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Agenda

1. Fundamentals of IAQ
2. Pollutant Sources and Controls
3. Air Filtration, Filter Ratings
4. HVAC and Home Performance Basics
5. Types of Ventilation Systems
6. Selecting Ventilation System for the Application
7. IAQ Sensors and Ventilation Controls

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Learning Objectives

- Identify the fundamentals of healthy indoor air quality
- Identify unique challenges posed by threat of SARS-CoV-2 transmission and airborne bioaerosols
- Understand air filtration, air filter rating metrics and filtration strategies for particulates and SARS-CoV-2
- Understand why leaky, drafty homes have more moisture issues and reduced indoor air quality, how to prioritize air sealing locations that matter most for energy, health and wellness

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Learning Objectives (cont'd)

- Recognize the relationship between air sealing and preventing moisture problems that lead to structural failures and IAQ problems.
- Interpret the fundamentals of ASHRAE 62.2, the national ventilation standard referenced in the energy codes.
- Understand how sensors measure indoor pollutants and IAQ parameters to help maintain optimal air quality
- Understand differences between negative, positive and balanced ventilation systems and how to select the best system

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Fundamentals of IAQ

Common pollutants, Health hazards, Control strategies

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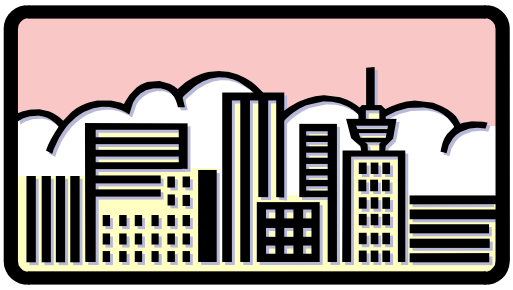
EPA Ranked Indoor Air Pollution One of the Top 5 Environmental Risks to Public Health



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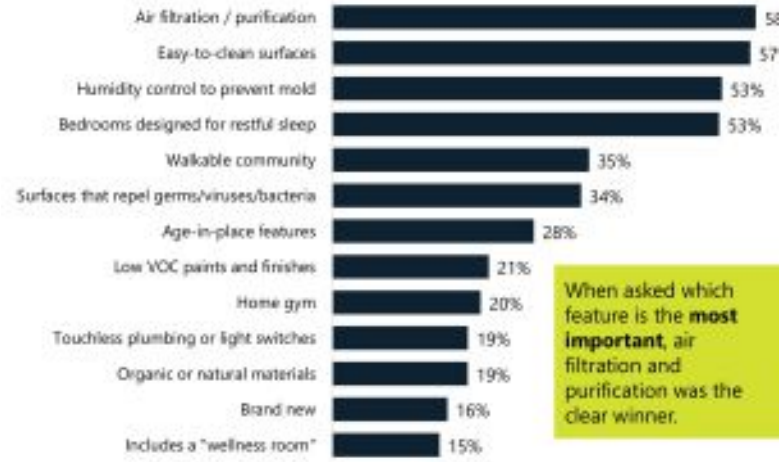
Which of the following would you require of a home for you to consider it to be a "healthy home"

Source: John Burns Real Estate Consulting, LLC, October 2020



When asked which feature is the **most important**, air filtration and purification was the clear winner.

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Air Pollution

- Air pollution from burning fossil fuels is responsible for > 8 million premature deaths per year worldwide (1 in 5 deaths 2018)
- 350,000 premature deaths in U.S. per year due to fossil fuel pollution

Vohra, et al., 2021

Indoor Air Pollution

- Indoor air pollutant levels are commonly higher than in outdoor air
- People spend approximately 87% of their time indoors

- Majority of our exposure to outdoor contaminants occurs indoors

Indoor Air Contaminants Impact:

- Health – acute and/or long term
  - Acute: irritation of eyes, nose & throat, headaches, dizziness, fatigue, asthma
  - Long-Term Effects: Respiratory and heart disease, cancer
- Comfort
- Well-being
- Learning outcomes
- Work performance: fatigue, difficulty concentrating & thinking clearly, reduced cognitive function

And are largely unregulated

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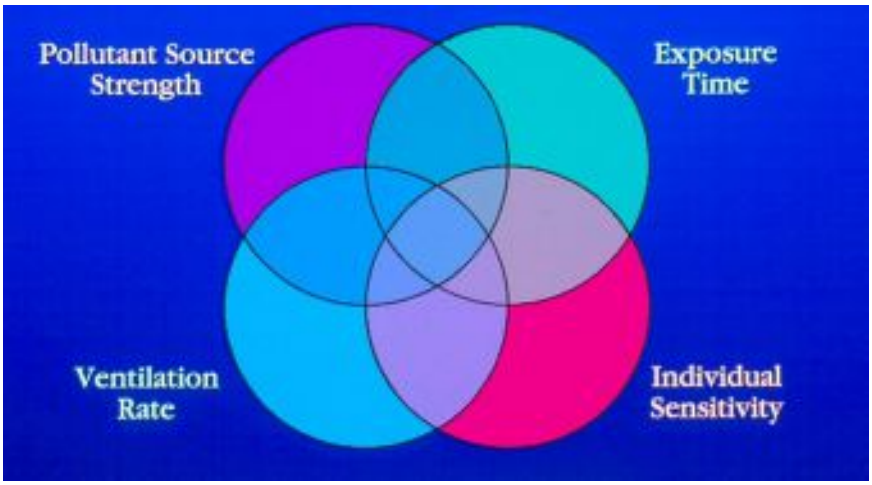
Factors Affecting Indoor Air Contaminant Exposures



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Causes of Indoor Air Quality Problems

- Release of Gases and Particles from Indoor Sources
  - Building materials and furnishings
  - Fuel Use
  - Maintenance and cleaning products
  - Personal use products (tobacco, candles, fragrances, hobbies)
  - Biological
- Introduction of Outdoor Air Pollutants Into the House
- Excess Moisture, Humidity
- Inadequate Ventilation, Filtration
- Pressurization/Depressurization Issues

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Indoor Air Quality Issues of Most Concern - 1991

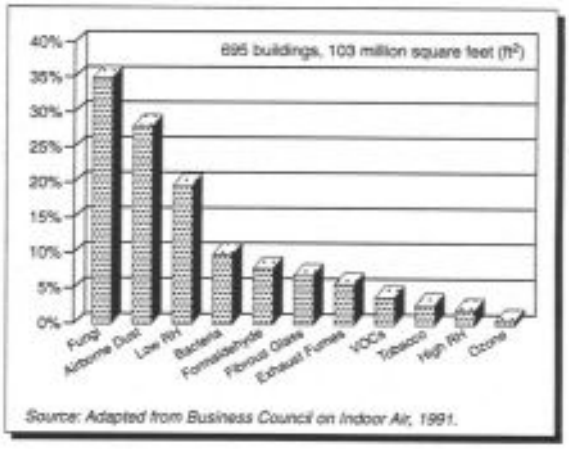

Figure 1-8. Microbial growth is the No. 1 IAQ problem in the nation.

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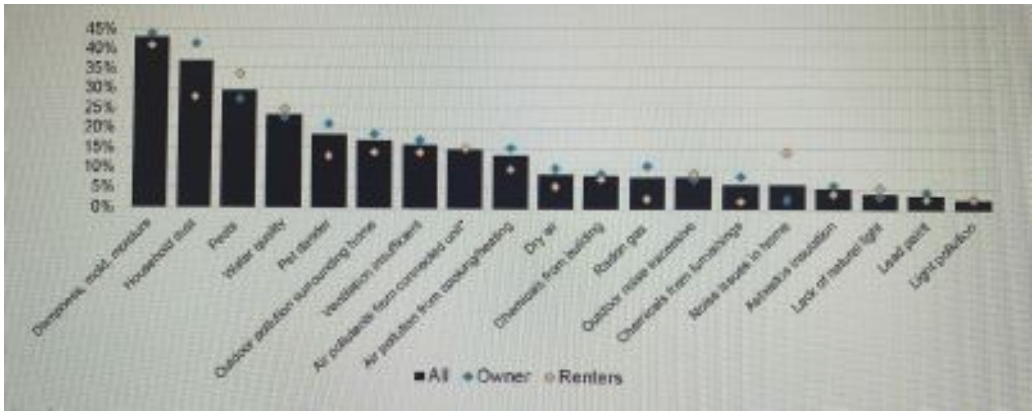
Indoor Air Quality Issues of Most Concern - 2018



Farnsworth Group and Joint Center Healthy Homes Surveys, **August 2018**

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Particulate Matter

- PM_{10}, $PM_{2.5}$, heavy metals, ultrafine particles
- Allergens: pollen, dust mites, pet dander & hair, pests
- Bioaerosols: **viruses**, bacteria, mold
- Fibers: asbestos, fibrous glass

Volatile Organic Compounds

- Chemicals from cleaning products
- VOC's released from furnishings, building materials, paints, adhesives, solvents

Gases

- Carbon dioxide
- Radon
- H_2S

Combustion Products

- Carbon monoxide
- Nitrogen dioxide
- Tobacco Smoke

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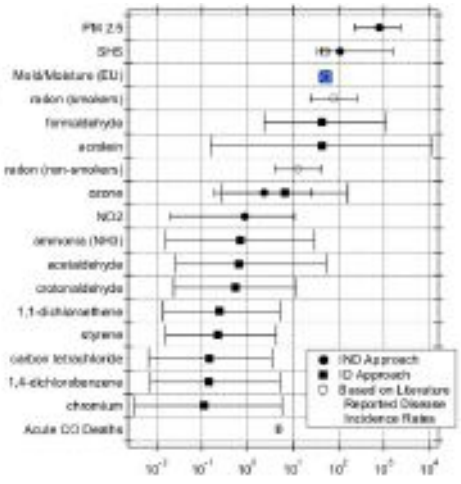
DALYs Lost (per year per 100,000 persons)

Estimate **Disability Adjusted Life Years**
DALYs consider severity of health outcomes
4-11 DALYs per 1000 people per year

$PM_{2.5}$
Secondhand smoke
Mold / moisture
Radon
Formaldehyde
Acrolein, Ozone, NO_2



Logue et al., Environmental Health Perspectives, 2012

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Fine Particulate Matter

Higher $PM_{2.5}$ Increased Severity:

- Strokes, cardiovascular illness, deaths
- Hospital admissions for respiratory distress
- Severity of chronic lung disease

How and Why…

- Lung irritation leads to more permeable tissue
- Inflammation of lung tissue releases chemicals that impact heart
- Changes in blood chemistry increase risk of clots.

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Gas Stoves Emit more $PM_{2.5}$ than Electric Ranges

- All cooking creates $PM_{2.5}$
- Particulate matter ($PM_{2.5}$ and higher)
- Nitrogen dioxide (NO_2)
- Carbon monoxide (CO)
- Formaldehyde

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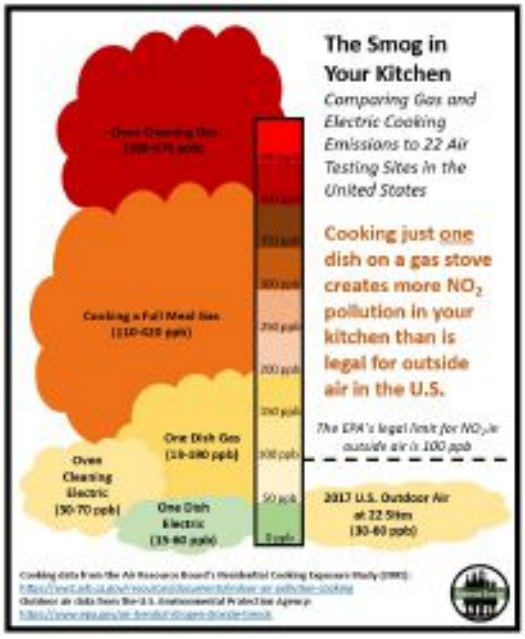

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Combustion- Related Air Pollution

Mounting evidence linking combustion-related air pollution with adverse brain development.

A study published in 2009 found evidence that infant through preschool-age early-life exposure (through age four) to indoor air pollution from gas appliances may be related to impaired cognitive function and may increase the risk of developing attention-deficit/hyperactivity disorder (ADHD) symptoms

Payne-Sturges, D.C. et al., *American Journal of Public Health*, 2019;

Morales, E. et al., American Journal of Epidemiology, 2009

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US Outdoor NO_2 Standard = 100 ppb for 1 Hour Exposure

Homes with gas stoves can contain approximately 50 to 400 percent higher concentrations of NO_2 than homes with electric stoves, often resulting in levels of indoor air pollution that would be illegal outdoors, according to a recent report by the Rocky Mountain Institute

https://rmi.org/insight/gas-stoves-pollution-health

Measured NO_2 Emissions from Gas Stoves	Peak (ppb)
Baking cake in oven	230
Roasting meat in oven	296
Frying bacon	104
Boiling water	184
Gas cooktop - no food	82–300
Gas oven - no food	130–546

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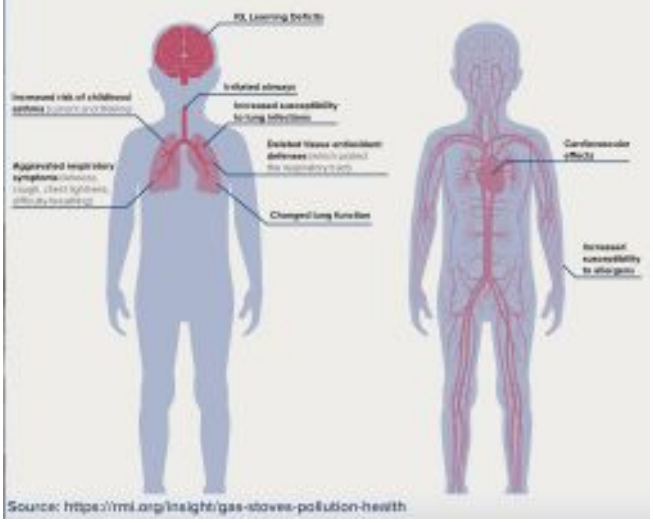
Gas stoves can produce elevated levels of Nitrogen Dioxide (NO_2), a toxic gas.
Health Effects of NO_2 in Children May Include:



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Infrequent Use of Kitchen Exhaust

Mullen et al., LBNL-5970E Reasons for NOT using exhaust system	Number	% of 193 using <50% of time
Not needed	92	48%
Too noisy	40	21%
Don't think about it	31	16%
Doesn't work	19	10%
Open window instead	17	9%
Other reasons	7	<4%
Wastes energy	3	<2%
No reason selected or don't know	23	12%

Singer, LBNL

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Induction Cooking

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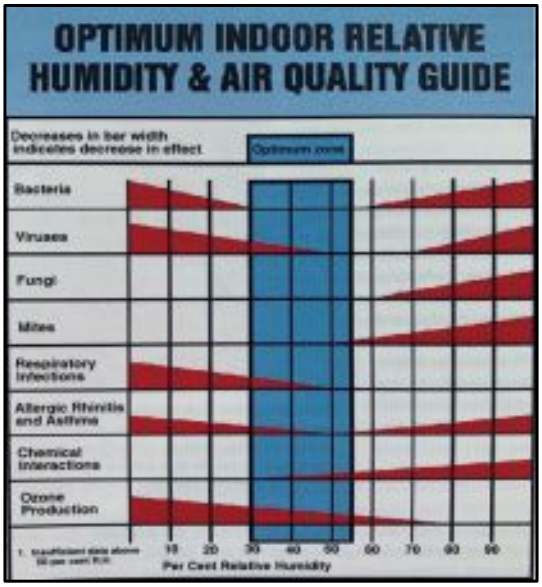

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High Relative Humidity, Dampness and Moisture

Cause mold and bacteria growth, dust mites, odors

Health effects include asthma, allergic reactions, respiratory problems

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Epa.gov/indoor-air-quality-iaq

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Volatile Organic Compounds

Product emissions are cumulative in a space

- ❑ Formaldehyde
- ❑ Flame retardants
- ❑ Volatile organic compounds from paint, glues, adhesives, etc.
- ❑ Phthalates

Select products that have been tested and certified by third party organizations or conform with recognized standards

UL GreenGuard Gold

UL GreenGuard Formaldehyde Free

Intertek VOC IAQ Certification

Green Seal

CRI Green Label & Green Label Plus

California CDPH

Berkeley Analytical ClearChem

ANSI/BIFMA e3

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Improving Indoor Air Quality

Source Control

- Remove source
  - Replace gas with electric
- Isolate source
- Minimize source
  - Tight building envelope
  - Low emitting products

Ventilation

- Deliver clean air to dilute and remove contaminants emitted by indoor sources
- Local exhaust ventilation

Air Cleaning

- Remove contaminants from outdoor air and recirculated indoor air using filtration

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Air Filtration, Filter Ratings

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Air Cleaning by Filtration and Adsorption

Removing Particles and/or Gases

- Used When Source Control and Dilution Ventilation Are Insufficient or Impractical
- Selection Is Based on Pollutant of Concern, Efficiency Criteria, Size of System and Cost

The Raterman Group, Ltd.

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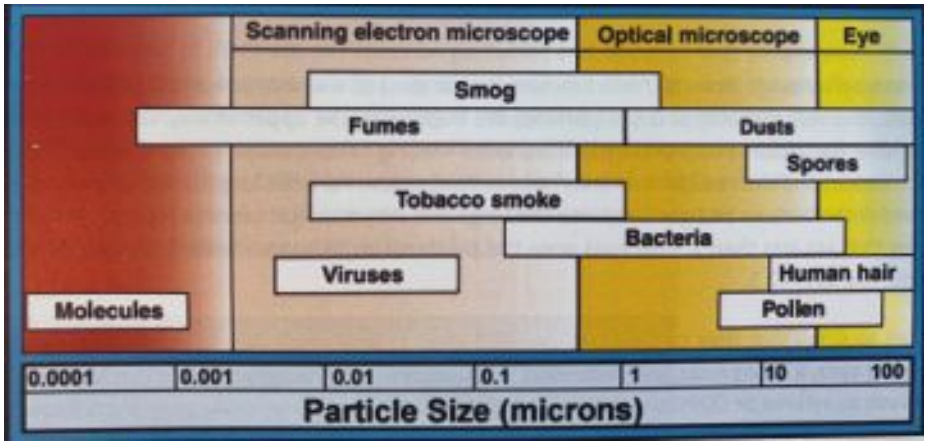

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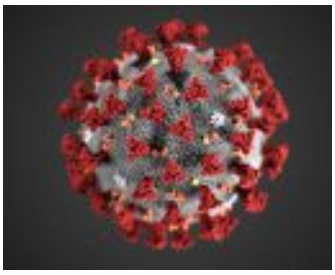
Pollen 4200x 8-100 microns

Bacteria 5500x 0.4-10 microns



SARS-CoV-2 0.7- .14 microns

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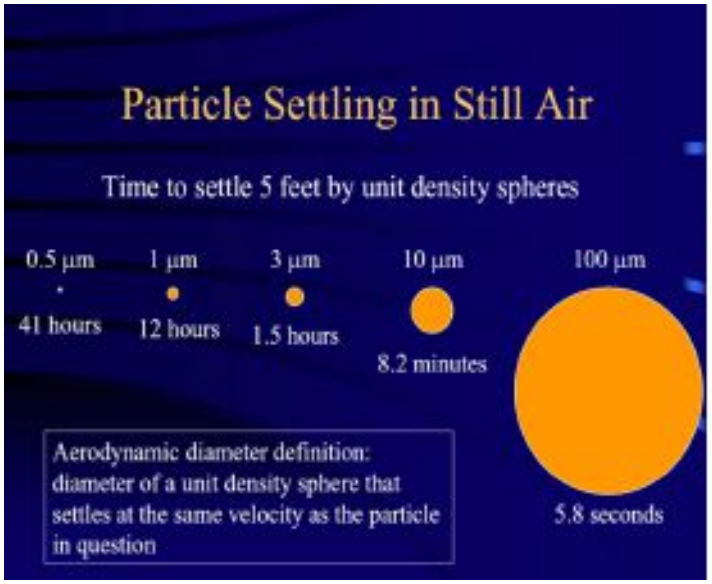

Figure: time for particles of different sizes to settle to the ground in still air, from the height of a person. From the CDC "Aerosols 101" presentation.

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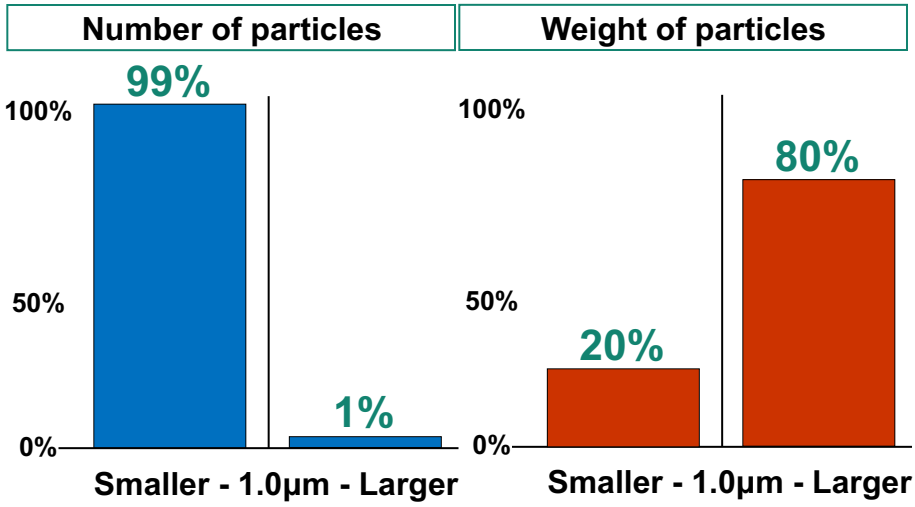
Particle Distribution By…



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MERV
Minimum Efficiency Reporting Values

ASHRAE Standard 52.2

- Particles in the range of 0.3 to 10 microns are dispersed into the air stream. A particle counter is used to count particles upstream and downstream

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MERV Parameters

Standard 52.2 Minimum Efficiency Reporting Value (MERV)	Composite Average Particle Size Efficiency, % in Size Range, µm			
	Range 1 (0.3-1.0)	Range 2 (1.0-3.0)	Range 3 (3.0-10.0)	Average Arrestance, %
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	$20 \le E_2$	$70 \le E_3$	n/a
9	n/a	$35 \le E_2$	$75 \le E_3$	n/a
10	n/a	$50 \le E_2 < 65$	$80 \le E_3$	n/a
11	$20 \le E_1$	$65 \le E_2 < 80$	$85 \le E_3$	n/a
12	$35 \le E_1$	$80 \le E_2$	$90 \le E_3$	n/a
13	$50 \le E_1$	$85 \le E_2$	$90 \le E_3$	n/a
14	$75 \le E_1 < 85$	$90 \le E_2$	$95 \le E_3$	n/a
15	$85 \le E_1 < 95$	$90 \le E_2$	$95 \le E_3$	n/a
16	$95 \le E_1$	$95 \le E_2$	$95 \le E_3$	n/a

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Residential Filtering for Airborne Virus Particles

Viral Filtration Efficiency

MERV 5:

12 – 40% (median 36%) at 0.17 in. W.G.

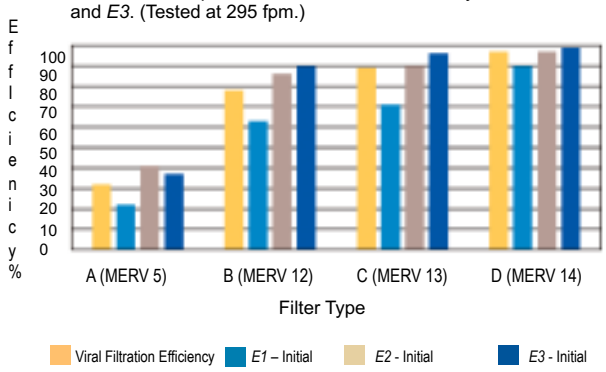
MERV 13:

79 – 98% (median 91%) at 0.18 in.W.G.

MERV 14:

95 – 99% (median 96%) at 0.24 in. W.G.

FIGURE 4 Comparison of viral filtration efficiency versus *E1, E2* and *E3*. (Tested at 295 fpm.)



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Air Cleaning Devices

When source reduction and dilution are insufficient

- Portable Air Cleaners with HEPA filters (select according to Clean Air Delivery Rate)
- Duct-mounted Air Cleaners with MERV 13 and above
- Gas-phase Air Cleaning required to remove gases, vapors

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HVAC & Home Performance Fundamentals

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Air Filtration Account for 30-40% of HTG & Cooling Costs

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2018 IECC Codes Requirements

Building Thermal Envelope
Section R402.4.1 – Air Leakage

Requires BOTH:

✓Whole-house pressure test

Air Leakage Rate	Climate Zone	Test Pressure
≤ 5 ACH	1-2	50 Pascals
≤ 3 ACH	3-8	50 Pascals

- Testing may occur any time after creation of all building envelope penetrations

✓Field verification of items listed in Table R402.5.1.1

Blower Door Metrics

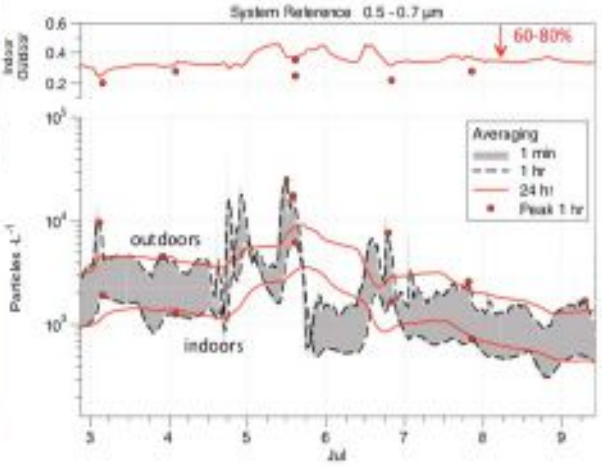
$$ACH50 = \frac{CFM\ 50 \times 60}{\text{Building Volume (cubic feet)}}$$

0 - 1.0 ACH	**Very tight**
1.5 - 3 ACH	**Tight**
3 - 5 ACH	**Moderately tight**
5 - 7 ACH	**Loose**
7 - 10 ACH	**Very loose**
10 + ACH	**Extremely loose**

Air tightness helps reduce outdoor particles

Built 2006, 1200 sf, 5 ach50,
Sealed ducts, 0.22 ach natural
Exhaust ventilation, MERV4 filter

$PM_{2.5}$ inside was
~50% lower than outdoors



Singer et al., Indoor Air, 2016

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Controlling Air Movement & Enhancing IAQ

- Controlling air flow reduces structural failures… air contains moisture
- Air leaks are pathways to transport pollutants
- IAQ problems are usually caused by:
  - Pollutant source
  - A pressure difference
  - A pathway
  - Lack of ventilation/dilution

AIRWAYS ARE PATHWAYS FOR POLLUTANTS

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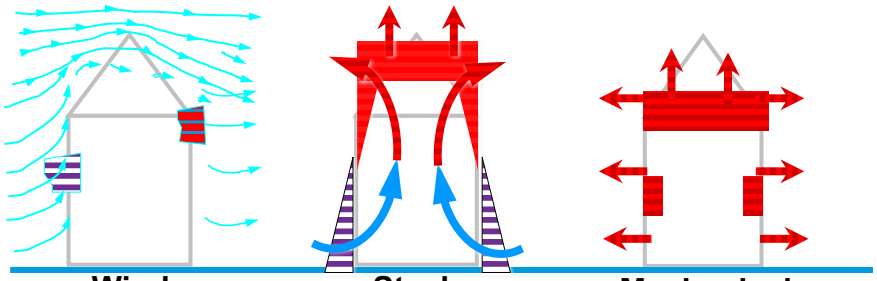
Cause of Air Infiltration in Buildings



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Air Leakage

- Airflow is measured in cubic feet per minute, also written as ft^3/min, or CFM.
- 1 CFM **Out** = 1 CFM **In**
- Airflow takes the path of least resistance.
- Air moves from **high-** to **low-pressure** areas.
- Air usually moves from **high-** to **low-temperature** areas.

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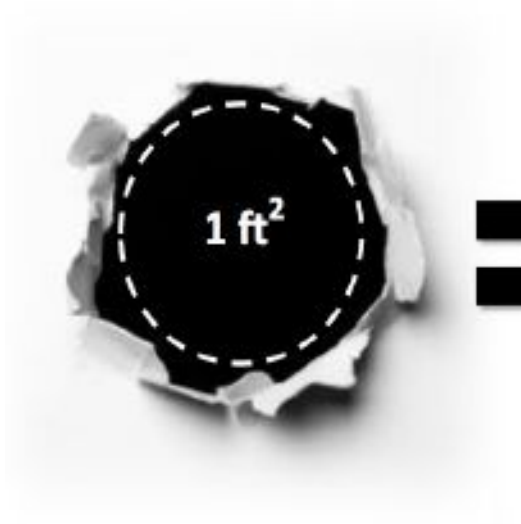
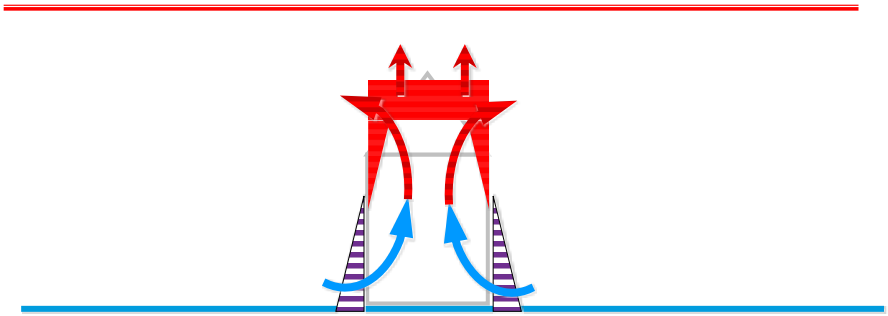


1101 CFM
(50 Pa)

50

Sources of Air Pressure Differential in Buildings



Stack Pressure

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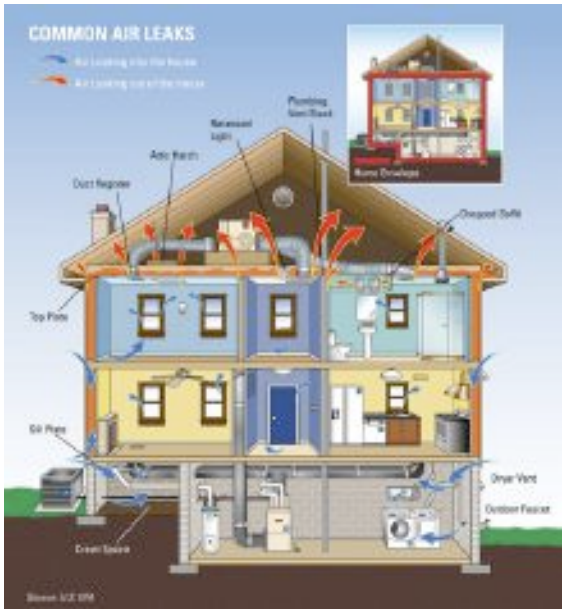

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Sources of Air Pressure Differential in Buildings

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300 cfm

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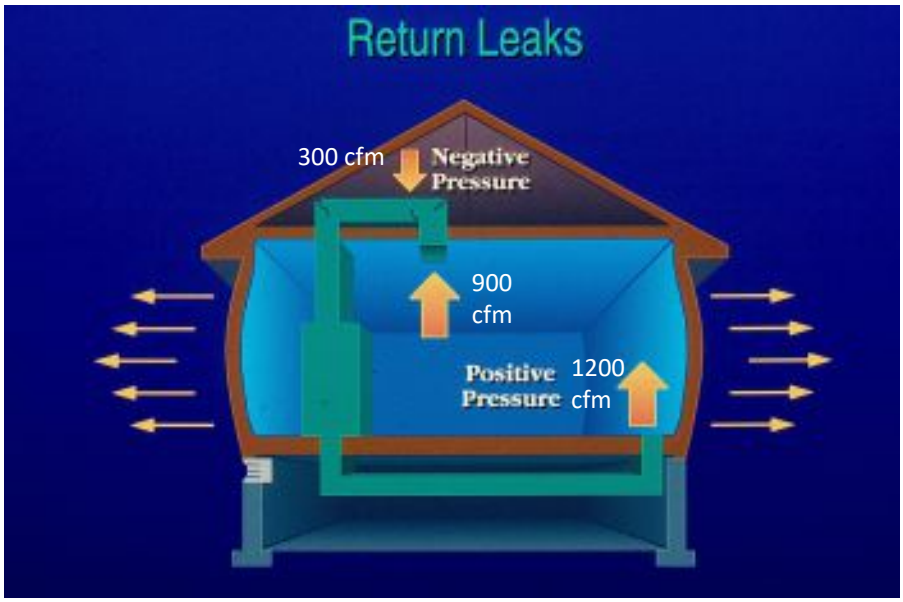

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Positive Pressures and Leaky Walls =

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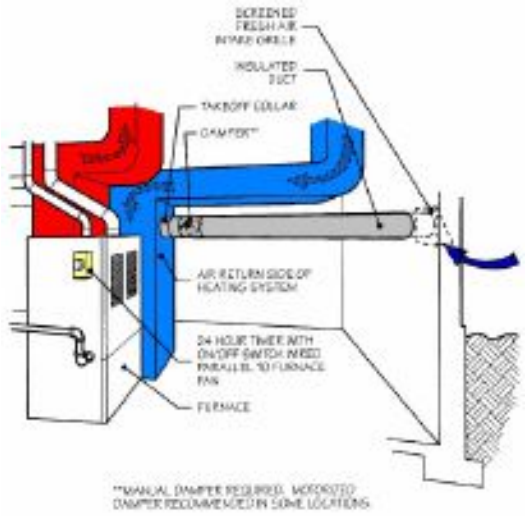
Integrated Forced Air System



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Return-Air Pathways

Minimum Door Cut Height for Return Air							
Cfm Under Door	Door Width (Inches)						
	24	**30**	**36**	**42**	**28**	**54**	**60**
	Clearance to Floor or Top of Carpet (inches)						
100	2.0	1.6	1.3	1.1	1.0	0.9	0.8
200	4.0	3.2	2.7	2.3	2.0	1.8	1.6
300	6.0	4.8	4.0	3.4	3.0	2.7	2.4
400	8.0	6.4	5.3	4.6	4.0	3.6	3.2

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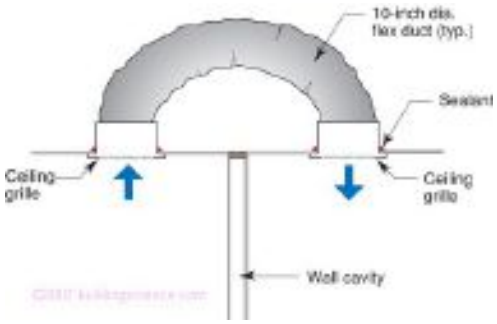
HVAC System Balancing

Options Include:

- Dedicated Returns
- Transfer Grilles
- Jump Ducts

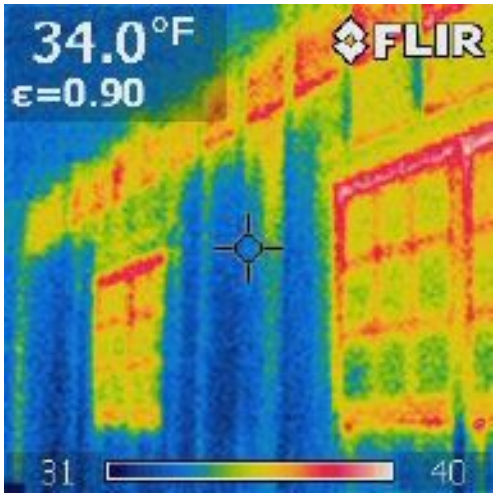


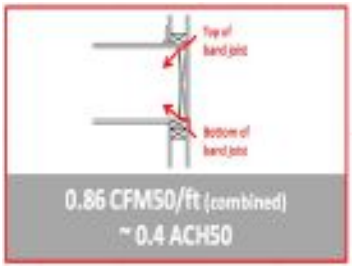
Courtesy: Mitsubishi Electric Trane HVAC US LLC

Heat pump space heating

Courtesy: Mitsubishi Electric Trane HVAC US LLC

Air Leakage Between Floors





Courtesy Dave Wolf, Ph.D.
Owens Corning, Science & Technology

Heat Loss at Band Joist

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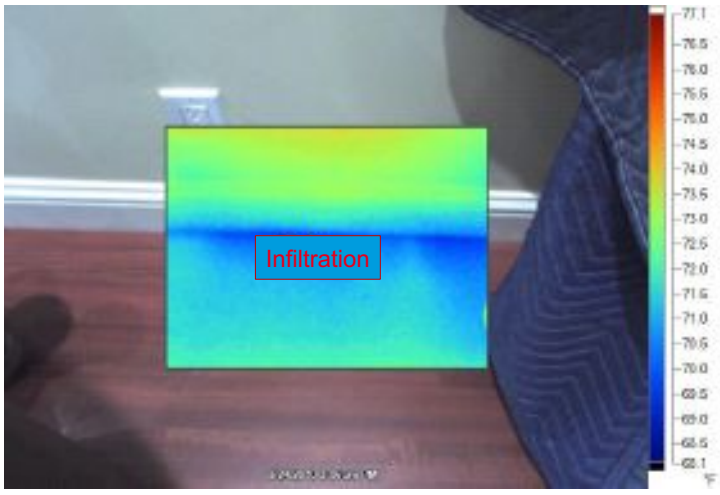

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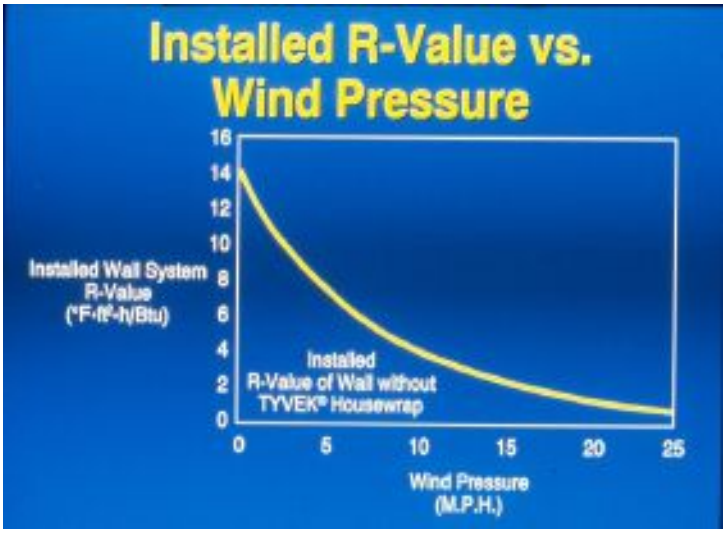
Wind Washing



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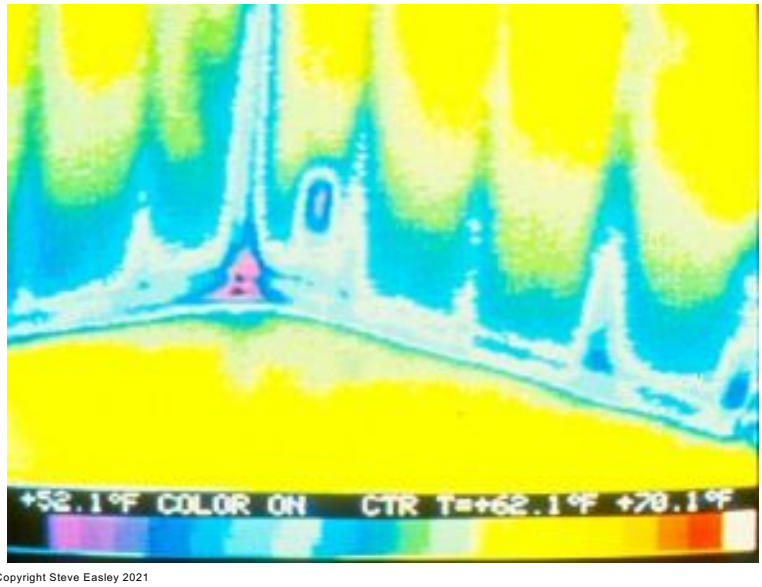
Wind Washing



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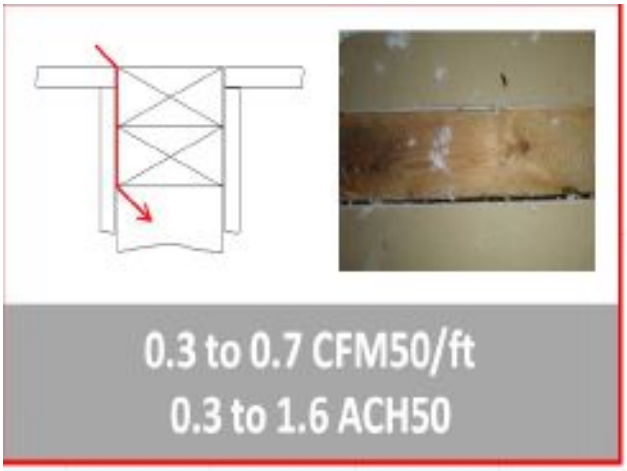

Dave Wolf, Ph.D.
Owens Corning, Science & Technology

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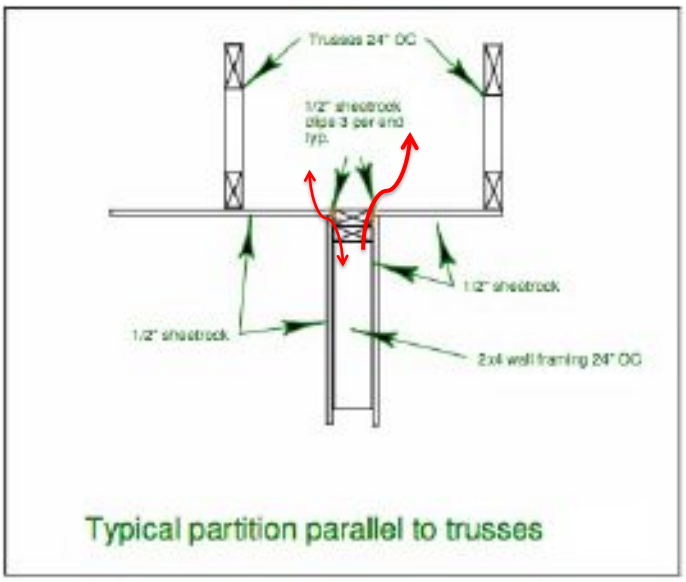

Typical partition parallel to trusses

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Plumbing Walls

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7.7 CFM50/boot
0.1 to 0.3 ACH50

Courtesy Dave Wolf, Ph.D.
Owens Corning, Science & Technology

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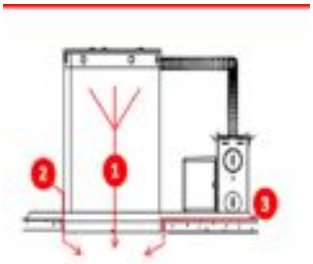
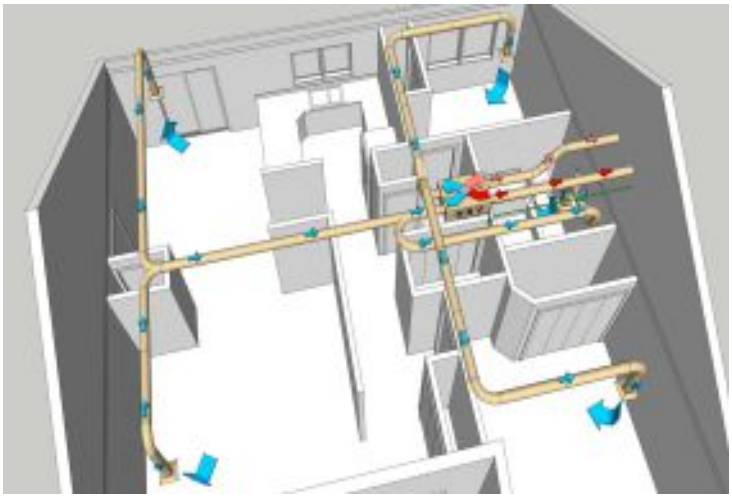


9.1 CFM50/light
0.2 to 0.3 ACH50

Courtesy Dave Wolf, Ph.D.
Owens Corning, Science & Technology

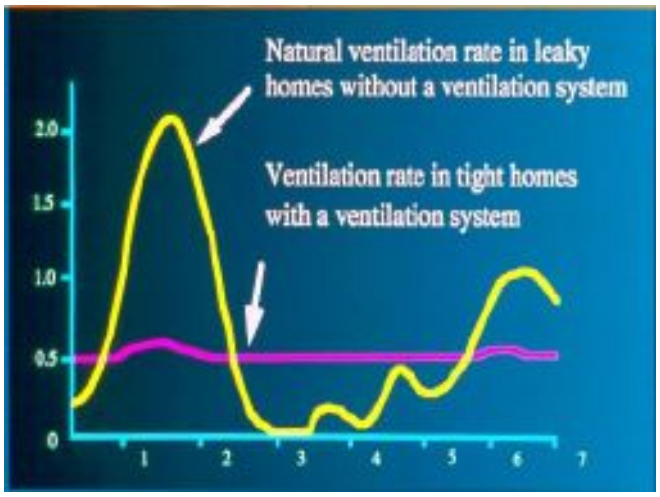
80

Understanding & Selecting Fresh Air Ventilation Systems



81

Natural vs. Mechanical Ventilation Rates



82

HVAC Misconceptions

Residential systems bring in outside air

Leaky older homes have better IAQ and fewer moisture problems

People regularly use windows for ventilation

<u>Reality</u>
Residential Forced air systems ONLY Heat, cool and recirculate air

83

Windows are Wonderful, But…

Their use is limited by:

- Use of heating, AC system
- Outdoor Humidity
- Outdoor Noise
- Security
- Privacy
- Outdoor air pollution – auto exhaust, second-hand smoke, etc.

More reasons to keep windows closed means mechanical ventilation systems are necessary.

84

Code Required Types Ventilation Systems

- Attic ventilation
- Crawlspace ventilation
- Spot ventilation, Baths and kitchens
- Whole House Ventilation (few states)

85

Spot Ventilation, Kitchens & Baths

TABLE M1507.4
MINIMUM REQUIRED LOCAL EXHAUST RATES FOR ONE- AND TWO-FAMILY DWELLINGS

AREA TO BE EXHAUSTED	EXHAUST RATES
Kitchens	100 cfm intermittent or 25 cfm continuous
Bathrooms—Toilet Rooms	Mechanical exhaust capacity of 50 cfm intermittent or 20 cfm continuous

For SI: 1 cubic foot per minute = 0.4719 L/s.

3 sones intermittent, Low speed **1 sone for continuous operation**

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Range Hoods, 100 CFM Min.

www.hvi.org

87

A Special Consideration

Make-Up Air

The whole-house automatic ventilation system also works with make-up air dampers to allow outside fresh air into the return air system, whenever a fan is running.

This may be desirable in extremely tight homes and for those with naturally vented combustion appliances.

88

Whole-House Ventilation

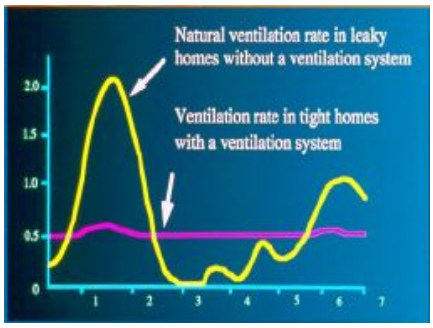
Whole-House Ventilation or continuous refers to providing a consistent level of ventilation throughout the day in order to remove indoor air pollutants of all types.

89

89

Why Controlled Fresh Air Ventilation (with Energy Recovery)

- **We Breath 3000 Gallons of Air Every Day**
- **Natural ventilation is uncontrolled therefore accidental ventilation**
- **Controlled ventilation is a key component to good IAQ**
- **Often**
- **Often required by code**
- **2012 IRC Section R303.4** requires whole-house mechanical ventilation in accordance with M1507.3, where the tested air infiltration rate is less than 5 ACH50 in accordance with N1102.4.1.2.



90

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How Much Ventilation Do we Need?

ASHRAE 62.2 2010-2019

What is ASHRAE 62.2?

American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)

It is the only nationally recognized indoor air quality standard developed solely for residences.

1st version 2003

62.2 2019 current version

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ASHRAE 62.2

Where is ASHRAE 62.2?

Top Green building Programs

- U.S.G.B.C. LEED® Program for Homes
- NAHB Green Home Building Guidelines
- EPA Indoor Air Plus
- California Building Codes

Proposed for International Residential Code (IRC)

92

ASHRAE 62.2

Building codes written to meet 62.2 require two types of ventilation in every home

- Intermittent ventilation for every kitchen and bathroom.
  - Bathroom = minimum 50 CFM, 3 Sones or less.
  - Kitchen = minimum 100 CFM, 3 Sones or less.
- Continuously operating mechanical ventilation system
  - High-rise residential – More than 3 stories (slightly higher ventilation rate)
  - Low-rise residential – 3 stories or less
    - Ventilation air requirements are based upon size of the home (ft2) and the number of bedrooms.
    - Sound level to be equal to or less than 1 Sone.

93

ASHRAE 62.2 Ventilation Standard:

There is no single answer

It Depends on…

- Number of occupants
- Lifestyle, behavior
- Pollutant loads
- Occupant sensitivity

It Varies by version year

- From person to person
- From house to house
- In the same house over time
- 0.35 Air Changes per hour
- or 15 cfm/person
- whichever is higher (usually 0.35 AC/h)

Lowest minimum residential ventilation rate in the world

- Home Ventilating Institute (www.HVI.org) recommends at least 0.5 AC/h

94

2010 vs 2016

Increases single family residential ventilation rates by an average of 51 percent for the 2,100 square foot prototype and 41 percent for the 2,700 square foot prototype

95

62.2 Example Ventilation Formula Method (varies by version)

The formula is:

$Q_{tot} = 0.03\ A_{floor} + 7.5 \times (N_{br} + 1)$

Where:

Q_{tot} = Total required ventilation rate in cubic feet per minute (CFM)

A_{floor} = Floor area in square feet

N_{br} = Number of bedrooms. Not to be less than one; used to estimate the number of occupants for design purposes.

96

ASHRAE 62.2: What's New in 2016

TABLE 4.1a (I-P) Ventilation Air Requirements, cfm

Floor Area, ft²	Bedrooms				
	1	2	3	4	5
<500	30	38	45	53	60
501–1000	45	53	60	68	75
1001–1500	60	68	75	83	90
1501–2000	75	83	90	98	105
2001–2500	90	98	105	113	120
2501–3000	105	113	120		
3001–3500	120	128	135		
3501–4000	135	143	150		
4001–4500	150	158	165		
4501–5000	165	173	180		

DWELLING UNIT FLOOR AREA (square feet)	NUMBER OF BEDROOMS				
	0 – 1	2 – 3	4 – 5	6 – 7	> 7
	Airflow in CFM				
< 1,500	30	45	60	75	90
1,501 – 3,000	45	60	75	90	105
3,001 – 4,500	60	75	90	105	120
4,501 – 6,000	75	90	105	120	135
6,001 – 7,500	90	105	120	135	150
> 7,500	105	120	135	150	165

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Figure 1: CFM Required for Bedrooms

Adapted from ASHRAE 62.2 – 2016 (for all Residences)

Ventilation Air Requirements in CFM

Floor Area ft2	Number of Bedrooms				
	1	2	3	4	5
Less Than 500	30	38	45	53	60
501-1000	45	53	60	68	75
1001-1500	60	68	75	83	90
1501-2000	75	83	90	98	105
2001-2500	90	98	105	113	120
2501-3000	105	113	120	128	135
3001-3500	120	128	135	143	150
3501-4000	135	143	150	158	165
4001-4500	150	158	165	173	180
4501-5000	165	173	180	188	195

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Ventilation Energy Penalty

2,700 SF home with 9' ceilings requires 120 cfm ventilation

120 CFM X 60 min/hr. =**7200 CFM/hr.**

2,700 SF x 9'= **24,300** volume

7,200CFM / 23,400 = .30 ACH
(Air changes per hour)

You have to re-heat of re-cool the air every 3 hours

ERV's can recovery 75%!

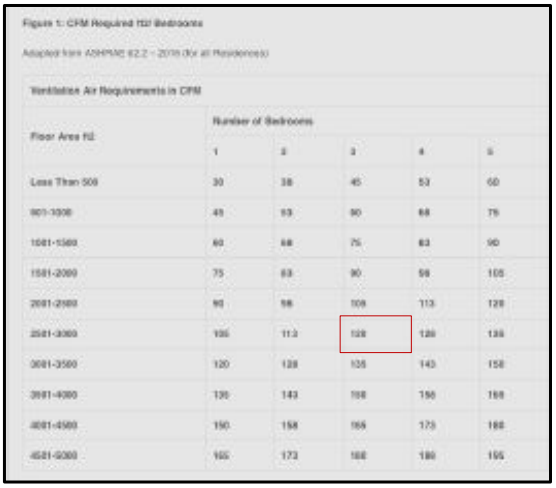
Figure 1: CFM Required for Bedrooms

Adapted from ASHRAE 62.2 – 2019 (for all Residences)

Ventilation Air Requirements in CFM

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2001-2500	90	98	105	113	120
2501-3000	105	113	120	128	135
3001-3500	120	128	135	143	150
3501-4000	135	143	150	158	165
4001-4500	150	158	165	173	180
4501-5000	165	173	180	188	195

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TABLE M1507.3.3(2) INTERMITTENT WHOLE-HOUSE MECHANICAL VENTILATION RATE FACTORS[a, b]

RUN-TIME PERCENTAGE IN EACH 4-HOUR SEGMENT	25%	33%	50%	66%	75%	100%
Factor[a]	4	3	2	1.5	1.3	1.0

a. For ventilation system run time values between those given, the factors are permitted to be determined by interpolation.

b. Extrapolation beyond the table is prohibited.

100

62.2-2016 Requires Labels

Provide to owner or occupant of dwelling unit:

Information on ventilation systems installed;

Instructions on proper operation; and instructions on proper maintenance.

Controls shall be labeled as to their function.

101

Types of Ventilation Systems

Selecting the best system

102

Three Basic Types of Ventilation Systems

Exhaust: Depressurizes the house.

- Not for use in homes with depressurization hazards: attached garage, radon, unsealed combustion appliances
- Source of air can't be controlled, air can't be filtered.

Supply: Pressurizes the house.

- Source of air is controlled, air can be filtered.
- Outdoor air is ducted to bedrooms and living areas.

Balanced

- Two fans exhaust & supply same volume at same time.
- Outdoor air is filtered & ducted to bedrooms and living areas.
- Cost to install & operate 2 fans can be offset by energy recovery.

Source of graphics: AirKingLimited.com, EnergyFederation.org, LifeBreath.com

Fresh Air Ventilation

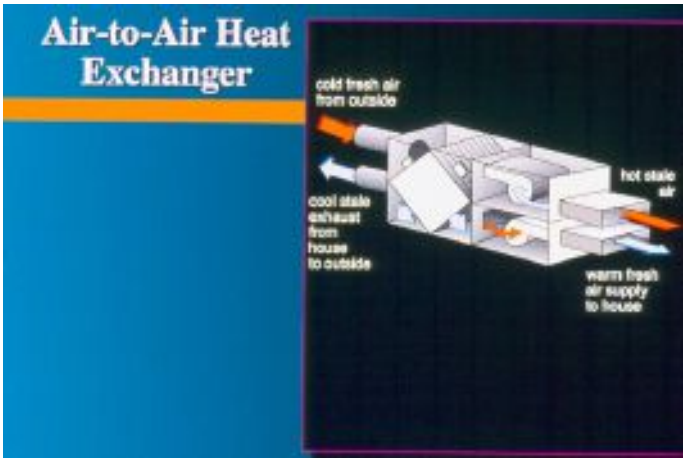

Image Courtesy Broan

105

Fresh Air Ventilation

106

Sensors

IAQ Sensors and Ventilation Controls

107

Connected Indoor Air Quality

108

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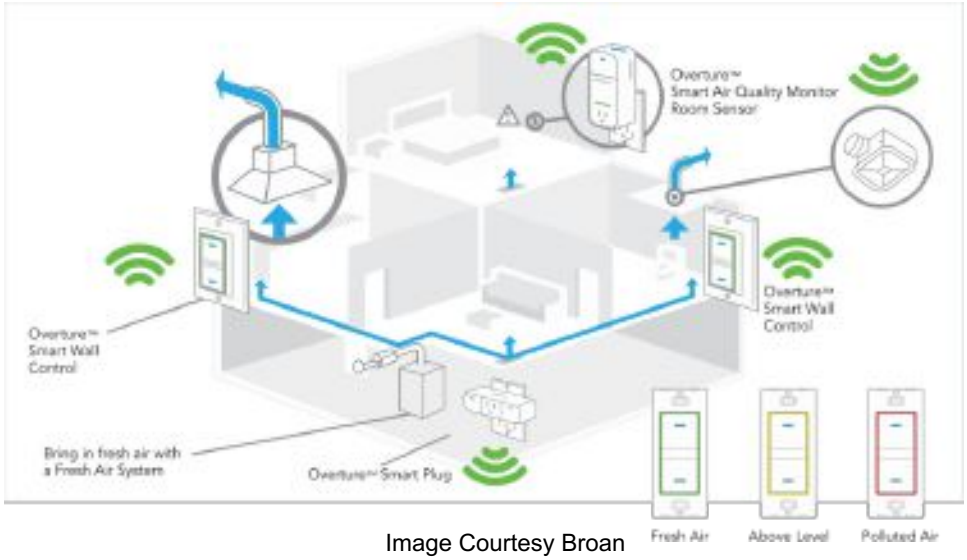

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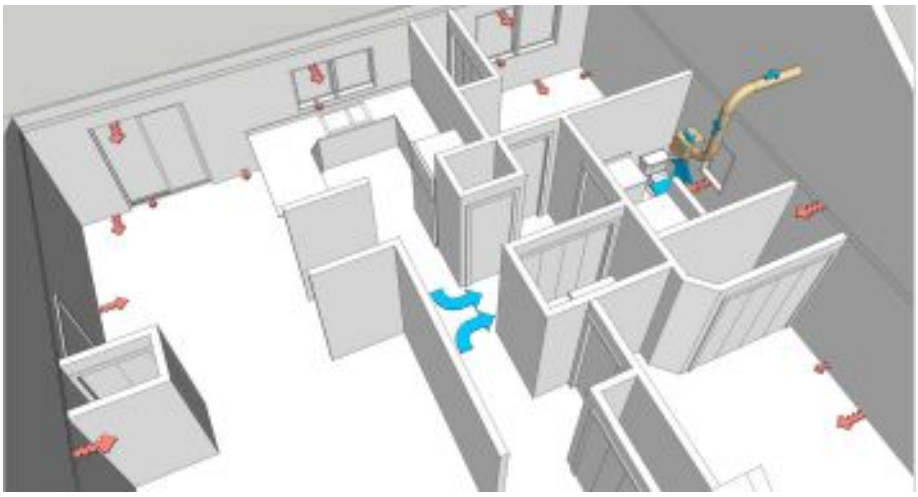
Negative Pressure – Single Fan, Bath



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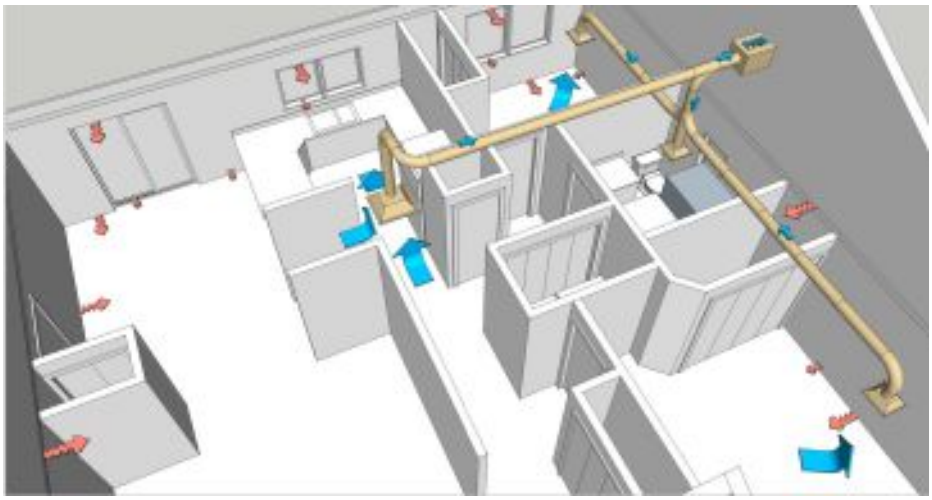
Negative Pressure – Multi - Port



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Issues w/ Depressurization

Backdrafting – fireplaces, water heaters, heating equipment, etc.

Outdoor contaminants enter unfiltered

Drafts

Radon intrusion

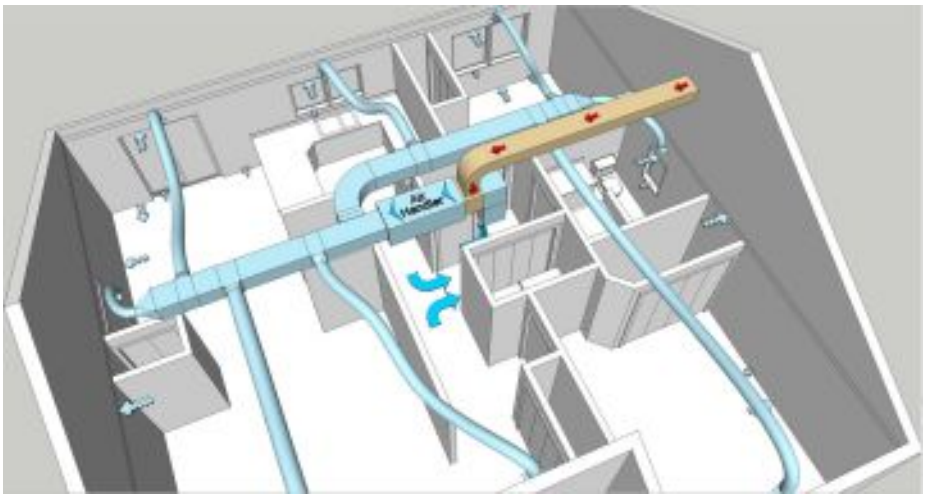
Building shell moisture problems

Increased energy bills

 SWA, Lois Arena PE 113

113

Positive Pressure System Distributed



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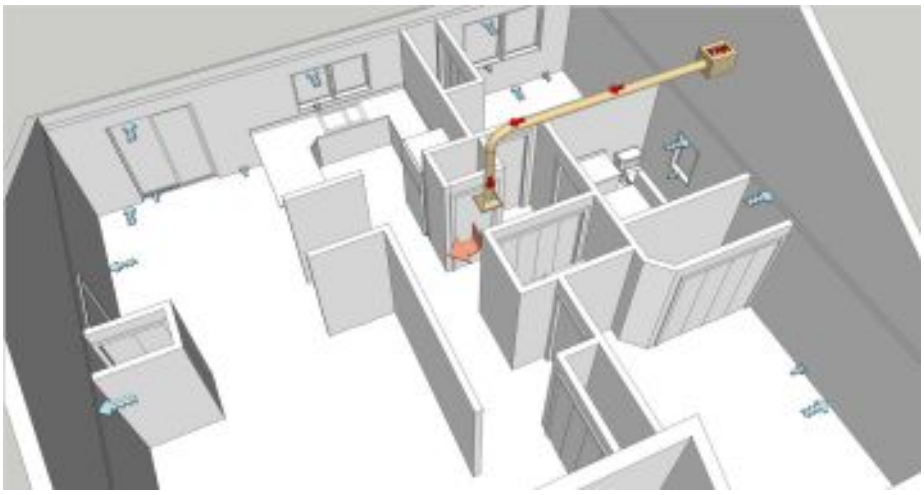
Positive Pressure – Single Fan



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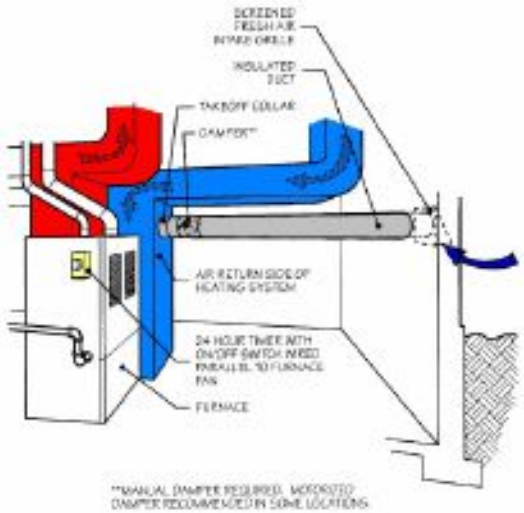
Integrated Forced Air System



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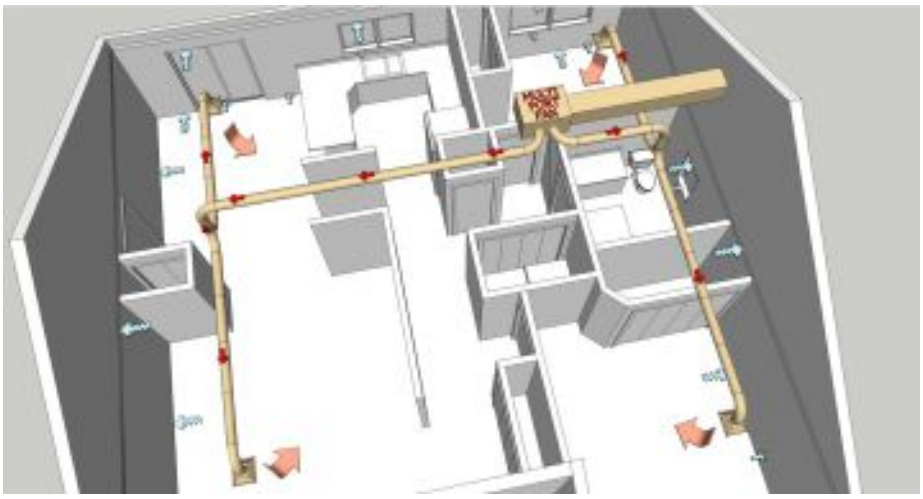
Positive Pressure Multiport



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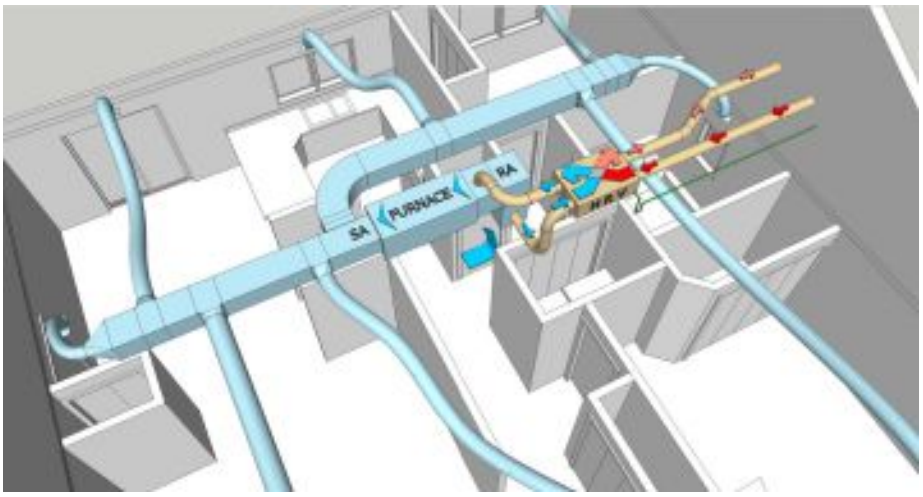
Balanced – HRV/ERV System Distribution



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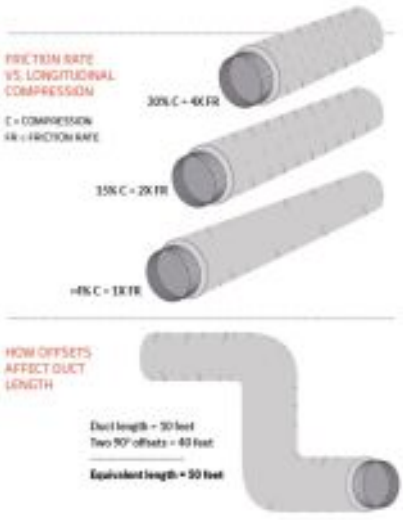

Illustration: Air Diffusion Council, "Flexible Duct Performance & Installation Standards," 5th Edition

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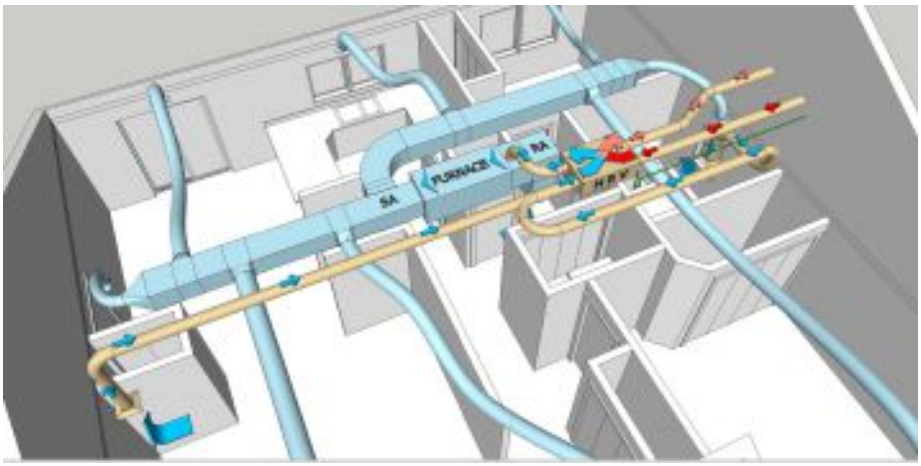
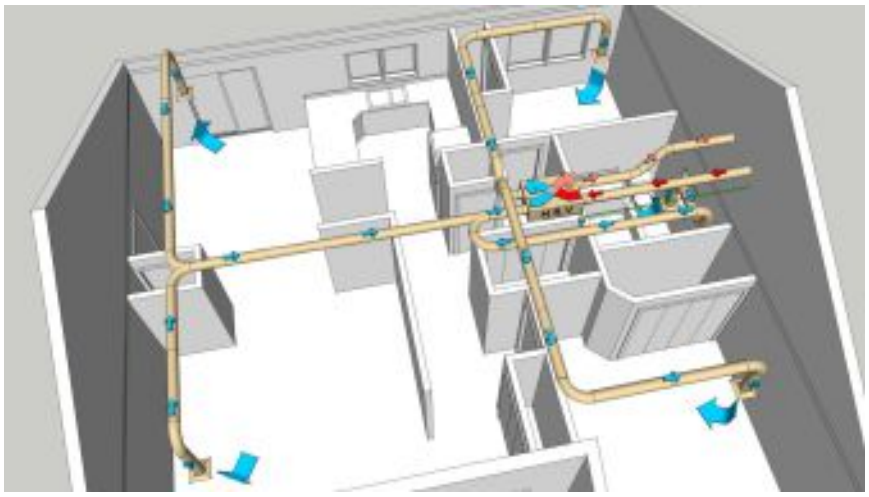
Balanced – HRV/ERV



121

Balanced – HRV/ERV Multiple inlets/outlets



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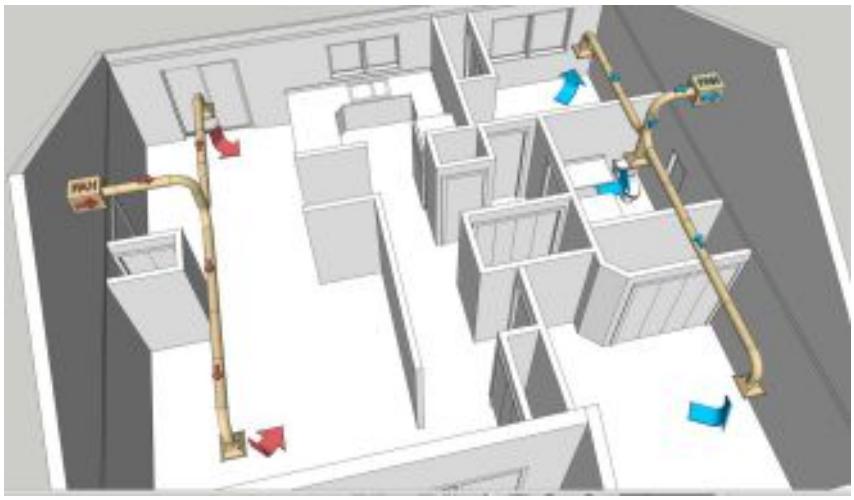
Balanced 2 - Fans



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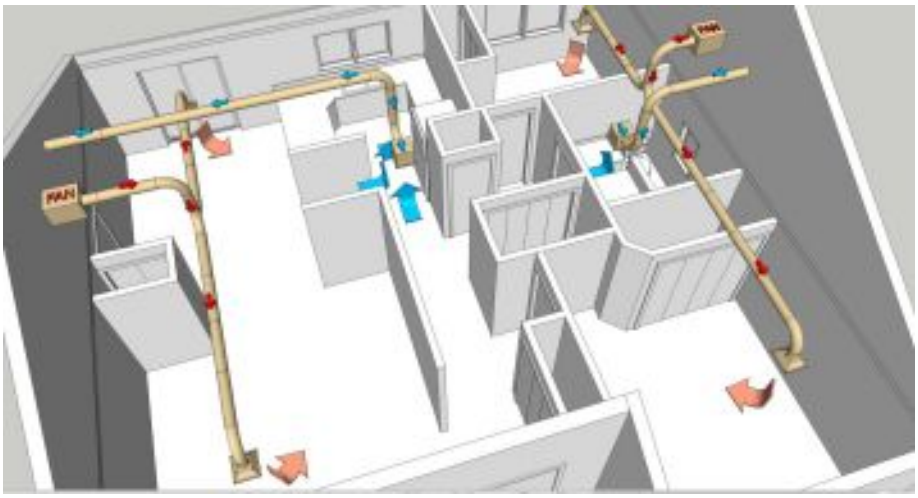
Balanced 3 - Fans



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Why not use the forced-air system for ventilation?

Heating & AC are intermittent and seasonal, but ventilation is needed continuously, year-round.

Air handlers are noisy and expensive to operate, so they operate only intermittently for ventilation.

Intermittent operation:

- Could create positive or negative pressures.
- Is MUCH less effective at controlling indoor pollutants.

Forced-air systems are 10X bigger than needed for ventilation. Such large fan, ducts can't effectively deliver ventilation air.

FA systems are adapted, but not designed for ventilation.

125

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2:00-3:30 pm ET
High Performance Walls: Master Class

- ✓ Focus on Opportunities and Challenges of High-Performance Wall Assemblies, Thermal Effectiveness, and the Rising Cost of Wood Products

Thursday, August 5
2:00-3:30 pm ET
Topic Coming Soon!

Thursday, September 23
2:00-3:30 pm ET
Journey of Residential Flashing: Master Class

- ✓ Deep Dive on Flashing: Products, Methods, Testing and Applications

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