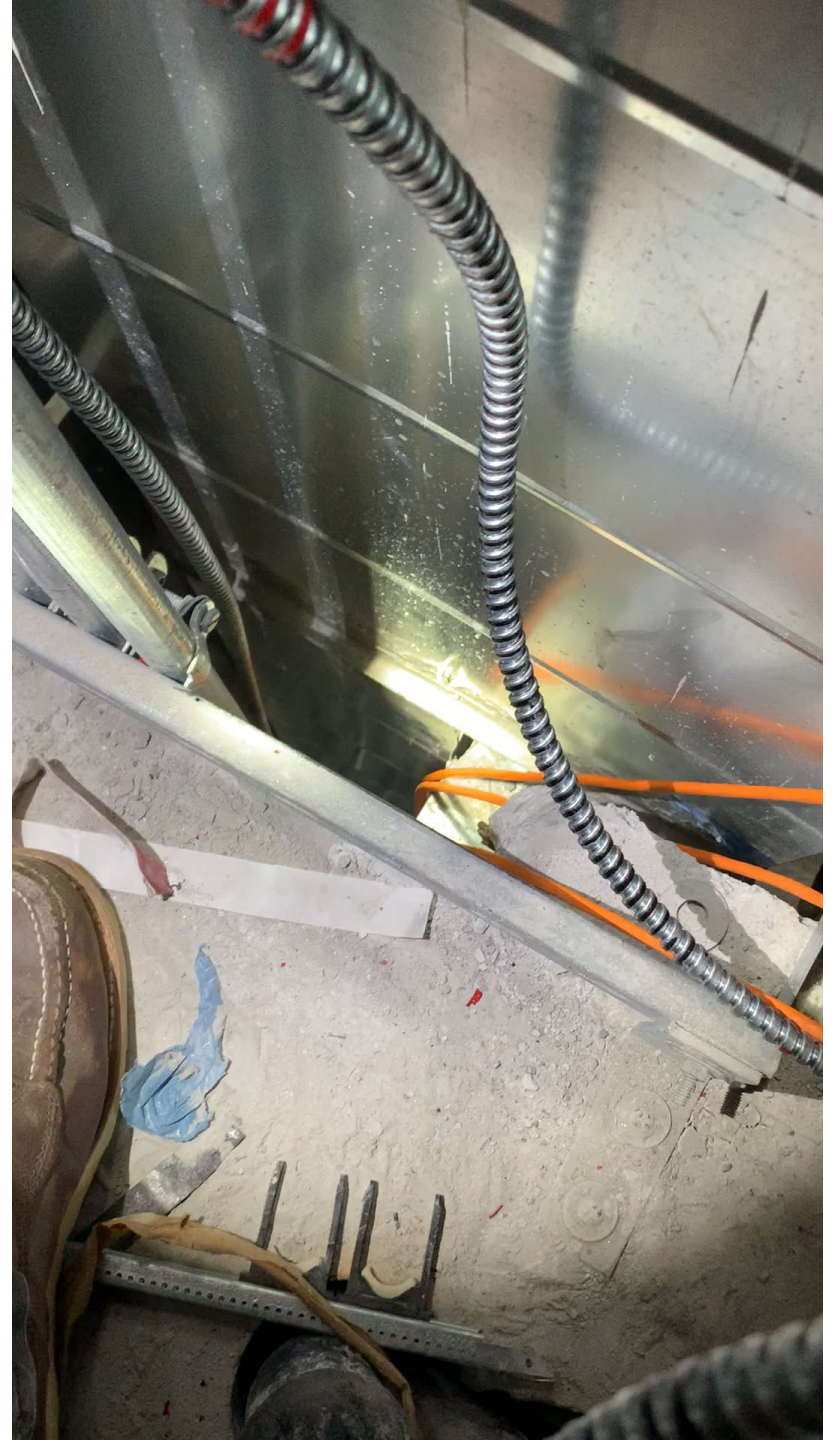
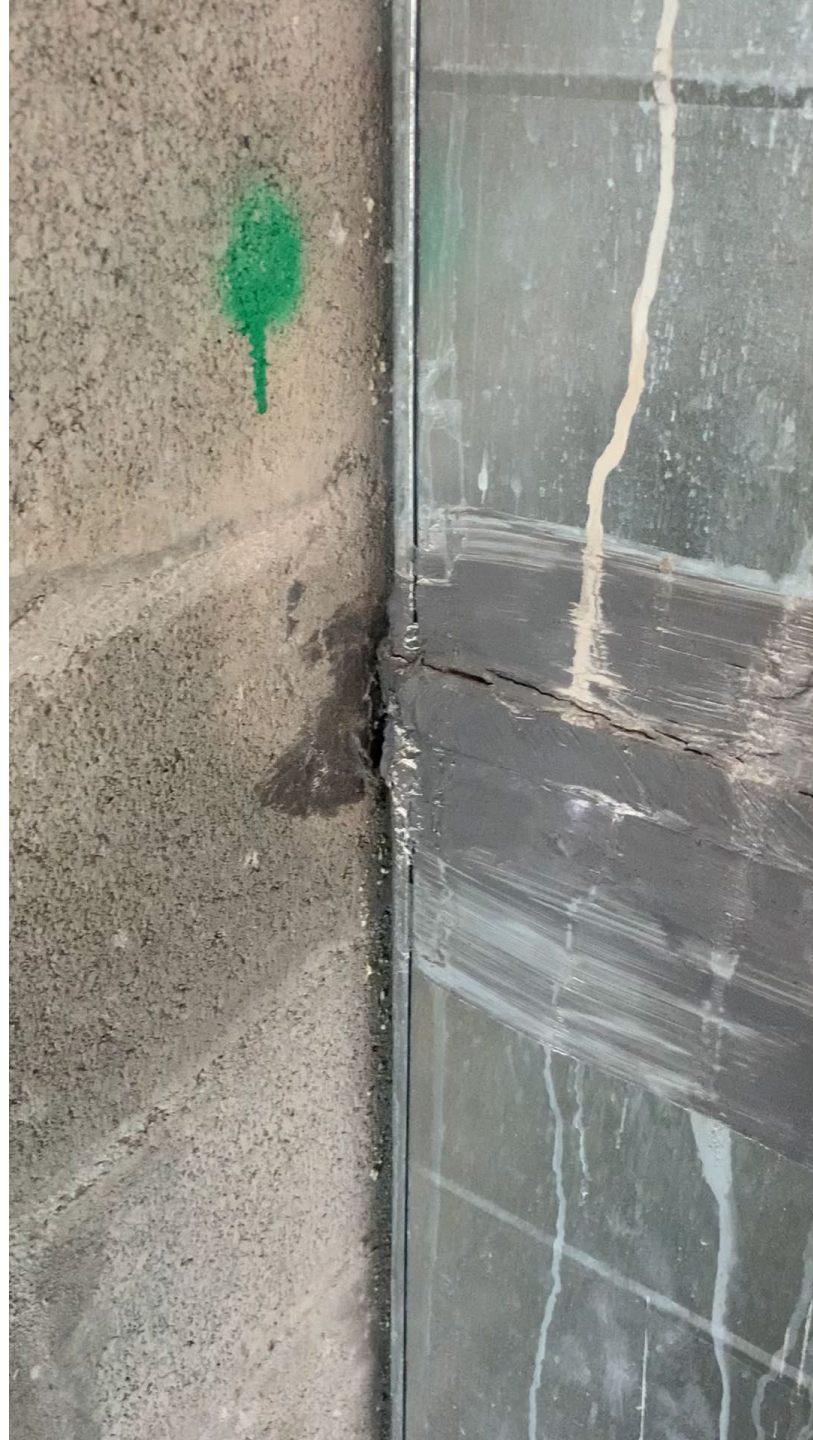
- Duct leakage is the leakage of air from ***Ductwork***
- Equipment leakage is the leakage of air from ***Equipment***
- Accessory leakage is the leakage of air from ***Accessories***
- Ventilation air system leakage is the **combination** of duct, equipment, and accessory leakage.



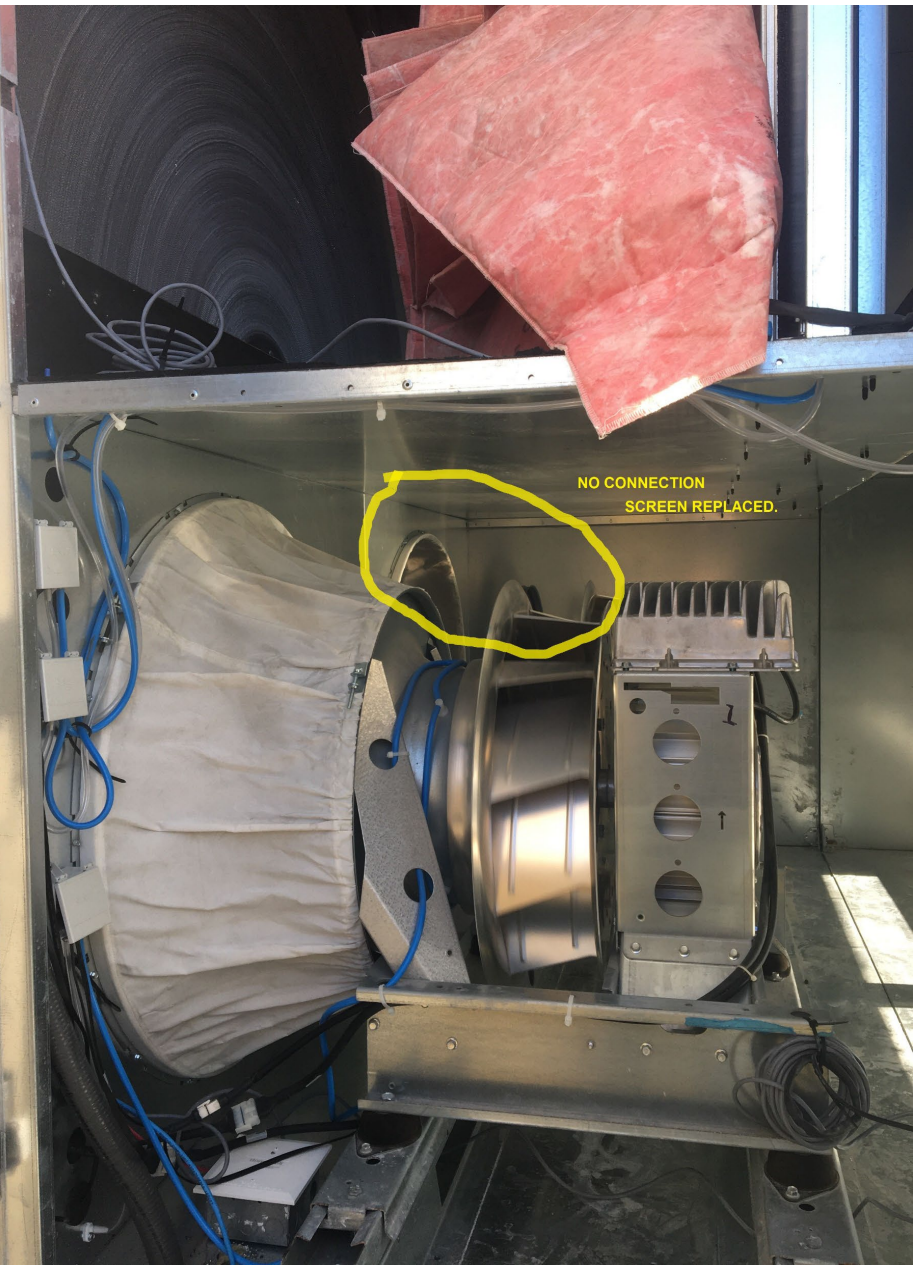
Duct Leakage \neq System Leakage

A note on PH certified ERV/HRV equipment leakage – Maximum leakage through the casing and cross stream leakage is limited to no more than 3%

Duct Leakage Examples



System Leakage Example Photos



Constant Air Flow Regulator (CAR) Damper Considerations



- Placement in duct and physical accessibility
- Installation into duct work
- Orientation of the damper
- Remove before Aeroseal



Duct Sealing with Aeroseal



- “Duct sealing from the inside.”
- Pressurized aerosolized particles forced through the duct systems and build up at leak locations.
- Can seal leaks up to ½” size.

Before



After



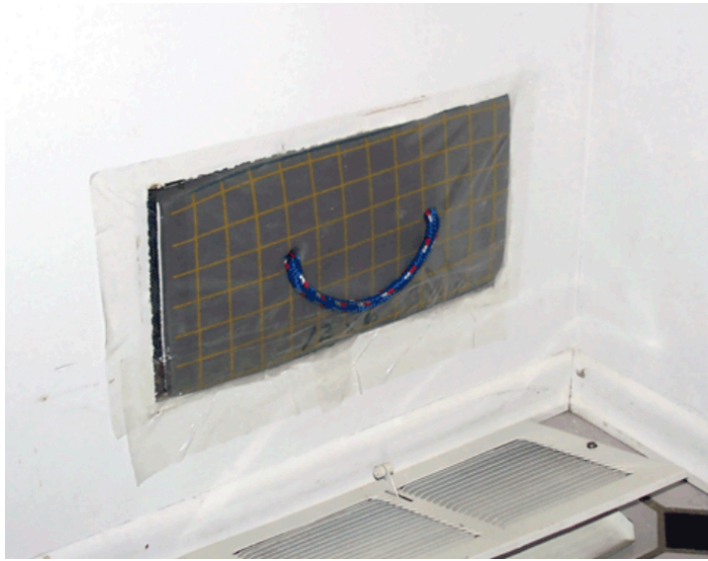
<https://www.alaskanac.com/air-duct-sealing/>



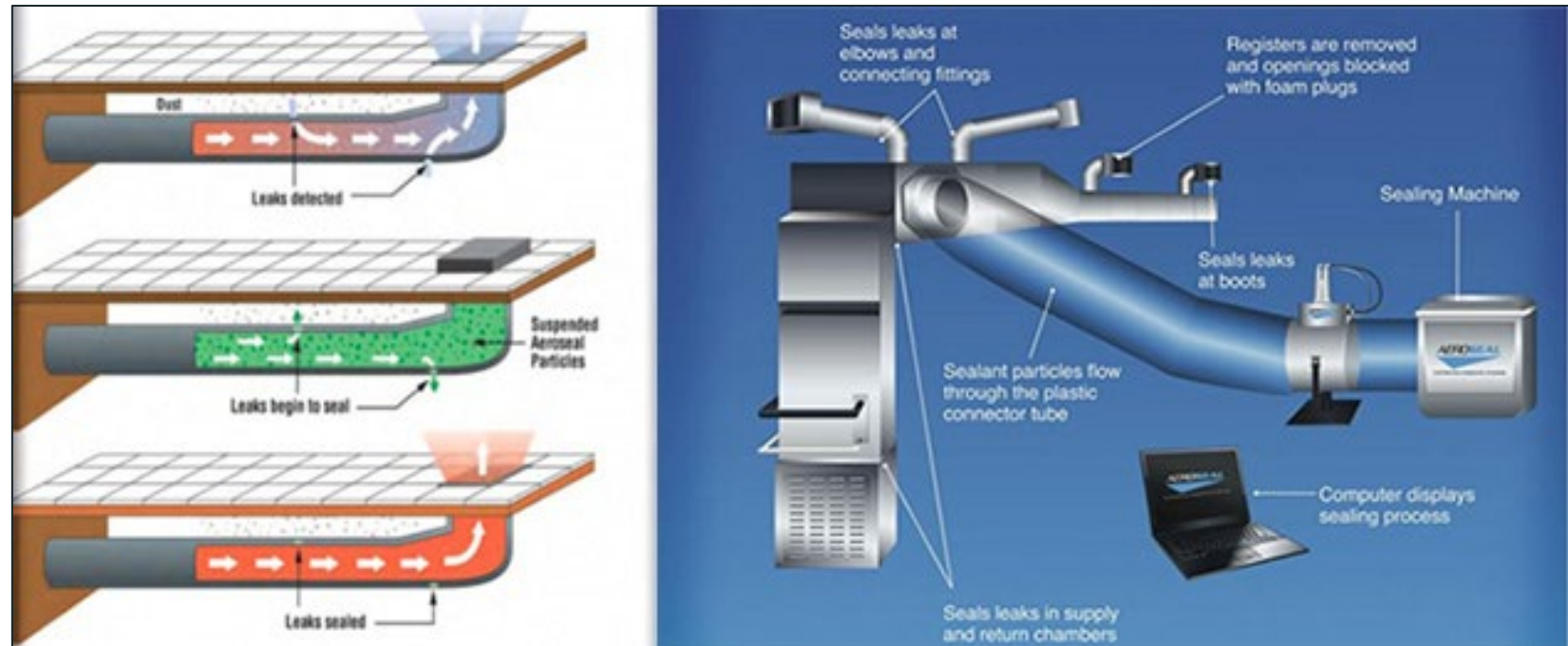
Duct Sealing with Aeroseal



- Ducts must be capped off with foam blocks
- Tape will not hold high pressure and will blow off



<https://www.insulwise.com/aeroseal/overview/>



What should you consider with using Aeroseal?



- Ensure ALL ductwork is installed
- Pre-seal test, post-seal test and leakage reduction
- Report at the standard operating pressure of the system
- Aeroseal specifications have two methods of identifying leakage targets
 - Fractional Leakage Method – Calculated 3% of total system flow for ventilation systems
 - SMACNA Leakage Method – Calculated ($\text{Leakage Max} = C_L * P^{0.65} * SA$)

Fractional Leakage Method \neq SMACNA Leakage Method

Aeroseal – Leakage Target Comparison




Project example, 5 ERV systems.

Recommended 3%
Fractional Leakage Method

| | ERV-NR-2 | | ERV-NR1 | | ERV-C1 | | ERV-R1 Supply | ERV-R2 Supply | ERV-R1 Exhaust | ERV-R2 Exhaust |
|--|----------|----------|---------|--------|--------|--------|------------------|------------------|-------------------|-------------------|
| Total (ft²) | 977.70 | 1,052.22 | 889.78 | 529.46 | 500.34 | 876.02 | 2,766.18 | 1,695.91 | 2,975.27 | 2,115.73 |
| CFM Design Flow: | 795 | 795 | 450 | 450 | 465 | 465 | 2,240 | 1,470 | 2,240 | 1,470 |
| Fractional Leakage Method in CFM | 24 | 24 | 14 | 14 | 14 | 14 | 67 | 44 | 67 | 44 |
| SMACNA Allowable Leakage Max = CL*P^{0.65}*SA | 159.7 | 171.9 | 145.4 | 86.5 | 81.7 | 143.1 | 452.0 | 277.1 | 486.1 | 345.7 |
| % Leakage of design flow using SMACNA Method | 20.1 | 21.6 | 32.3 | 19.2 | 17.6 | 30.8 | 20.2 | 18.8 | 21.7 | 23.5 |
| % Difference Fractional V.S. SMACNA | 148% | 151% | 166% | 146% | 142% | 164% | 148% | 145% | 151% | 155% |

Aeroseal Reports – What Do These Graphs Tell Us?





DUCT SEALING REPORT

Duct Sealing Performed For:

| | |
|---------------------------|---|
| DATE: 7/29/2021 | AEROSEAL CASE ID: [REDACTED] SYSTEM DESCRIPTION: TX-3 SEAL DESCRIPTION: Seal 1 HARDWARE: Gen2 TECHNICIAN: HB |
|---------------------------|---|

Overall Sealing Results:

BEFORE SERVICE

275.7 CFM of Leakage, equivalent to a 12.0 Square Inch Hole or 69% of the system capacity of 400.0 CFM

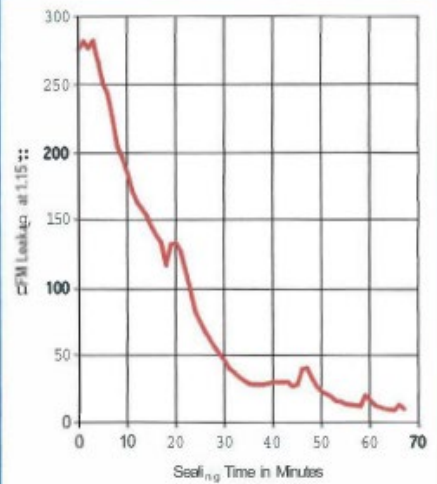
AFTER SERVICE

10.5 CFM of Leakage, equivalent to a 0.5 Square Inch Hole or 2.6% of system capacity

This corresponds to a **96% Reduction in Duct Leakage**

NOTE: Duct leakage results are calculated in Cubic Feet per Minute (CFM) measured at a STANDARD OPERATING PRESSURE of 1.15 wg.

Aeroseal Sealing Progress:



Duct Sealing Performed By:

| | |
|---|------------|
| 0 | [REDACTED] |
|---|------------|

Aeroseal process uses DuctSeal sealant that is certified to meet requirements listed in UL 1381 standard: "Outline of Investigation for Aerosol Duct Sealant"


Certificate of Completion

Duct Sealing Performed For:
 [REDACTED]

Aeroseal Technician: [REDACTED]
Aeroseal C: [REDACTED]

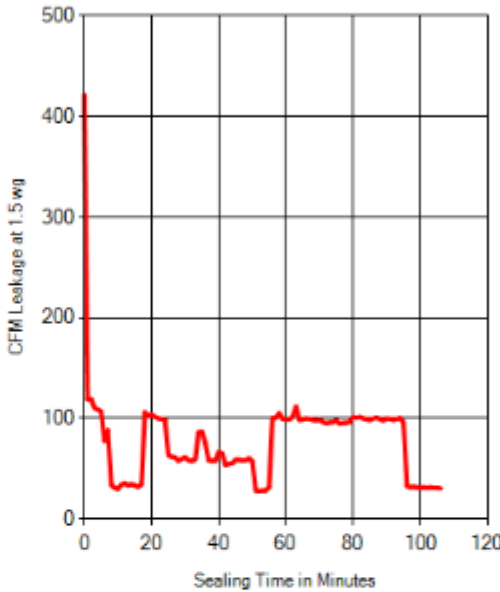
Sealing Results

| | |
|------------------------|--------------------|
| SMACNA Level | 8 |
| Initial CFM | 421.4 |
| Final CFM | 30.7 |
| Target CFM | 220.3 |
| Operating Pressure | 1.5 wg |
| Surface Area | 2115.73 ft² |
| Duct Leakage Reduction | 92.7% |



Duct Sealing From The Inside

Aeroseal Sealing Profile



| | |
|--------------------|--------------------|
| Model | |
| Duct Type | Exhaust |
| System Description | ERV Exhaust |
| Seal Description | ERV Exhaust |
| Hardware | Gen2 |

Duct Sealing Performed By:
 [REDACTED]



Testing and Balancing

Testing and Balancing



- Engage a certified third party balancing professional (NEBB, AABC)
 - Have a **pre-meeting** with the balancer to discuss procedures and expectations
 - Identify flow measuring devices acceptable for the project
- Unitized ERV's – access strategy must be developed in ERV closet to access the ducts to test for air flows at the unit
 - Some units have built in pressure taps
- Central ERV's
 - Built in display
- CAR damper access strategy must be developed
 - CAR dampers typically **need fine tuned adjustments** by the TAB contractor and factory pre-sets have been **insufficient in meeting PHIUS tolerances**

Testing and Balancing – Comparing Flow Hoods



Key Findings of LBNL Report - 47382

“Extensive laboratory tests and several field tests have shown that commercially available standard flow hoods do not meet the accuracy criteria for many of the diagnostics that flow hoods are often used for. 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.*”



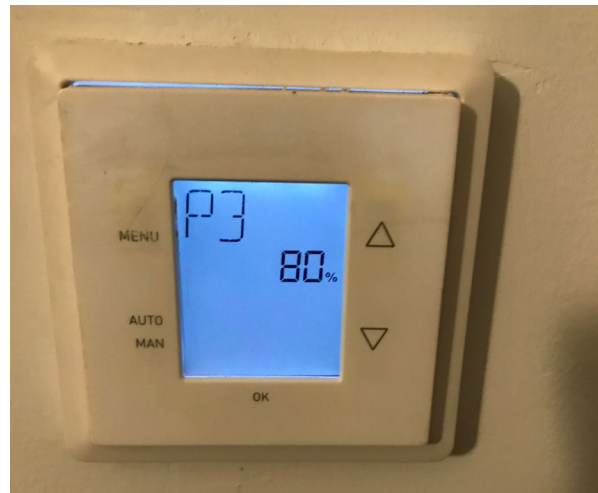
“The laboratory results for the reference active flow hood show an RMS error of only 2%.”

Testing and Balancing



Manufacturer: [REDACTED]
 Model: [REDACTED]
 Location: Apt 6C Closet

| Drawing | Area Served | Supply/ Return | Grille | | CFM | |
|---------|-------------|-------------------|--------|------|--------|--------|
| | | | Type | Size | Design | Actual |
| 27 | Apt 6C | ERV Supply | SWR | 6x4 | 15 | 15 |
| 28 | Apt 6C | ERV Supply | SWR | 6x4 | 15 | 15 |
| 30 | Apt 6C | ERV Supply | SWR | 6x4 | 15 | 15 |
| 32 | Apt 6C | IKX | SWG | 6x6 | 25 | 25 |
| 33 | Apt 6C | TX | CG | 6x6 | 20 | 20 |



Recommendations for Project Success - Design



- **Size the ERV** such that the standard operating flow rate is approximately 50% of the maximum flow of the unit to optimize efficiency.
 - Allows for additional fan capacity to overcome system leakage.
- Account for **buffer in the energy model** for system leakage (~10%)
 - Not accounting for leakage could cause failure to meet space conditioning and/or source energy thresholds
- Understand the **energy penalty of additional system leakage** on the energy model
 - As CFM flow increases, fan energy in W/cfm increases
- Combining ventilation ductwork and heating/cooling system ductwork is very difficult/impossible to construct, verify and TAB

Recommendations for Project Success - Construction



- Specify and require **ductwork shop drawings** and As-Built drawings for review
- Mechanical **engineer** should be **engaged during construction** and conducting inspections
- Early engagement of TAB contractor and Aeroseal installer
- **Contractor trainings** to ensure all parties are aware of the project's goals
- Borescope ductwork prior to Aeroseal installation to find any major disconnects
- Third party **duct leakage testing post Aeroseal** to verify project goals have been achieved

Bridging the Gap



Design



Construction

Questions?





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