Ventilation Strategies

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Overview

- Strategy overview – pros and cons
  - Exhaust
  - Supply
  - Balanced
- When/how to use non-exhaust
- Controls
- Low-cost options

A Brief History of Ventilation Standards

- 15 cfm/person originated from smell tests in the 1930s (Yaglou et al. 1936) and more or less again in 1983 (Cain et al.; Fanger et al.)
  - How much air did we need to not be offended by each other's body odor?
  - Used bioeffluents (and 1930s hygiene) as a surrogate for IAQ
  - Suggested might actually want 20 cfm/person
    - Or 25 cfm for schools
    - Or even 50% more for schools if the children hadn't bathed or changed their underwear in a week

appear rapidly as the space is vacated. This is in great contrast to tobacco odor, butyric and valeric acid and ozone which disappear at a much slower rate.

MINIMUM OUTDOOR AIR REQUIREMENTS FOR VENTILATION[13]

Based Upon Odor Impressions†

Type of Occupants	Air Space Per Person, Cu Ft	Requirements Cfm Per Person
Heating season with or without recirculation. Air not conditioned.		
Sedentary adults of Average Socio-economic Status	100 200 300 500	25 16 12 7
Laborers	200	23
Grade school children of poor class	200	38
Grade school children of better class	200	18
Grade school children of best class	100	22
Heating season. Air humidified by means of centrifugal humidifier. Total air circulation 30 cfm per person.		
Sedentary Adults	200	12
Summer season. Air cooled and dehumidified by means of a spray dehumidifier. Total air circulation 30 cfm per person.		
Sedentary Adults	200	4*

†Impressions upon entering room from relatively clean air at threshold odor intensity.

*Values provisionally restricted to the conditions of the tests.

Odor Control

If odors are present in air to an objectionable degree, they may be masked by more agreeable odors, diluted until they are no longer a nuisance or removed entirely.

When complete odor removal is not practicable, odors may sometimes be masked or blanketed by the introduction of other odors which are not unpleasant and contribute to a sensation of cleanliness

Survey Question

- How many existing homes undergoing retrofit must get some sort of exhaust ventilation?

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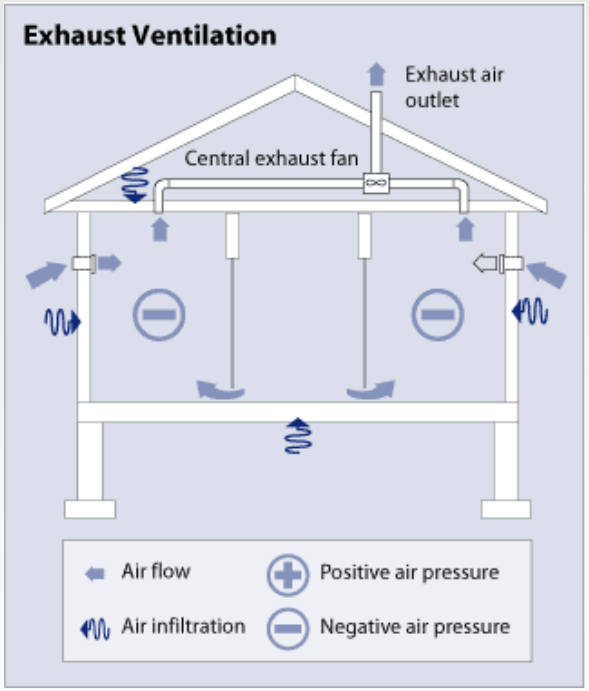
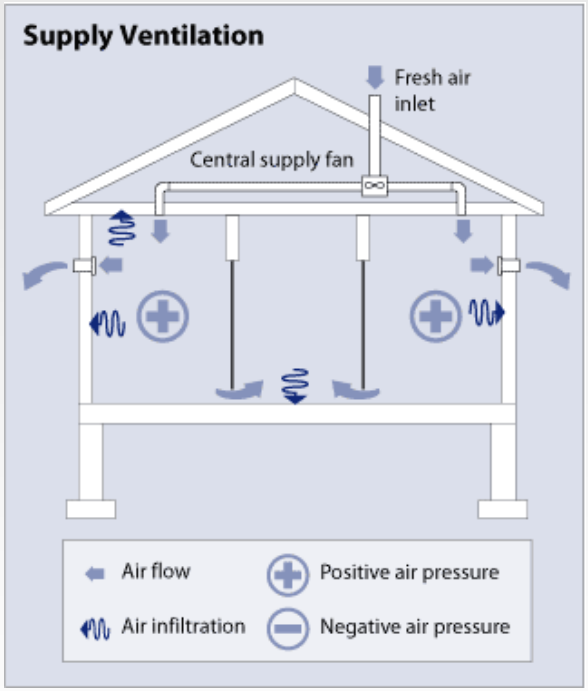
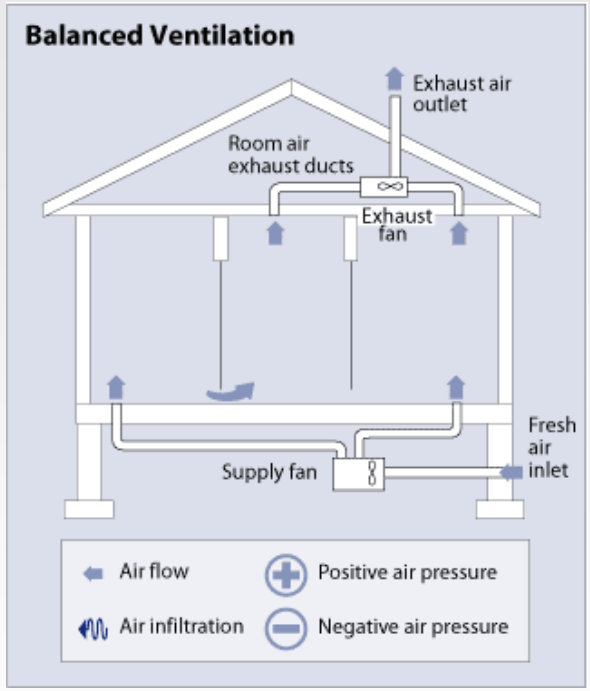
General Ventilation Approaches



Exhaust Only



Supply Only



Balanced
Exhaust and Supply

Exhaust-only

PROS

- Removes contaminants at source
- Simple
- Inexpensive to operate
- No need to condition ventilation air

CONS

- Doesn't guarantee delivery of "fresh" air to each space
- Makeup air source unknown
- Requires maintenance
- Depressurization – combustion appliances

Supply-only

PROS

- Guarantees delivery of "fresh" air to each space
- Known source of air
- No depressurization risk – can actually help combustion appliances
- Less risk of issues in hot/humid climates

CONS

- No direct removal of contaminants
- Requires maintenance
- Fan operation cost higher
- Need to condition ventilation air
- If integrated with H/AC, need good controls and tight ducts

Balanced (HRV/ERV)

PROS

- Guarantees delivery of "fresh" air to each space
- Removes contaminants at source
- Known source of air
- No depressurization risk*
- Recovers heat (HRV & ERV) and possibly moisture (ERV)

CONS

- Requires maintenance
- Fan operation cost moderate
- If integrated with H/AC, need good controls and tight ducts
- First cost is high

	Source ctrl.	Fresh air deliv.	Make up air	Oper. cost	First cost	Need to cond. air	Neg. press	Maint.	Cntrls /ducts
EOV									
SOV									#
HRV/ ERV							*		#

importance of ducts assumes connection to H/AC

Considerations

- 62.2 does NOT require exhaust; there may be times when you want something else
  - Combustion safety concern
    - Though it is rarely the 62.2 fan that is the big issue
  - Bad outdoor air

- When exhaust seems like a bad idea, consider supply or balanced

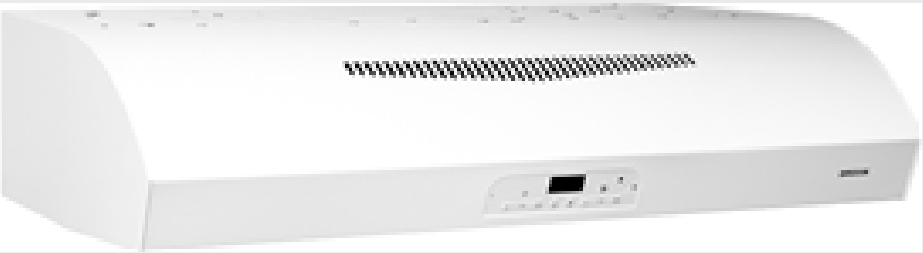
Is exhaust or supply better

- Depends on your philosophy
- Get bad stuff out ASAP? Exhaust
- Get outdoor air to everyone? Supply
- Bad outdoor air? Supply or balanced, with filtration
- Balanced can do both if designed to do so

Let's say you choose exhaust

- Consider choosing a fan that also serves as local exhaust
  - Bathrooms – need to have return air pathway
  - Kitchens
- Provides best outcomes for residents
  - Rooms where more contaminants are generated
- Gets rid of deficits

System Choices Exhaust Only
Kitchen Range Exhaust Hoods



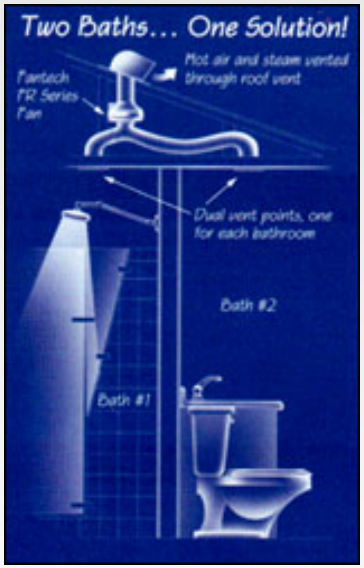
Air King ECV
Continuous: 30, 50, 70, 90 CFM @ 0.3 sones
High speed: 250 CFM @ 3.5 sones
Fan power: 75 Watts, max.
Light: 26 Watts
Ducting: Horizontal or vertical

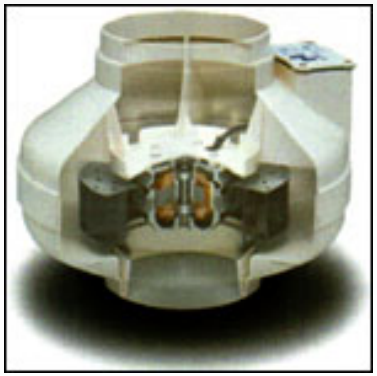
Broan QP330WW
Continuous: 100 CFM @ 0.3 sones
High speed: 450 CFM @ 5 sones
Fan power: 40 Watts, max.
Light: up to 200 Watts
Ducting: Horizontal or vertical

Panasonic WhisperWall

70 CFM
8 inch duct
10 1/8 grille size
1.1 sones
3.9 CFM/Watt at 0.1” static
18 Watts at 0.03” static
Model: FV-08WQ1

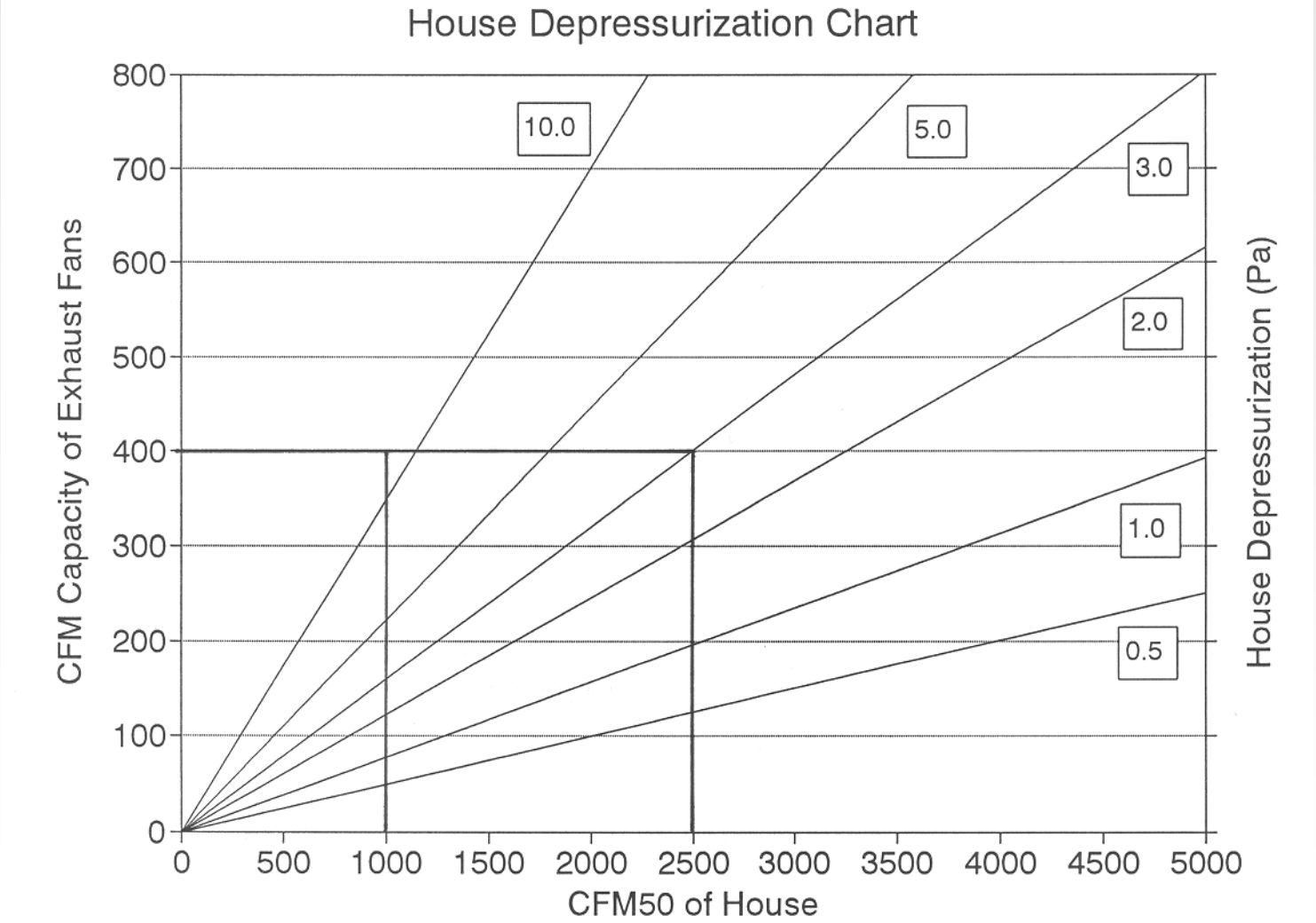
In-line fans


Two Baths... One Solution!
Moist air and steam vented through roof vent
Fantech FR Series Fan
Dual vent points, one for each bathroom
Bath #2
Bath #1

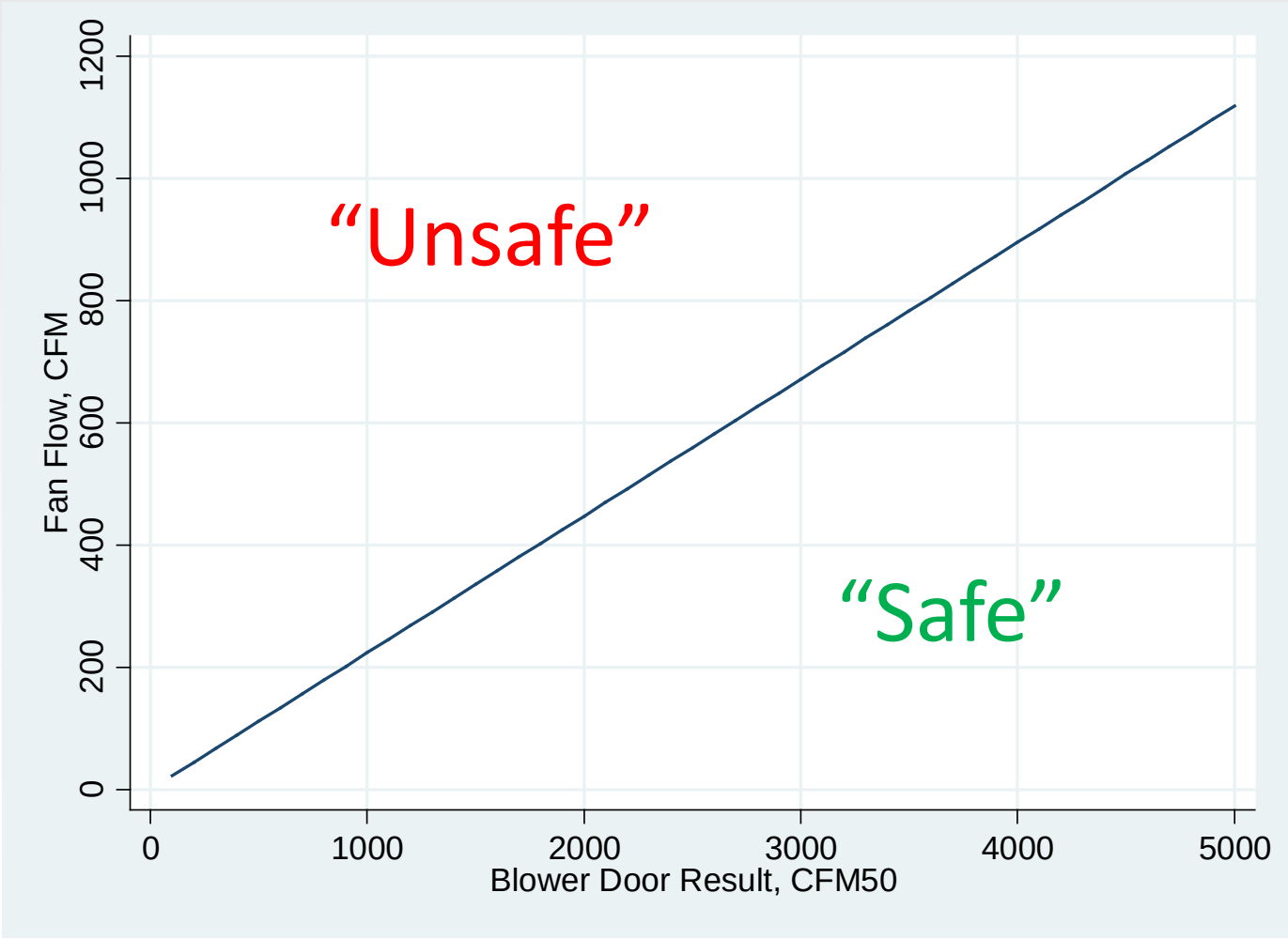


When Exhaust = Bad Idea

Combustion Safety



Allowable net exhaust flows, -5 Pa Limit



Source of air?

- For exhaust, can be from anywhere
  - Air sealing helps isolate "bad" spaces
  - May not always be possible
- For supply, outdoors is not always "clean"
  - …though 62.2 assumes it is

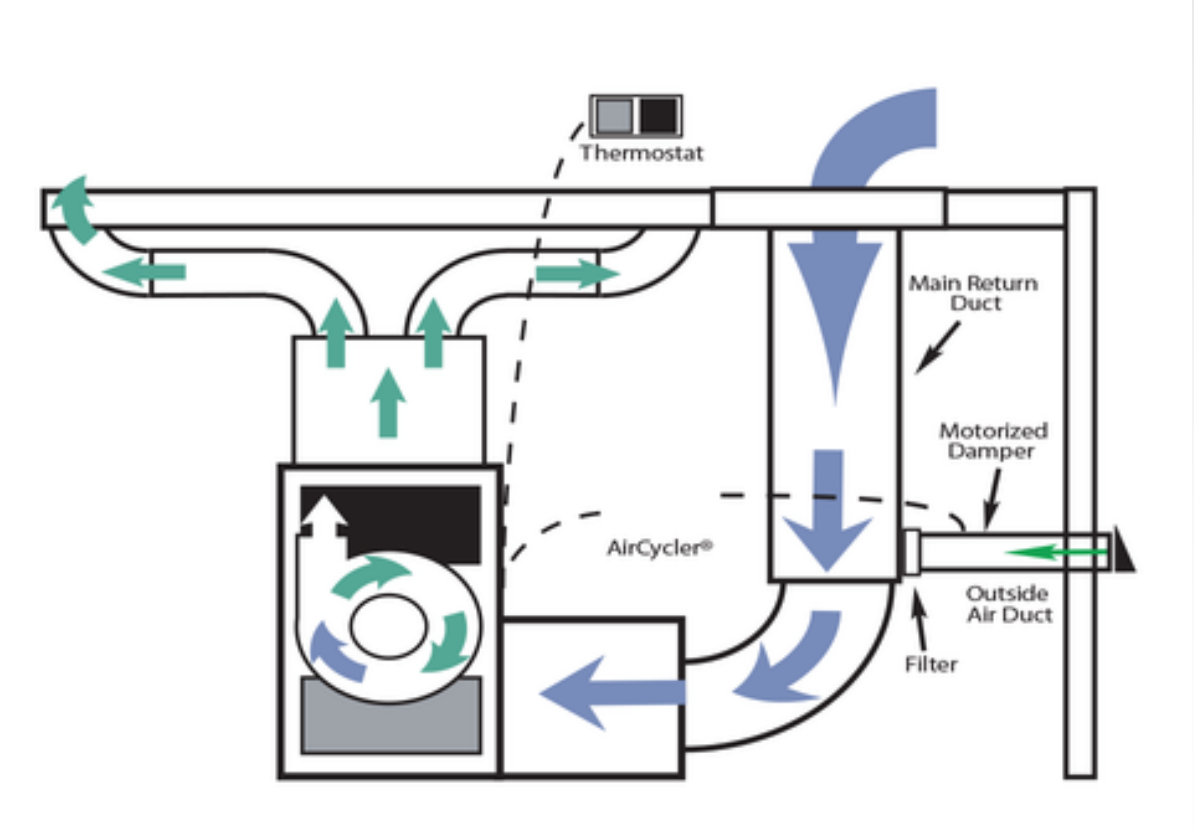
Bad Outdoor Air

Exhaust and bad outdoor air

- Insulated homes act as a filter, BUT…
  - they don’t filter many of the small particles that are worst for health
  - not all leaks are through the insulation

Supply Ventilation

Supply Ventilation to Furnace Return Air



Source: AirCycler, http://www.aircycler.com/pages/aircycler-frv

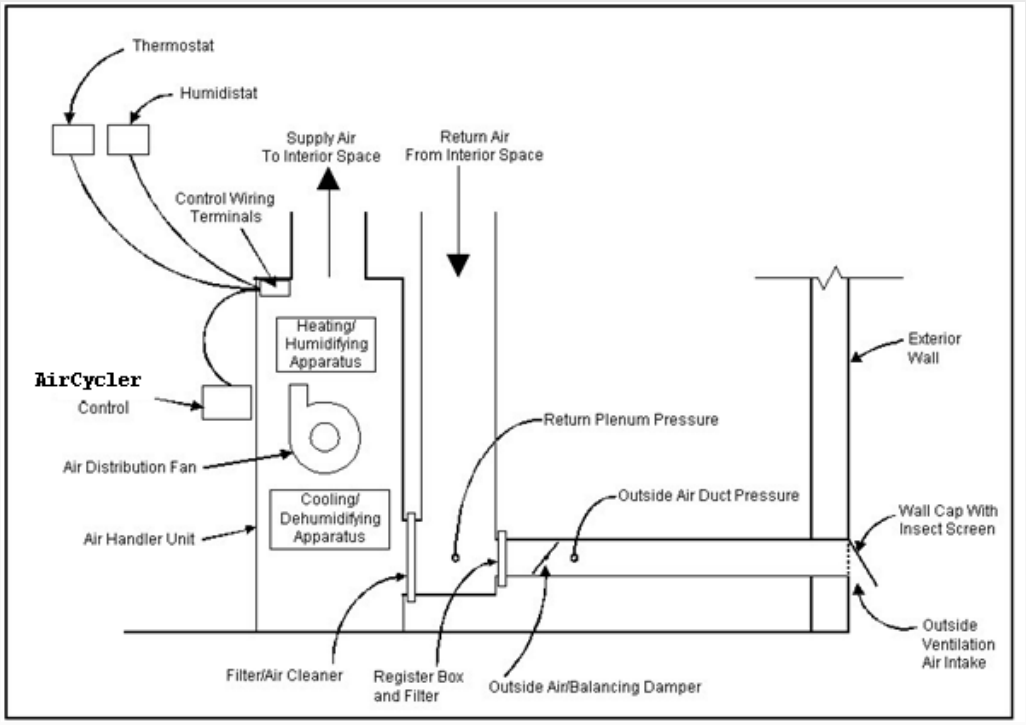
Supply Ventilation to Furnace Return Air

(or equivalent)

AirCycler

Field Controls Damper

Controls for Ventilation Integrated with Furnace System



AirCycler

http://www.aircycler.com/

Supply-Only

©Residential Ventilation Handbook, McGraw-Hill, Raymer 2009

Supply-Only
Dedicated Systems

Supply air systems including duct connections and filters and flow regulators

Particles - Filtration

- Need a filter that will remove respirable particles
- Need to consider pressure drop

- Others have their own ratings, e.g.
  - Home Depot, use minimum FPR of 7
  - 3M, use minimum MPR of 1000

Standard 52.2 Minimum Efficiency Reporting Value (MERV)	Composite Average Particle Size Efficiency, % in Size Range, μm			Average Arrestance, %, by Standard 52.1 Method
	Range 1 0.30 - 1.0	Range 2 1.0 - 3.0	Range 3 3.0 - 10.0	
1	n/a	n/a	$E_3 < 20$	$A_{avg} < 65$
2	n/a	n/a	$E_3 < 20$	$65 \le A_{avg} < 70$
3	n/a	n/a	$E_3 < 20$	$70 \le A_{avg} < 75$
4	n/a	n/a	$E_3 < 20$	$75 \le A_{avg}$
5	n/a	n/a	$20 \le E_3 < 35$	n/a
6	n/a	n/a	$35 \le E_3 < 50$	n/a
7	n/a	n/a	$50 \le E_3 < 70$	n/a
8	n/a	n/a	$70 \le E_3$	n/a
9	n/a	$E_2 < 50$	$85 \le E_3$	n/a
10	n/a	$50 \le E_2 < 65$	$85 \le E_3$	n/a
11	n/a	$65 \le E_2 < 80$	$85 \le E_3$	n/a
12	n/a	$80 \le E_2$	$90 \le E_3$	n/a
13	$E_1 < 75$	$90 \le E_2$	$90 \le E_3$	n/a
14	$75 \le E_1 < 85$	$90 \le E_2$	$90 \le E_3$	n/a
15	$85 \le E_1 < 95$	$90 \le E_2$	$90 \le E_3$	n/a
16	$95 \le E_1$	$95 \le E_2$	$95 \le E_3$	n/a

ASHRAE Standard 52.2-2007

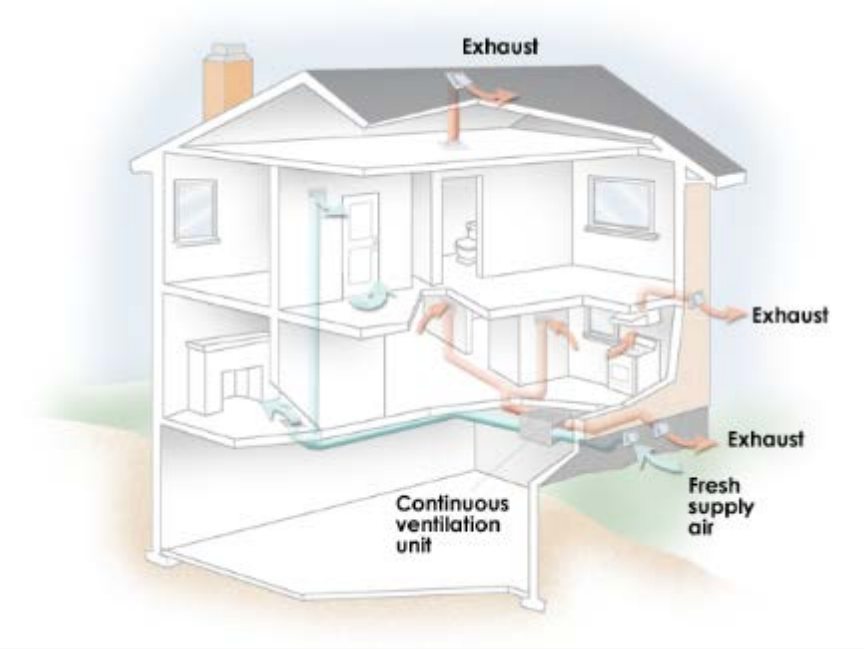
Balanced Ventilation

Balanced Ventilation

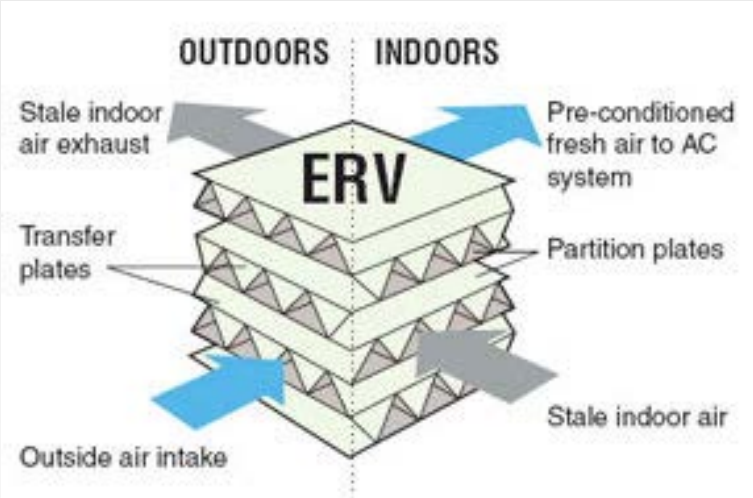
- Exhaust and supply ventilation should have equal cfm
  - Balanced without recovery
    - Interlocked supply and exhaust ventilation
  - Heat Recovery Ventilator (HRV)
    - unit transfers sensible heat only with no humidity transfer
  - Energy Recovery Ventilator (ERV)
    - Unit transfers sensible heat and humidity

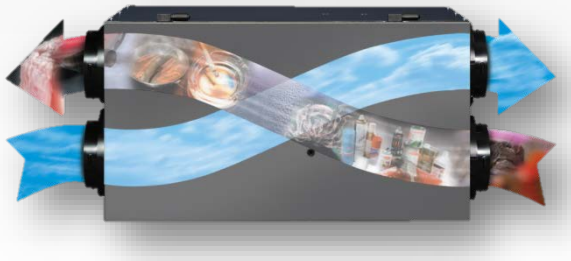
Balanced with Heat or Energy Recovery

Dedicated ducting

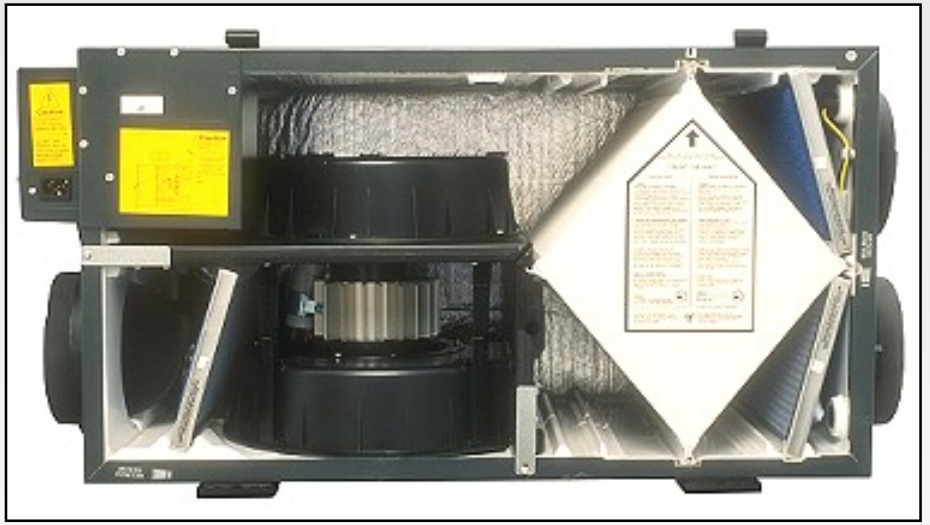


Source: ©Residential Ventilation Handbook, McGraw-Hill, Paul Raymer, 2009





Heat Recovery Ventilators (HRV)



Venmar HRV, inside view

Heat Recovery Ventilators (HRV)

Must be installed in an accessible place for service.
Should be inside the conditioned space for maximu
efficiency.

Primary System Design Choices – Balanced with heat or energy recovery

Different efficiency ratings for HRVs and ERVs

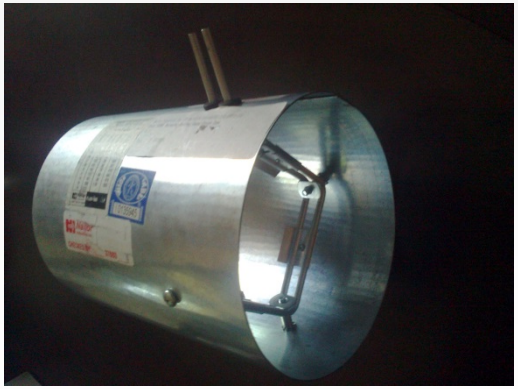
Sensible Recovery Efficiency (SRE) is the number that defines the "sensible energy recovered minus the supply fan energy and preheat coil energy, divided by the sensible energy exhausted plus the exhaust fan energy. This calculation corrects for the effects of cross-leakage, purchased energy for fan and controls, as well as defrost systems."

This info is available on the HVI certification sheet.

Single room ERV

Generic Specifications		
CFM at low-high speed	64-146	108-235
Apparent sensible effectiveness at 0°C	83 %	77 %
Warranty on components	5 years	5 years
Warranty on the core	Lifetime	Lifetime

Flow Measurement - Supply



Controls

62.2-2016 Controls

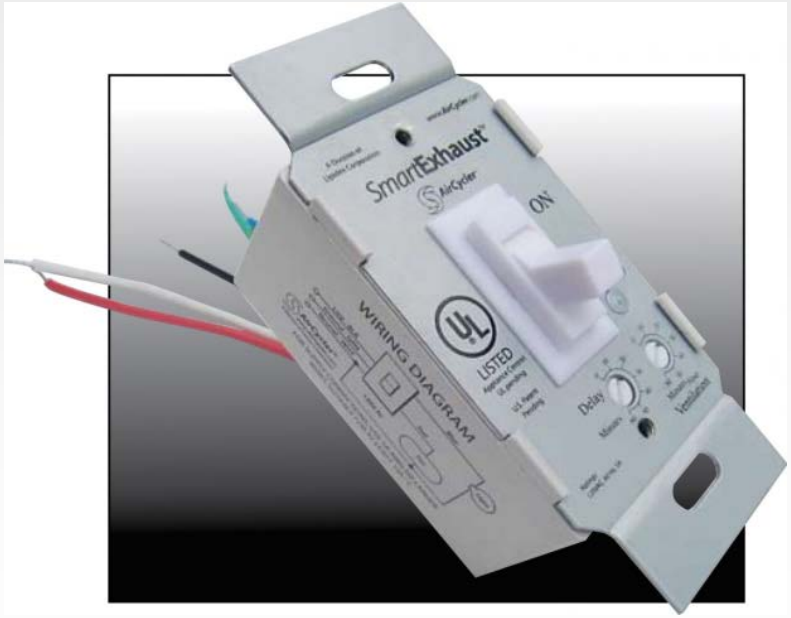
Whole Building Ventilation

- "Readily accessible manual ON-OFF control … shall be provided"
- "… including but not limited to a fan switch or a dedicated branch-circuit overcurrent device …"
  - Existing homes can use non-dedicated circuit breaker

- "Controls shall include text or an icon indicating the system's function."

Controls

- Intermittent controls must be automated



Aircycler

Controls

- For multiple speed controls whole-dwelling ventilation is generally set to the lower flow

Panasonic

- Switch provides temporary boost when needed

“Hybrid” system/controls

- Supply ventilation with intake into return
  - When there is a call for heat/AC the fan is running anyway, but…
  - …when there is no call for heat it is a very expensive fan for ventilation

- Exhaust fans use very little motor energy

“Hybrid” system/controls

- Aircycler g2-k control
  - uses the supply ventilation system when the heating need can provide it
  - when the heat is not needed, use an exhaust fan

Exhaust Fans – Low-cost Options

- Use existing fans
  - If they are working ok
  - Just add an appropriate control
- Use existing houses – replace a poor fan
- Put exhaust into a bathroom or kitchen
  - Reduces the “local exhaust deficit”

What is the Cost of Operating Ventilation Fans?

Ventilation Electrical Usage

- This is a fairly simple calculation for unbalanced ventilation.
- For balanced ventilation, there is usually some degree of energy recovery.

Cost to run the fan motor

- Depends on
  - Power draw of the fan (Watts)
  - How long the fan is run (hours)
  - Cost of electricity ($/kWh)
- Cost = $\frac{Watts}{1000} * \frac{hours}{year} * \frac{\$}{kWh}$
- If run continuously, $\frac{hours}{year} = 8760$

Cost to condition ventilation air

- Depends on
  - Ventilation fan flow rate (CFM)
  - Hours per day of runtime (hours)
  - Heating Degree Days, **Base 60**
  - Cost of fuel ($/unit of fuel)
  - Heating content of fuel (BTUs/unit of fuel)
  - Efficiency of heating system

Cost to condition ventilation air

- Typically, an exhaust fan INCREASES the total amount of outdoor air by about half of the fan flow rate
  - For example, a 50 CFM fan will increase the TOTAL outdoor air flow by about 25 CFM

- Can think of conditioning of ventilation air as being in three parts
  - Heat loss rate of ventilation air
  - Climate
  - Cost of fuel

Cost to condition ventilation air

- Heat loss rate of ventilation air (can be thought of as a *UA*) is

$$0.5 * 1.08 * CFM * \frac{hours}{day}$$

- Climate is characterized by HDD60

- Cost of fuel is

$$\frac{\$}{unit\ fuel} * \frac{unit\ fuel}{output\ BTUs} = \frac{\$}{unit\ fuel} * \frac{unit\ fuel}{input\ BTUs} * \frac{1}{eff}$$

Cost to condition ventilation air

- Therefore, combining the three components gives

$$Cost = \frac{0.5 * 1.08 * CFM * \frac{hours}{day} * HDD60 * \frac{\$}{unit\ fuel}}{\frac{input\ BTUs}{unit\ fuel} * eff}$$

- Inputs needed
  - CFM, cost of fuel, efficiency
- Look up
  - HDD60, input BTUs per unit of fuel

Cost of Operation

- Costs – example
  - Assume 30 CFM fan running continuously
  - Assume 11 watts
  - Assume 10 cents/kWh, $1.00/therm, 90% furnace

Cost of Operation

- Costs – example
  - Electricity for motor ➡ $9.64/yr
  - Gas for heating ➡ $22.38/yr in Detroit
    $18.93/yr in Boston
    $28.38/yr in Minneapolis
    $20.92/yr in Denver
    $10.86/yr in Raleigh
  - Higher heating cost for propane or electric heat

Summary

- Exhaust is NOT necessary
- Supply and balanced are options, use when appropriate
- Good controls can reduce installation and operation costs
- Cost of operation does not have to be high

Questions?