Indoor Air Quality & Ventilation

by
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ALASKA CENTER for Appropriate Technology

Speaker

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- Certified AHFC Rater
- LEED for Homes Green Rater
- Building Performance Institute (BPI) Building Analyst
- BPI Healthy Home Evaluator
- ITC Level II thermographer
- ABAA Certified Air Barrier Auditor
- Air Barrier Testing Professional
- Combustion Safety Specialist
- SOA Mechanical Administrator
- SOA Plumbing License.
- UA Journeyman Pipefitter/Plumber

I have been working in construction since 1998 and have traveled across the State of Alaska performing Energy Audits and building diagnostic on everything from Natatoriums in South East Alaska, to Groceries Stores in the Aleutians and residential and commercial audits across Alaska for the last 10 years.

ALASKA CENTER for Appropriate Technology

What is a Healthy Home?

- Free of Contaminates & Allergens
- Free of Mold
- Free of Lead and Asbestos
- Free of Carbon Monoxide
- Free of VOCs
- Free of RADON
- Free of Dust & Dust Mites
- Free of Pest and Rodents
- Free of Trip Hazards
- Free of Second Hand Smoke
- Free of People, kids, pets etc. etc. 

Do You or some one You know have?

- Allergies
- Asthma or Asthma symptoms
- Chronic Bronchitis
- Ear Infections
- Eye irritations
- Headaches or Migraines
- Hay Fever
- Respiratory Disease
- Sinus Problems
- Skin Infections or Rash
- Any injuries that happened at home
- Been Poisoned in or by their Home

The Eight Principals of a Healthy Home

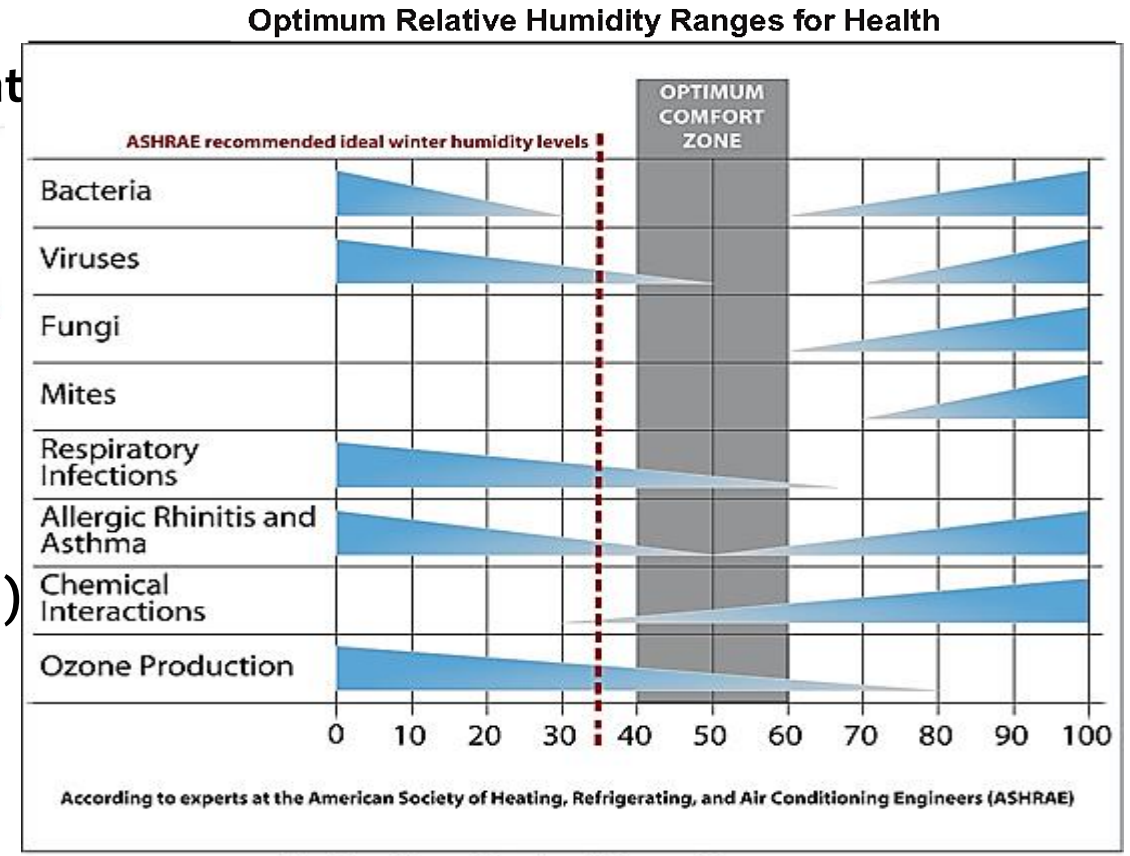
- ❑ Dry
- ❑ Clean
- ❑ Pest-Free
- ❑ Safe
- ❑ Contaminant-Free
- ❑ Ventilated
- ❑ Maintained
- ❑ Comfortable

According to the CDC

What are Asthma Triggers

- Pollen & Outdoor Molds
- House Dust Mites
- Animal Dander/Excrement
- Cockroaches/Mice
- Indoor Molds
- Tobacco Smoke
- Wood Smoke (PM2.5 & 10)
- Chemicals/Pesticides

How does moisture affect the health of a home?



Optimal humidity levels by pollutant type

Optimum Relative Humidity Ranges for Health

General Ventilation Design

MITE OR MITE NOT?

3 WAYS TO GET RID OF DUST MITES AND THEIR STUPID ALLERGENS

#1: Always dust with damp rags and mops. Dry rags just stir up the dust.

#2: Regularly wash bedding in very hot water (over 130º F) until the dust mites start believing in global warming. You can also freeze blankets. That will kill the dust mites, too!

#3: Cough up the money for a vacuum cleaner with a HEPA filter. It'll help trap allergens so the money is all you're coughing up.

#4: BONUS TIP: Routinely Call Your Favorite Cleaning Service (Ahem...That's Us, Right?)

https://recyclenebraska.org/does-steam-cleaning-carpets-kill-dust-mites/

DUST MITE FACTS

DID YOU KNOW?

Many people are allergic to things like their furry pets, dust, and smelly socks (just kidding on that last one).

But the most common thing people are allergic to in the home is dust mite allergen.

This dust mite image is hundreds of times larger than an actual dust mite. In fact, several of them could fit on the period at the end of this sentence.

Dust mites live in almost everyone's bedding, pillows, and mattresses. There are some people who are allergic to the waste material left behind by these creatures. Gross, huh?

Dust mites are very sensitive to dry air and light, so keeping the humidity level low can actually kill them.

Dust mites do not have eyes; they don't need them. All they need is a warm, moist environment to feed on you - well, actually they feed on the dead skin cells which flake off your body everyday.

SUPERPOWERS:

Irritates your nose, eye, and lungs, leading to congestion, coughing, and itching.

SECRET HIDEOUTS:

Lives on your bed, in your pillow, or even on your favorite chair.

THE BEST DEFENSE

Your doctor can determine if you are allergic to dust mites and prescribe medications or immunotherapy to control your reactions.

Encase your pillows, mattresses, and box springs in comfortable, zippered mite-proof covers to reduce your exposure. Also, wash all bedding in hot water.

LET US HELP!

ALLERGYcenter of SpartanburgENT

Call us at 864-582-2900 or visit us on the web at www.spartanburgent.com.

Contaminate Removal

1. Identify the Contaminate

2. Identify the Sources

3. Understand the Risk and Implement Controls.

4. Remove or Mitigate Contaminates at the source.

Dust Mite

Mice Feces in an Attic Space

Pollutant	Potential Sources
Environmental Tobacco Smoke	Lighted cigarettes, cigars and pipes
Combustion Contaminants	Furnaces, generators, gas or kerosene space heaters, tobacco products, outdoor air and vehicles, ovens and ranges
Biological Contaminants	Bird droppings, cockroaches or rodents, dust mites on upholstered furniture or carpeting, or body odors
Volatile Organic Compounds (VOCs)	Paints, stains, varnishes, solvents, pesticides, adhesives, wood preservatives, waxes, polishes, cleansers, lubricants, sealants, dyes, air fresheners, fuels, plastics, copy machines, printers, tobacco products, perfumes, and dry cleaned clothing
Formaldehyde	Particle board, plywood, cabinetry, furniture and fabrics
Soil gases (radon, sewer gas, VOCs, methane)	Soil and rock (radon), sewer drain leak, dry drain traps, leaking underground storage tanks, and land fills
Pesticides	Termiticides, insecticides, rodenticides, fungicides, disinfectants and herbicides
Particles and Fibers	Printing, paper handling, smoking and other combustion, outdoor sources, deterioration of materials, construction/renovation, vacuuming, and insulation

Health Problems Caused by Volatile Organic Compounds (VOCs)

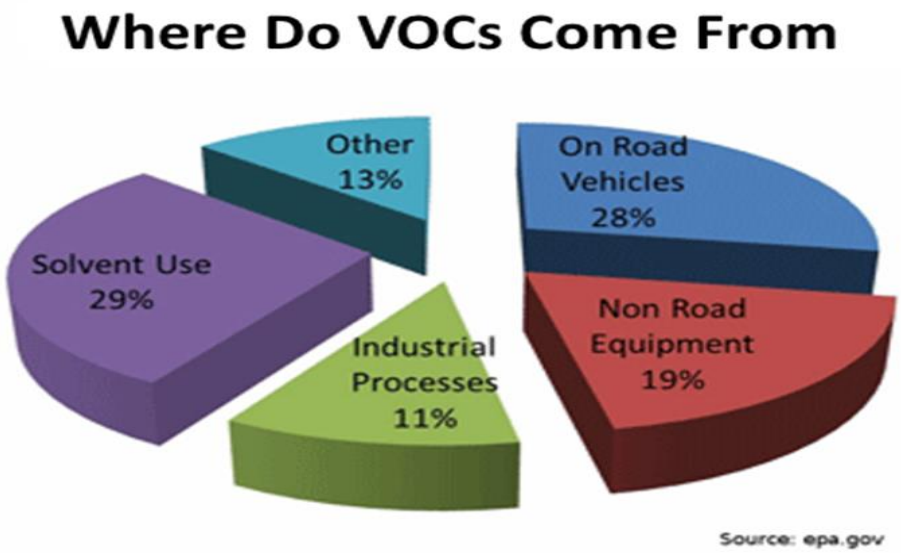
Immediate or Acute Health Effects:

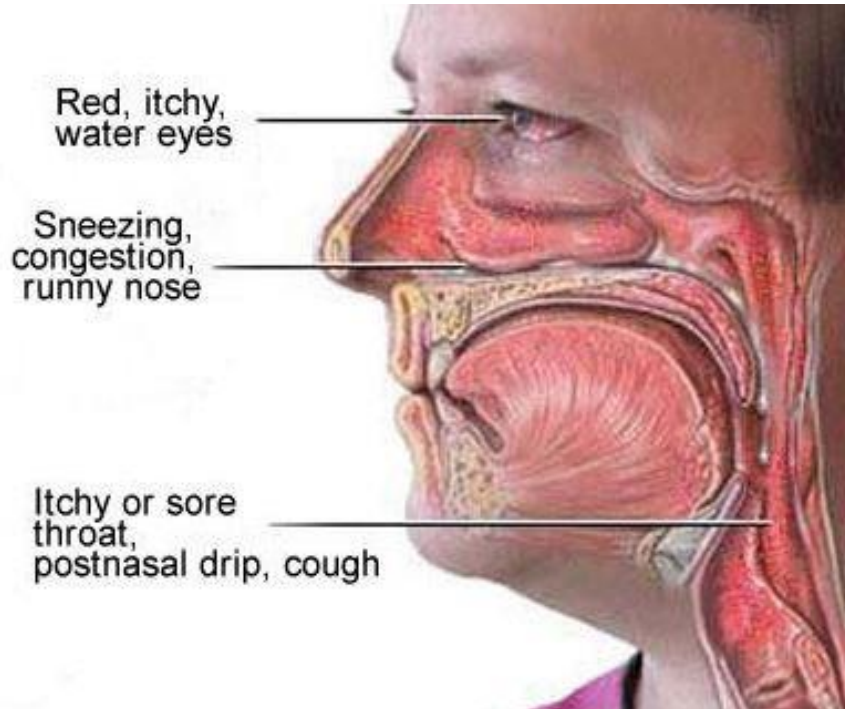
- Headaches
- Eye, nose & throat irritation
- Allergic Skin reaction
- Difficulty breathing
- Nausea &/or vomiting
- Confusion
- Loss of coordination
- Dizziness
- Fatigue
- Nosebleeds

Long-term Chronic Health Effects:

- Damage to the heart, liver or kidneys
- Damage to the central nervous system
- Cancer

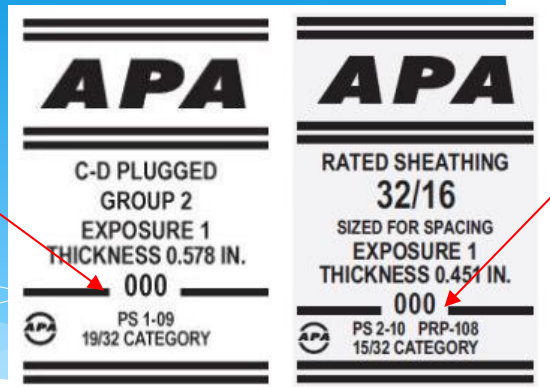
http://greenguard.org/en/indoorAirQuality/iaq_healthImpacts.aspx





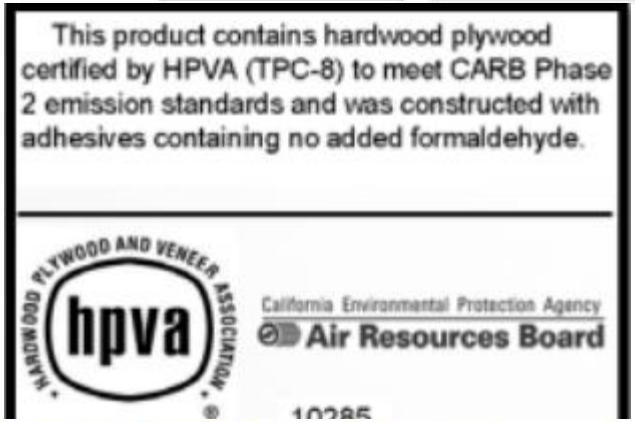
How to Find Indoor EPA airPLUS Compliant Low-Emission Products

- http://www.apawood.org/plywood



- http://www.hpva.org/sites/default/files/CARB%20TPC8%20LIST%202015-6- 4.pdf

- http://productguide.ulenvironment.com/SearchResults.aspx?CertificationID=1



- http://www.kcma.org/Members/ESP_Certified_Manufacturers

- https://www.epa.gov/sites/production/files/2015-10/documents/how_to_find_compliant_low_emission_products_508.pdf

- https://www.epa.gov/sites/production/files/2018-03/documents/indoor_airplus_construction_specifications.pdf

Formaldehyde

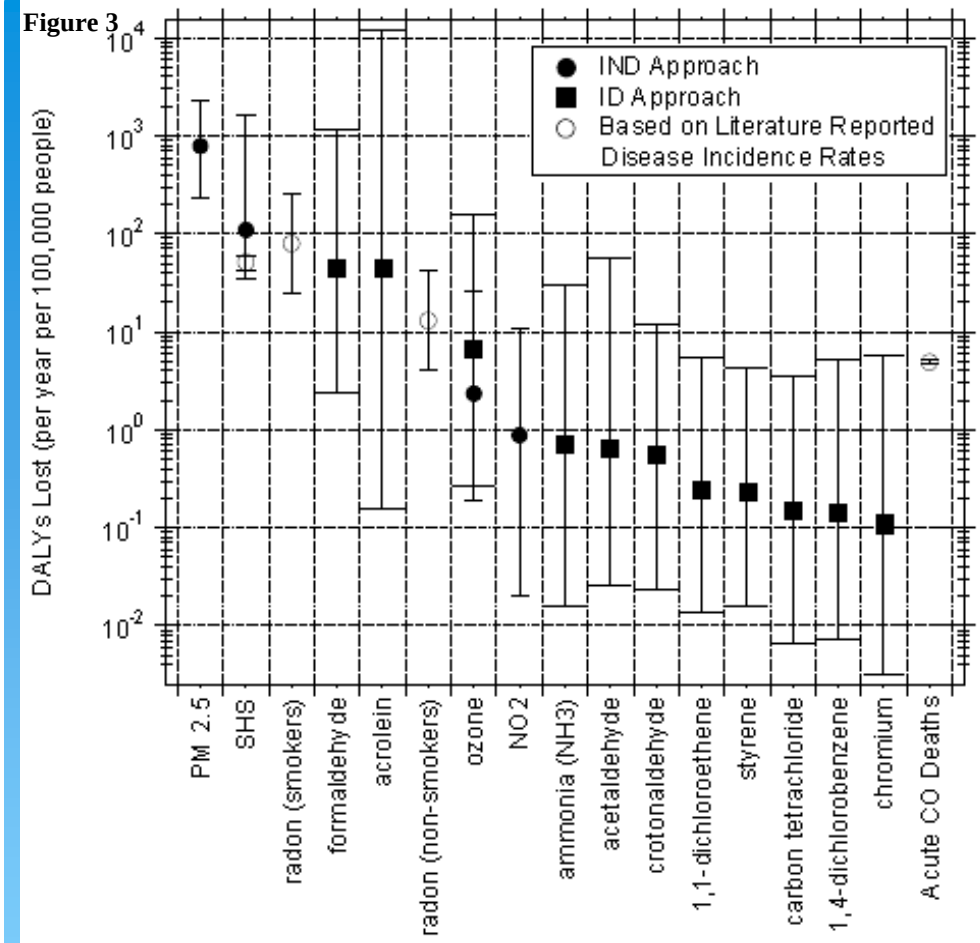
"As formaldehyde resins are used in many construction materials it is one of the more common indoor air pollutants. At concentrations above 0.1 ppm in air formaldehyde can irritate the eyes and mucous membranes, resulting in watery eyes. Formaldehyde inhaled at this concentration may cause headaches, a burning sensation in the throat, and difficulty breathing, and can trigger or aggravate asthma symptoms. A 1988 Canadian study of houses with urea-formaldehyde foam insulation found that formaldehyde levels as low as 0.046 ppm were positively correlated with eye and nasal irritation. A recent review of studies has shown a strong association between exposure to formaldehyde and the development of childhood asthma. The primary exposure concern is for the workers in the industries producing or using formaldehyde."

https://en.wikipedia.org/wiki/Formaldehyde

Formaldehyde Mitigation

* **Use NAF or ULEF products and properly ventilate your home.**
* Look for products labeled by manufacturers as **"California 93120 Compliant for Formaldehyde"** or **"California Phase 2 Compliant,"** as well as **"No added formaldehyde" (NAF)** or **"Ultra low-emitting formaldehyde" (ULEF).**
* Mills that have been identified by a CARB-approved Third Party Certifier as producers of CARB compliant composite wood products: http://www.arb.ca.gov/toxics/compwood/tpc/listofmills.htm List of approved No added formaldehyde (NAF) or Ultra low-emitting formaldehyde (ULEF) mills: http://www.arb.ca.gov/toxics/compwood/naf_ulef/listofnaf_ulef.htm

Figure 3



The Impact!

Figure 3: Estimated population averaged annual cost, in DALYs, of chronic air pollutant inhalation in U.S. residences; results for the 12 pollutants with highest median DALY estimates.

The markers represent the central estimate and the whiskers extend to the 95th percentile CI. The square marker indicates pollutant DALYs calculated using the Intake-DALYs (ID) approach.

The circle markers indicate the DALYs calculated using the Intake-Incidence-DALYs (IND) approach. Radon, acute CO deaths, and SHS

DALYs were calculated using disease incidence rates attributed to them in the literature.

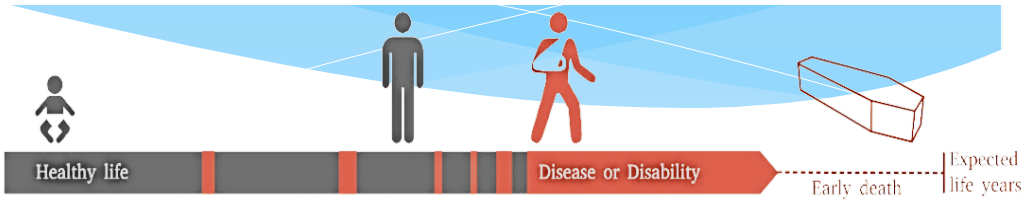
Logue JM, Price PN, Sherman MH, Singer BC, 2011 A Method to Estimate the Chronic Health Impact of Air Pollutants in U.S. Residences. Environ Health Perspectives doi:10.1289/ehp.1104035 LBNL- 5267E

DALY

The disability-adjusted life year (DALY) is a measure of overall disease burden, expressed as the number of years lost due to ill-health, disability or early death

= YLD Years Lived with Disability

+ YLL Years of Life Lost

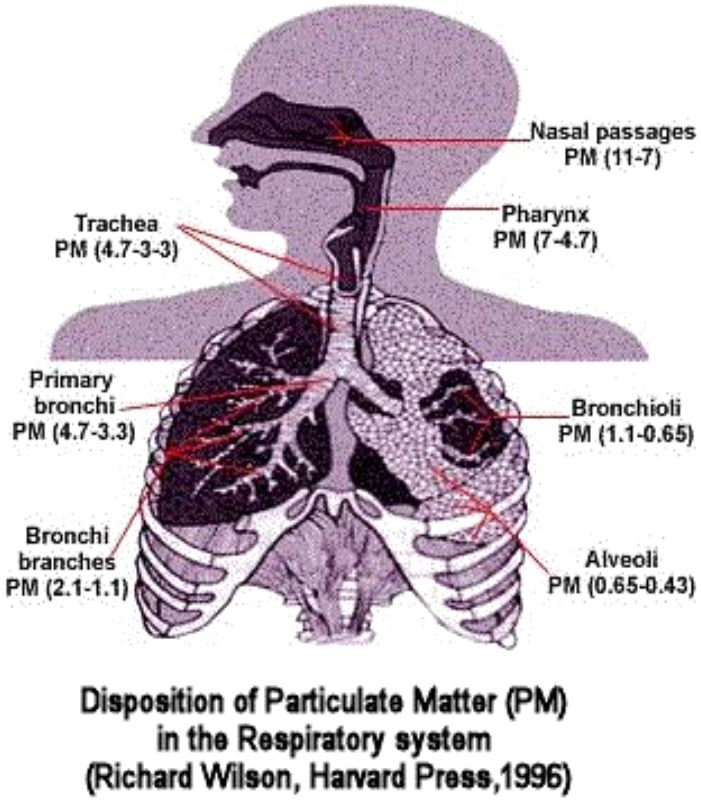


"Particle pollution includes:

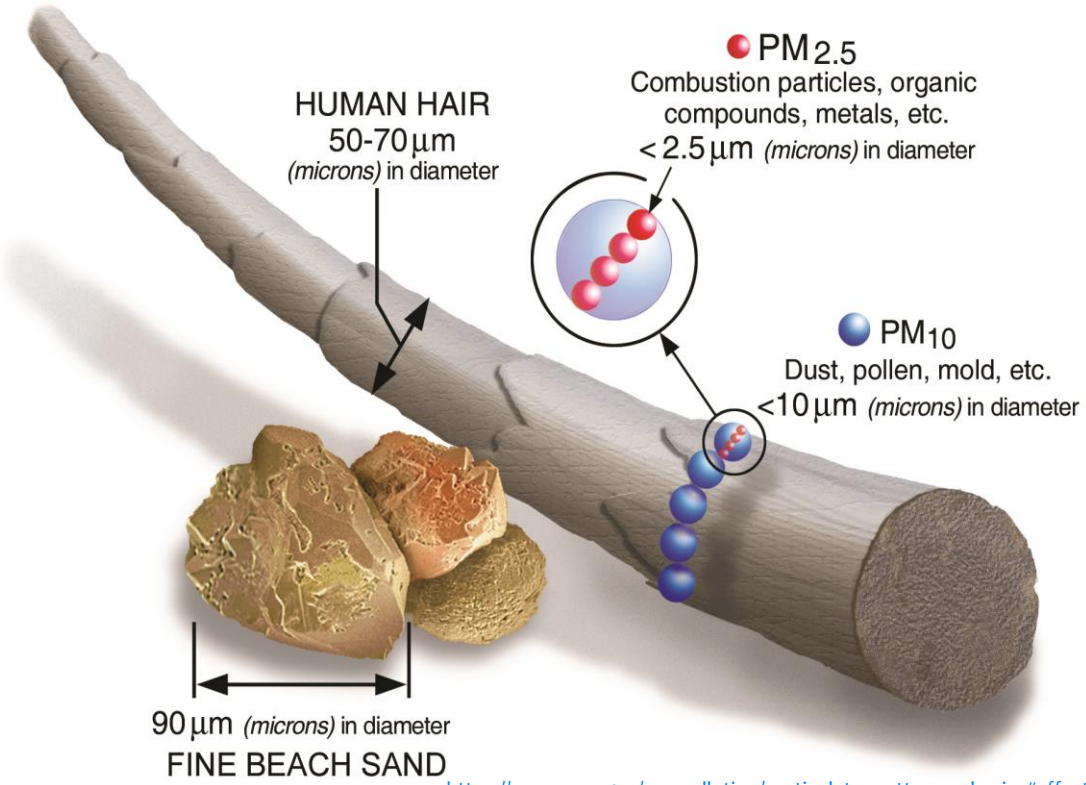
PM_{10} : inhalable particles, with diameters that are generally 10 micrometers and smaller; and

$PM_{2.5}$: fine inhalable particles, with diameters that are generally 2.5 micrometers and smaller.

How small is 2.5 micrometers? Think about a single hair from your head. The average human hair is about 70 micrometers in diameter – making it 30 times larger than the largest fine particle." https://www.epa.gov/pm-pollution/particulate-matter-pm-basics#effects



Disposition of Particulate Matter (PM) in the Respiratory system (Richard Wilson, Harvard Press,1996)



http://www.cleanairtas.com/smoke/smoke-is-toxic.htm

https://www.epa.gov/pm-pollution/particulate-matter-pm-basics#effects

Indoor PM Sources

Indoor PM can be generated through cooking, combustion activities including burning of candles, use of fireplaces, use of unvented space heaters or kerosene heaters, cigarette smoking, particles and some hobbies. Indoor PM can also be of biological origin or particles of outdoor origin.

Steps to Reduce Exposure to Indoor PM

- ❑ Vent all fuel-fired combustion appliances to the outdoors (including stoves, heaters and furnaces)
- ❑ Install and use exhaust fans vented to the outside when cooking
- ❑ Avoid the use of unvented stoves, fireplaces or space heaters indoors. If you must use unvented appliances follow manufacturers' instructions especially related to ventilation..
- ❑ Choose properly sized woodstoves, certified to meet EPA emission standards; make certain that doors on all woodstoves fit tightly.
- ❑ Use appropriate wood in stoves and fireplaces. Check EPA's Burn Wise program for Safe Wood-burning Practices
- ❑ Have a trained professional inspect, clean and tune-up central heating system (furnace, flues and chimneys) annually. Repair any leaks properly.
- ❑ Change filters on central heating and cooling systems and air cleaners according to manufacturer's directions.

https://www.epa.gov/indoor-air-quality-iaq/indoor-particulate-matter#indoor_pm

About the Indoor airPLUS Construction Specifications

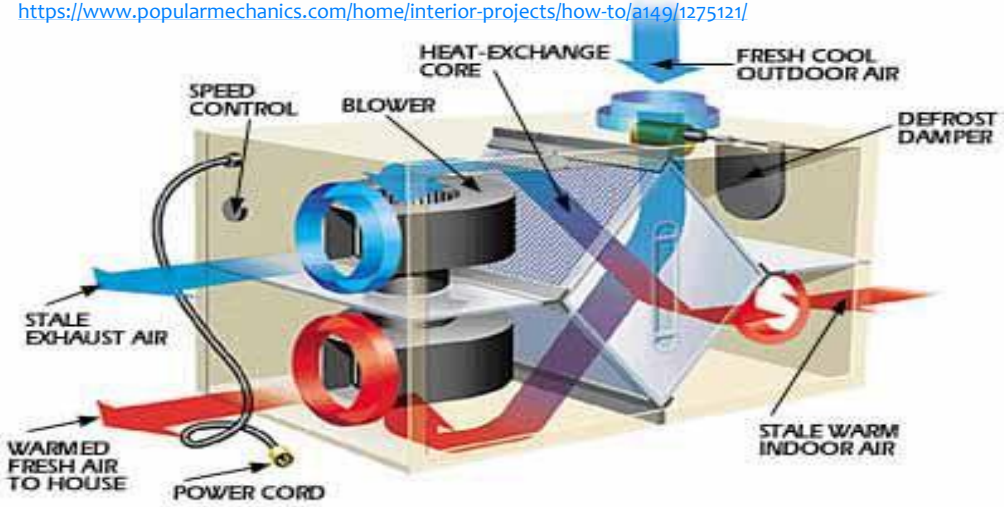
These specifications were developed by the EPA to recognize new homes equipped with a comprehensive set of Indoor Air Quality (IAQ) features. For more information, visit epa.gov/indoorairplus

How to Qualify a Home for the Indoor airPLUS Label

Homes that comply with these specifications and are verified with a completed Indoor airPLUS Verification Checklist can use Indoor airPLUS as a complementary label to ENERGY STAR for New Homes. ***Only ENERGY STAR qualified homes are eligible for this label.*** Verification can be completed during the ENERGY STAR inspection process, and must be conducted in accordance with Residential Energy Services Network (RESNET) Standards by a RESNET-accredited provider and must meet all applicable codes. Instructions for Indoor airPLUS verification are on the back page of the Verification Checklist.

Ventilation Systems

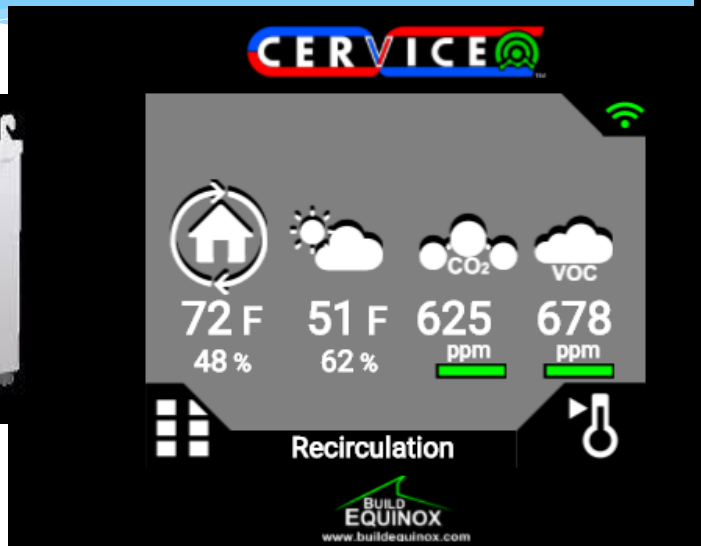
https://www.popularmechanics.com/home/interior-projects/how-to/a149/1275121/



Panasonic Exhaust Fan

HRVs or HRVs with a Heat pump

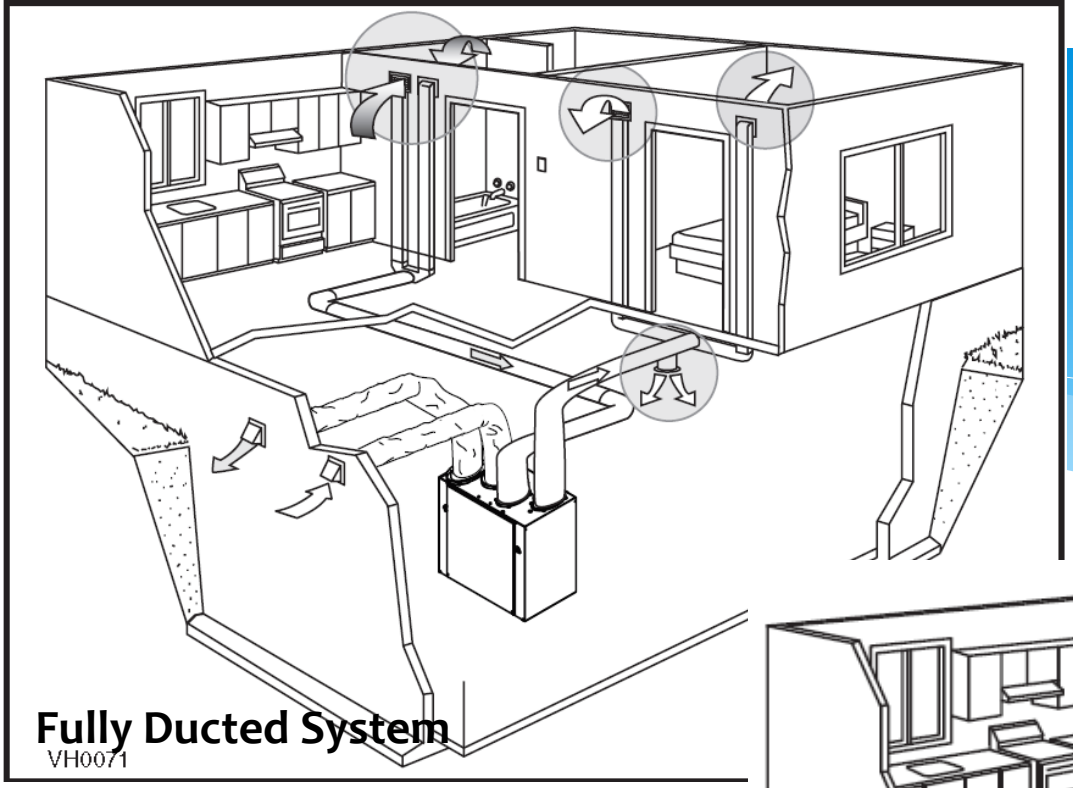
https://www.minotair.com/minotair-pentacare-v12_en/



CERV by Build Equinox

http://www.greenbuildingadvisor.com/articles/dept/musings/balanced-ventilation-system-built-heat-pump

HRV Installation & Balancing

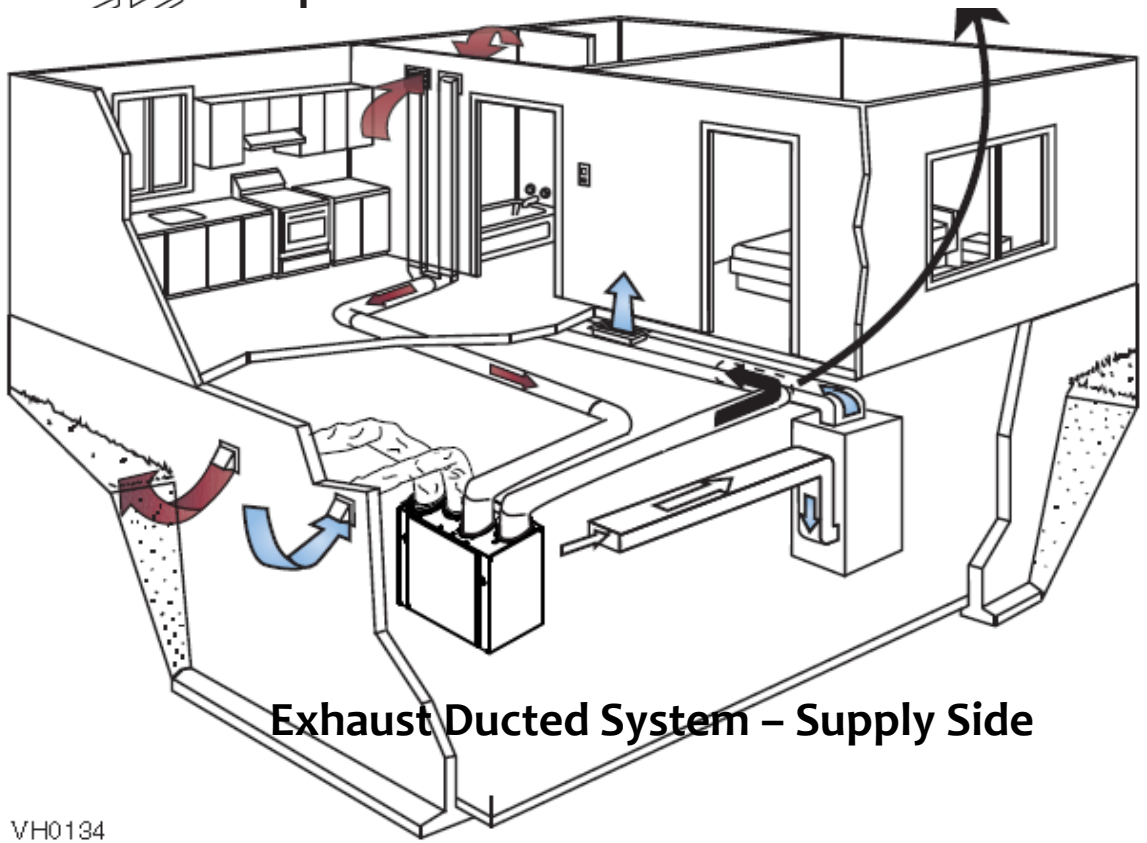


Fully Ducted System

VH0071

HRV Balancing is critical to:

- Improve Comfort
- System Performance
- Reduced Maintenance
- Reduce impact to Building Envelope
- Verification of ASHREA compliance
- Reduced noise and vibration

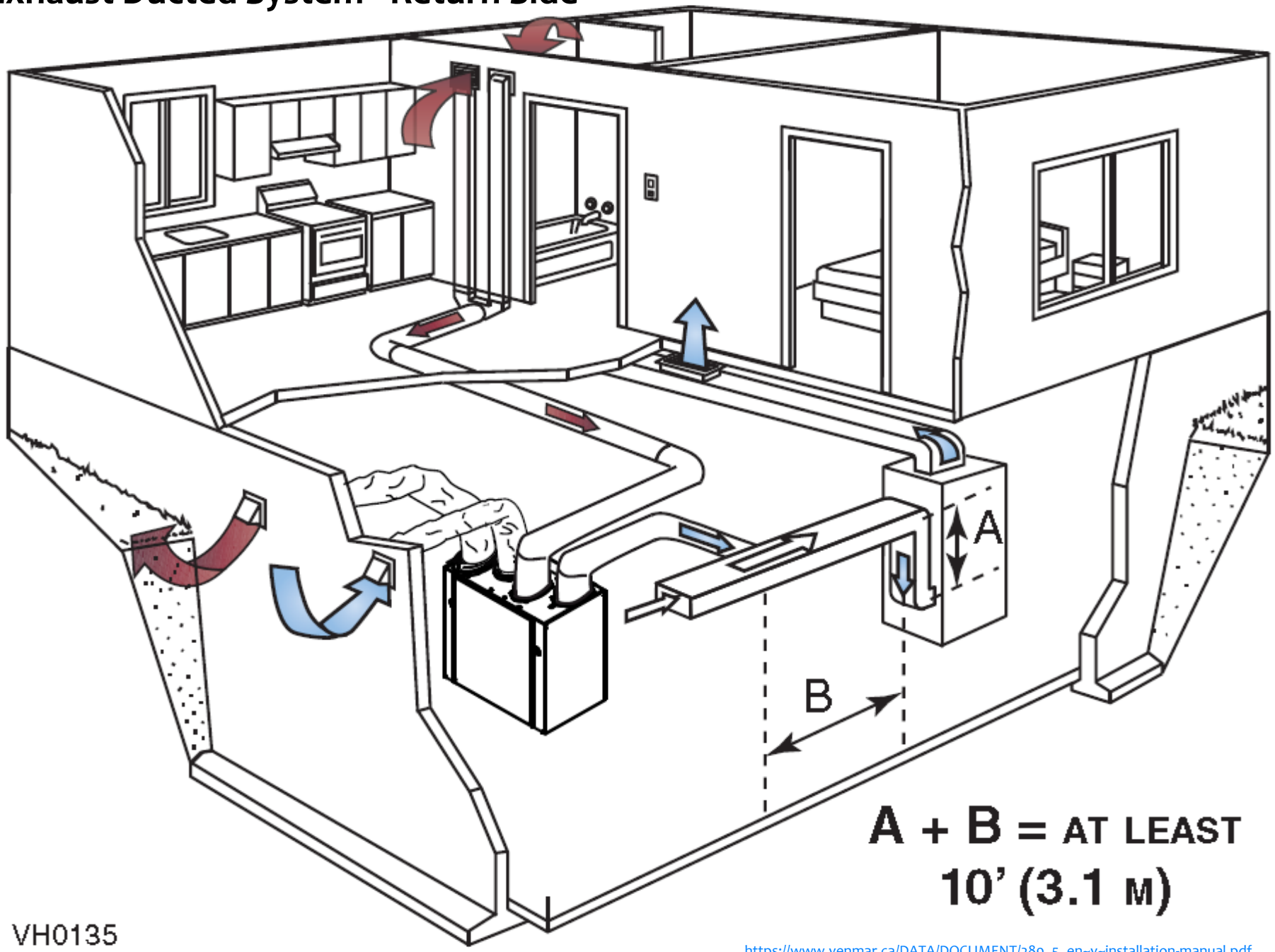


Exhaust Ducted System – Supply Side

VH0134

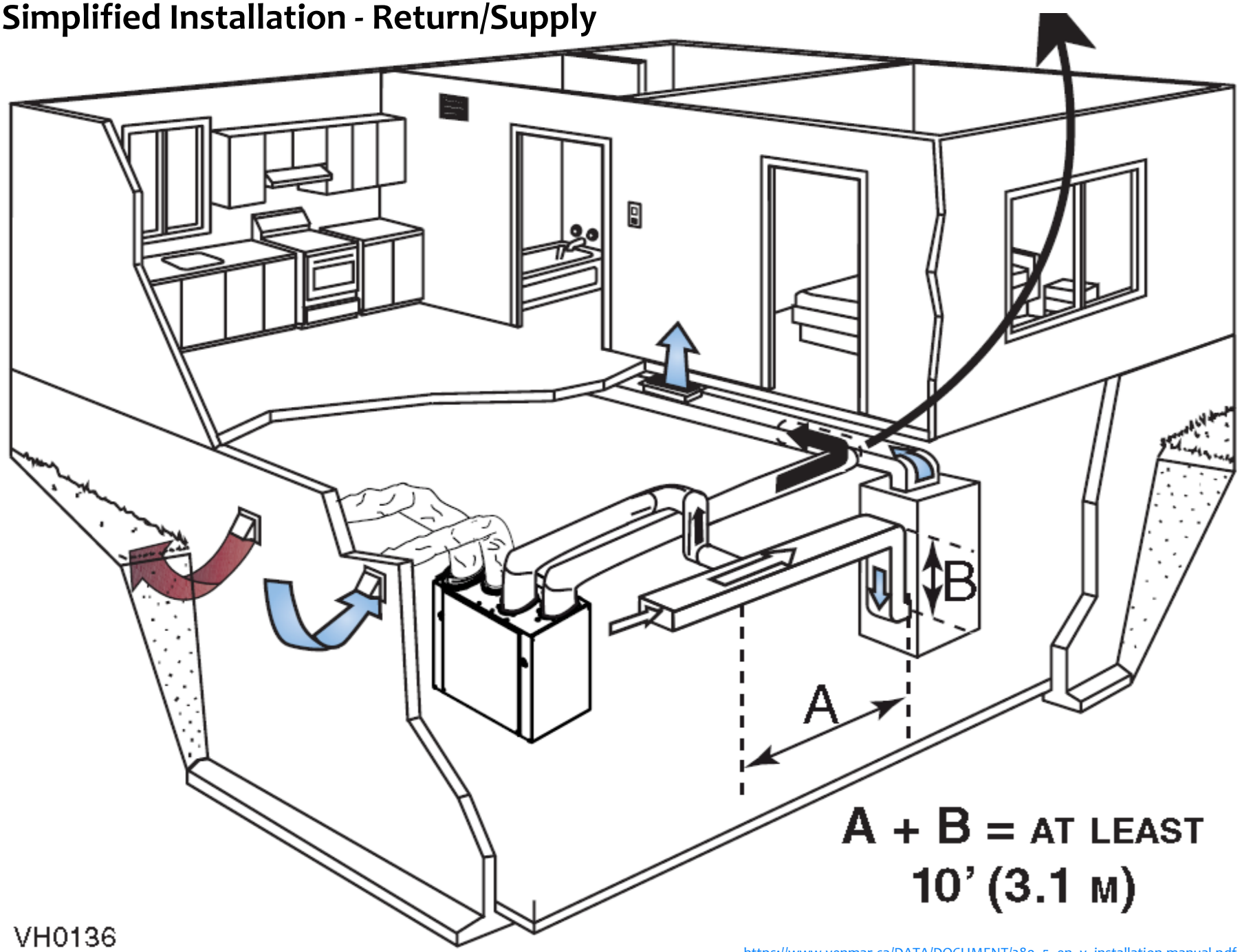
https://www.venmar.ca/DATA/DOCUMENT/289_5_en~v~installation-manual.pdf

Exhaust Ducted System - Return Side



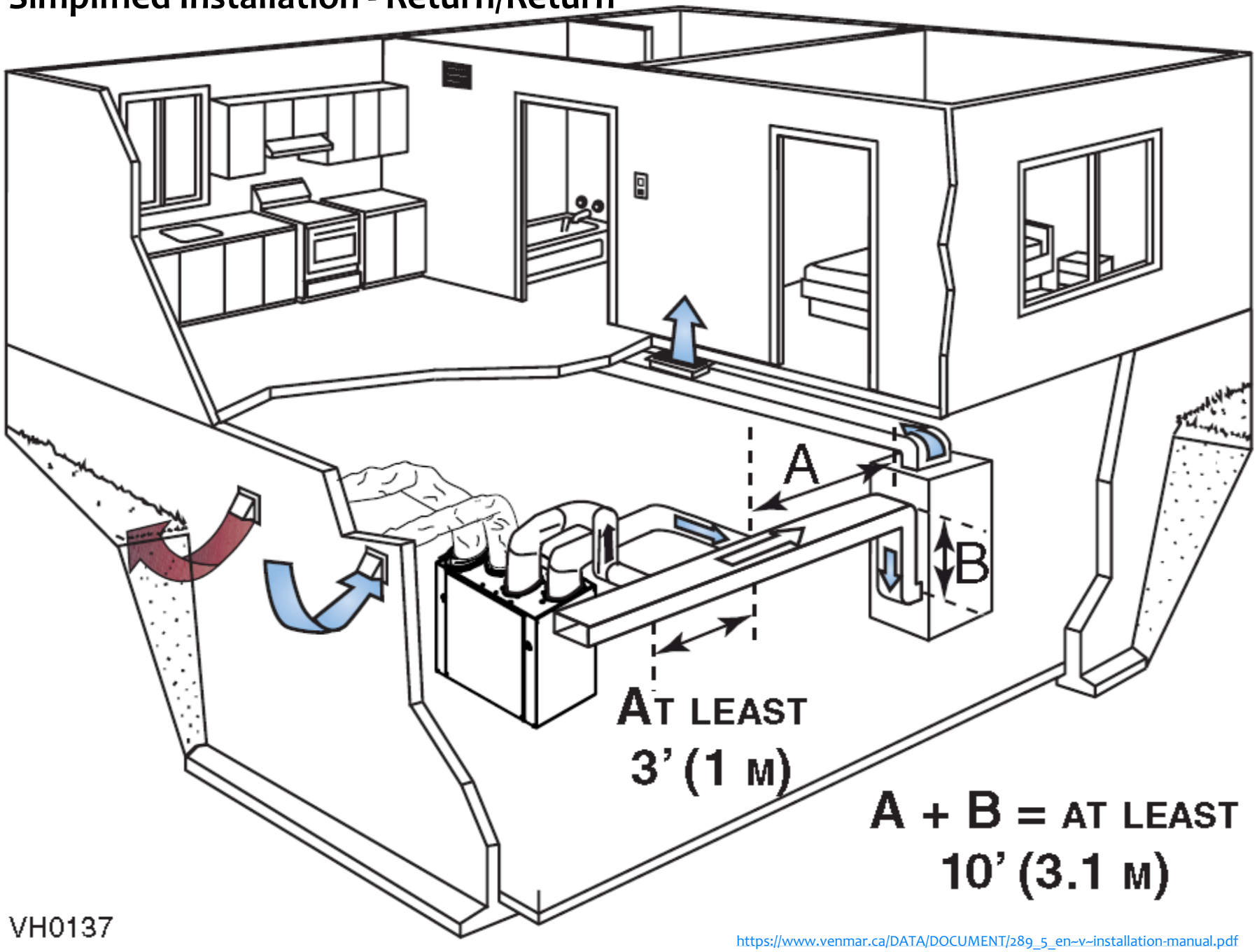
https://www.venmar.ca/DATA/DOCUMENT/289_5_en~v~installation-manual.pdf

Simplified Installation - Return/Supply



https://www.venmar.ca/DATA/DOCUMENT/289_5_en~v~installation-manual.pdf

Simplified Installation - Return/Return



https://www.venmar.ca/DATA/DOCUMENT/289_5_en~v~installation-manual.pdf

Installation Failures

- Failure to Follow Manufacture Recommendations.
- ASHREA 62.2 Adaptations
- 4.3 & 5.4 Failure of the Installer to TAB their own work.
- 6.2 Instructions & Labeling
- 6.4 Exhaust exceeds 15cfm/100ft^2
- 6.7 Minimum Filtration of Supply Air
- BEES Amend. R403.2.4 Ducting shall be smooth walled or be supported along its full length and have sufficient radius,
- Is Flexible ducting necessary?
- Incomplete Work
- Exhaust Dampers painted shut

If we don't test it, we don't know!

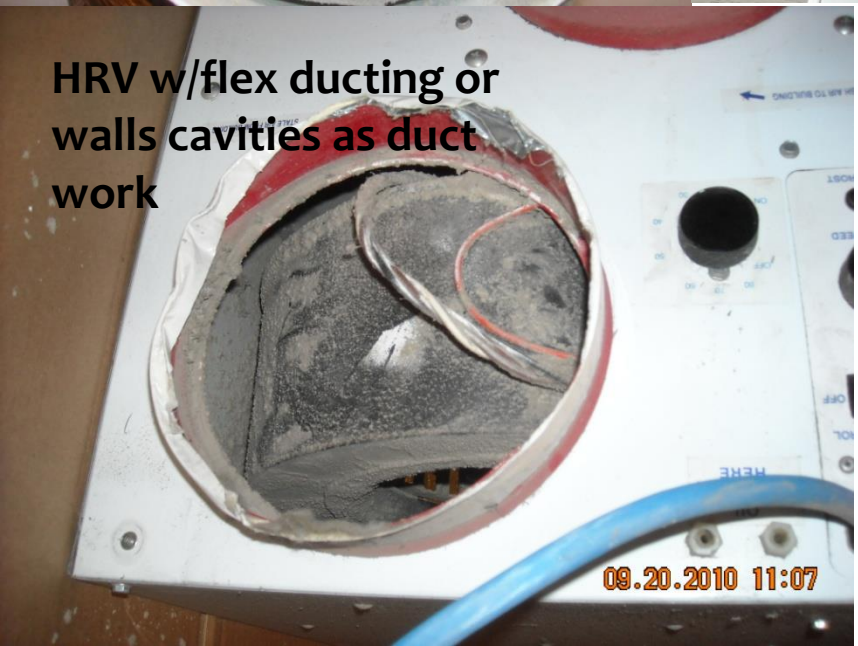
Ventilation Maintenance

* HRV Manufactures recommendations
* Regular Maintenance every 3 months (or Monthly) Including:
  * Cleaning the unit and filters
  * Cleaning the condensation tray
  * Check and clean air intake hoods
* Annual or By-Annual Maintenance (depending on Manufacture)
  * Remove and Clean the Core or Thermal Wheel
  * Remove and clean the fan assembly
  * Check operation of all working parts (Motorized Dampers)
  * Clean Duct Work Annually if required (depending on Manufacture)

Maintenance Failures

Inside flex ducting

HRV Intakes & Exhaust



HRV w/flex ducting or walls cavities as duct work

Bee Hive in bath fan ducting

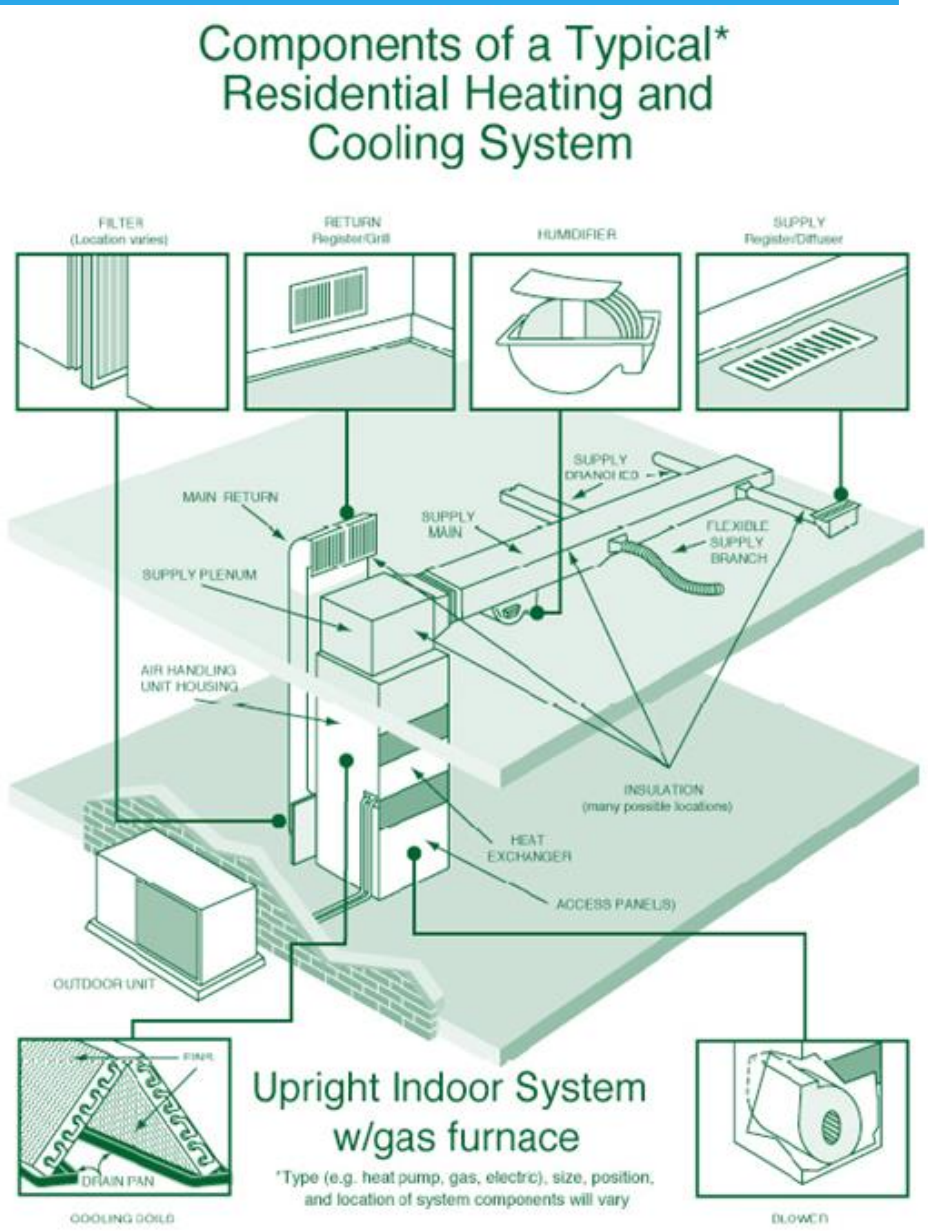
Filtration is Necessary!

Should You Have your Ducts Cleaned?

You Should Consider having the air ducts in your home cleaned if:

- ❑ There is substantial visible mold growth is present in hard surface (e.g., sheet metal) ducts or on other components of your heating and cooling system.
- ❑ Ducts are infested with vermin (e.g., rodents or insects)
- ❑ Ducts are clogged with excessive amounts of dust and debris and/or particles are actually released into the home from your supply registers.
- ❑ Your IAQ or health is impacted by elevated PM10 or PM2.5 because of Asthmatic Symptoms

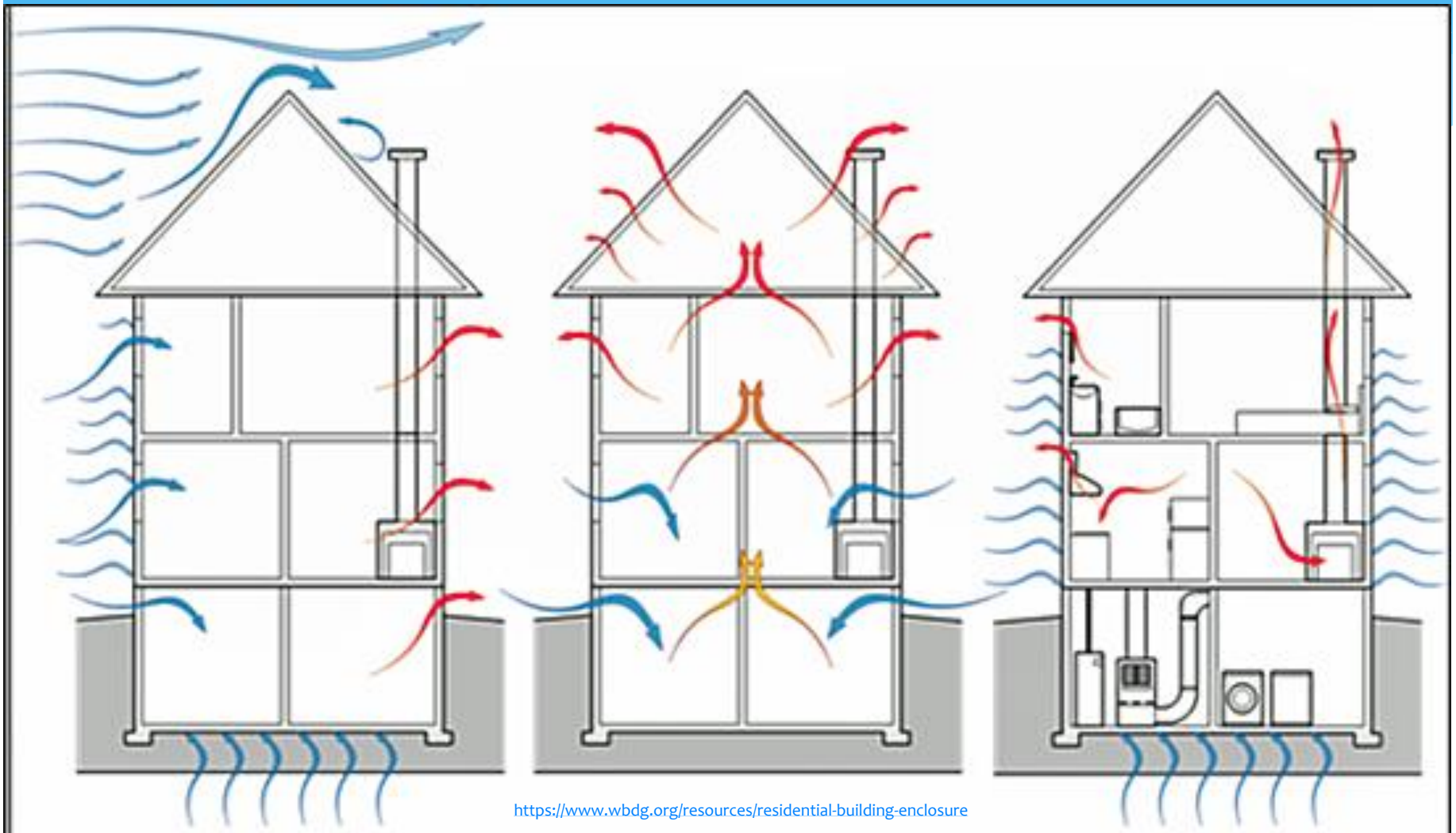
https://www.epa.gov/sites/production/files/2014-07/documents/airducts.pdf



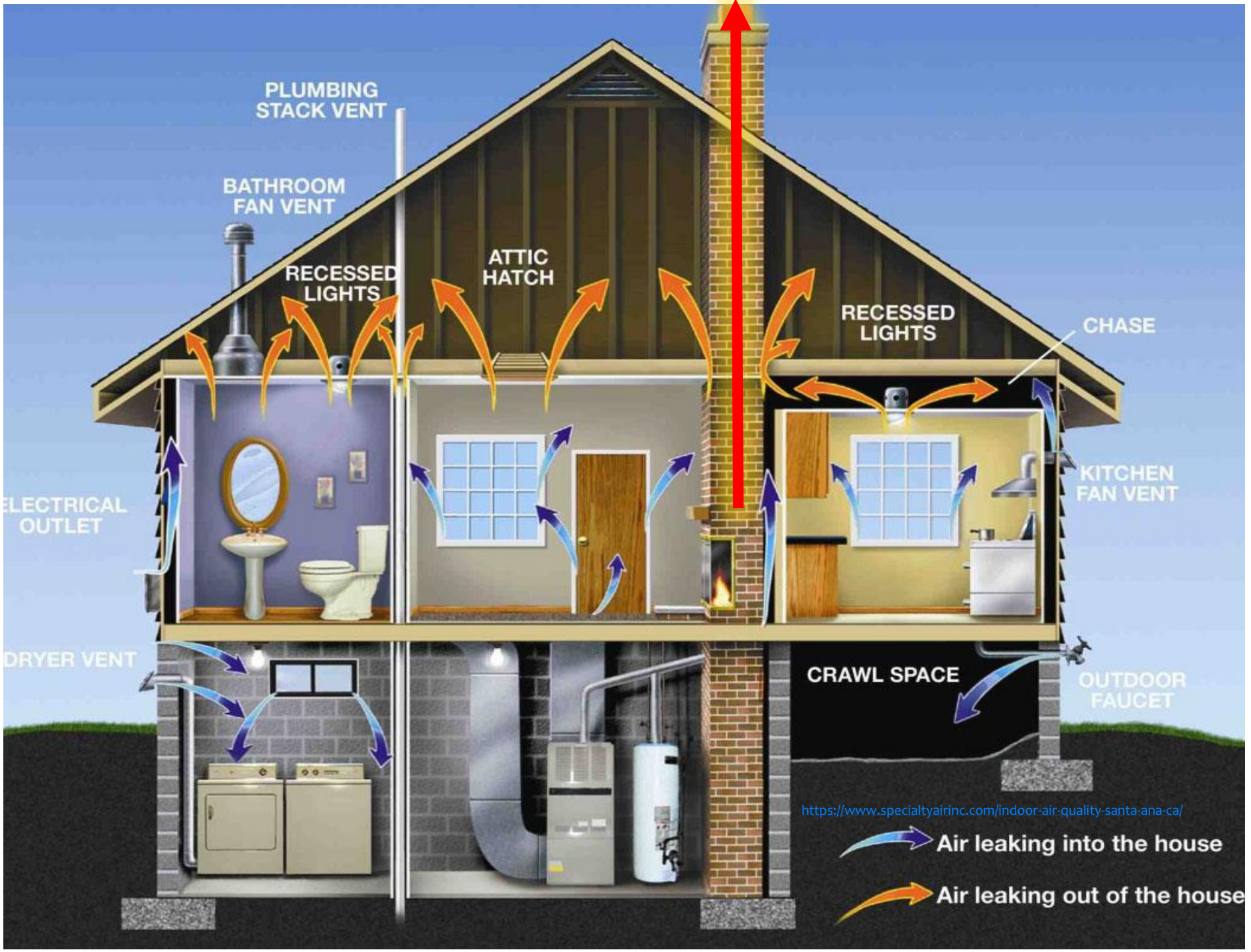
Filtration

* ***MERV = Minimum Efficiency Reporting Value.*** Regulated by standards set by ASHRAE, furnace filter contains a MERV rating.
* MERV ratings range from 1-16, and the rating is designed to measure the *worst-case* performance of a rated air filter on particles in the size range of:
* .3 to 10 micron range (known as E_3),
* 1.0-3.0 micron range (known as E_2), and
* .3-1.0 micron range (known as E_1).
* See Table below

The Building Effect

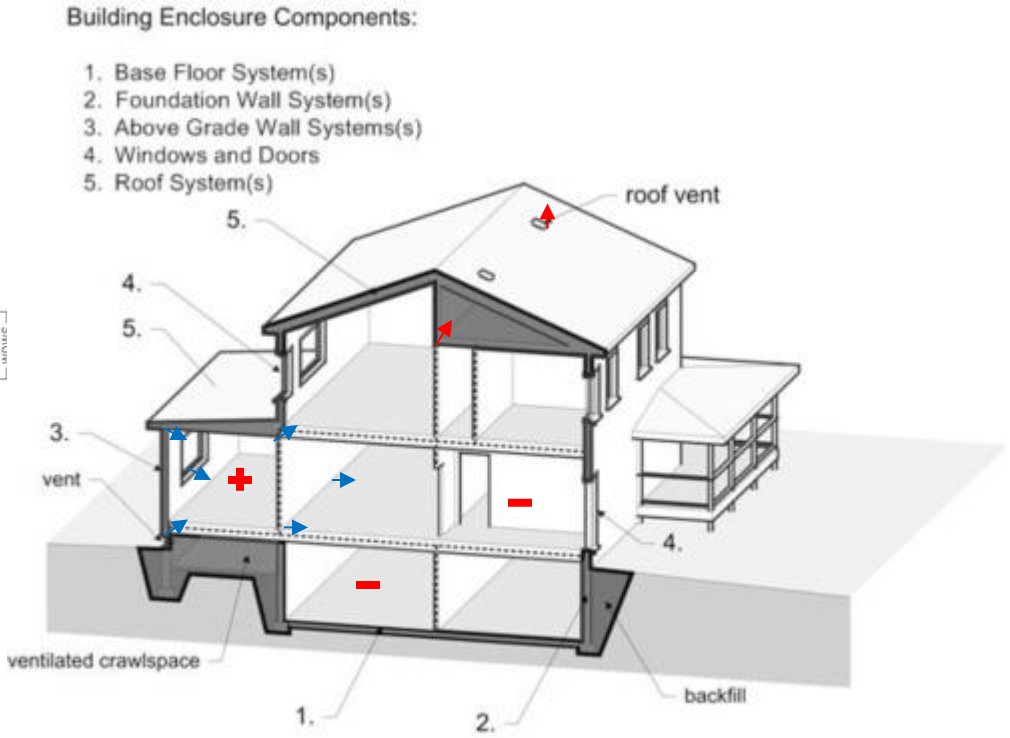


https://www.wbdg.org/resources/residential-building-enclosure


PLUMBING STACK VENT
BATHROOM FAN VENT
RECESSED LIGHTS
ATTIC HATCH
RECESSED LIGHTS
CHASE
KITCHEN FAN VENT
ELECTRICAL OUTLET
DRYER VENT
CRAWL SPACE
OUTDOOR FAUCET
https://www.specialtyairinc.com/indoor-air-quality-santa-ana-ca/
Air leaking into the house
Air leaking out of the house

Attached Garage Spaces

https://www.cnceptz.com/house-plans-with-attached-garage/



Garage Ventilation is Recommended

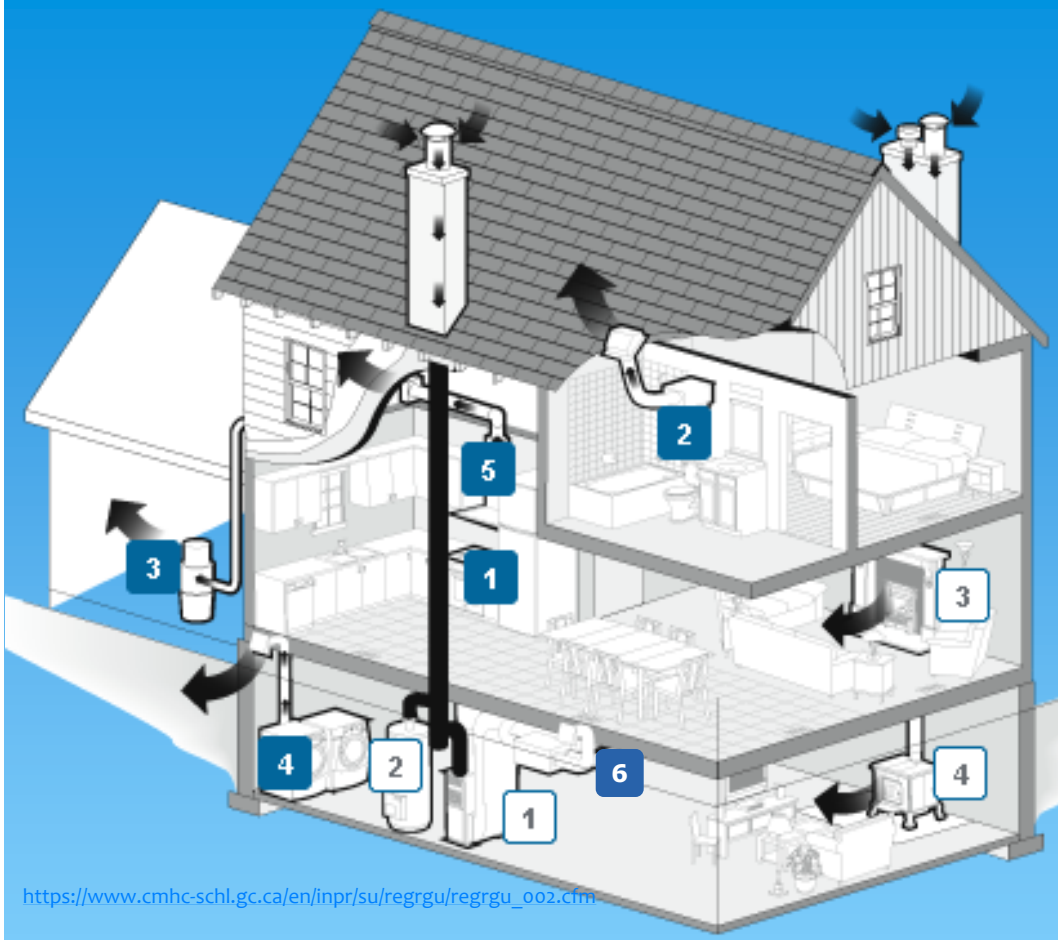
https://buildingscience.com/documents/digests/bsd-018-the-building-enclosure_revised

Building Enclosure

Interior Spatial Separators

Combustion Safety

Some appliances can cause depressurization within the home. A newly installed kitchen range hood or down draft can exhaust anywhere from 100cfm to 600cfm of air out of the house and cause a back draft condition and potentially life threatening condition in the home.



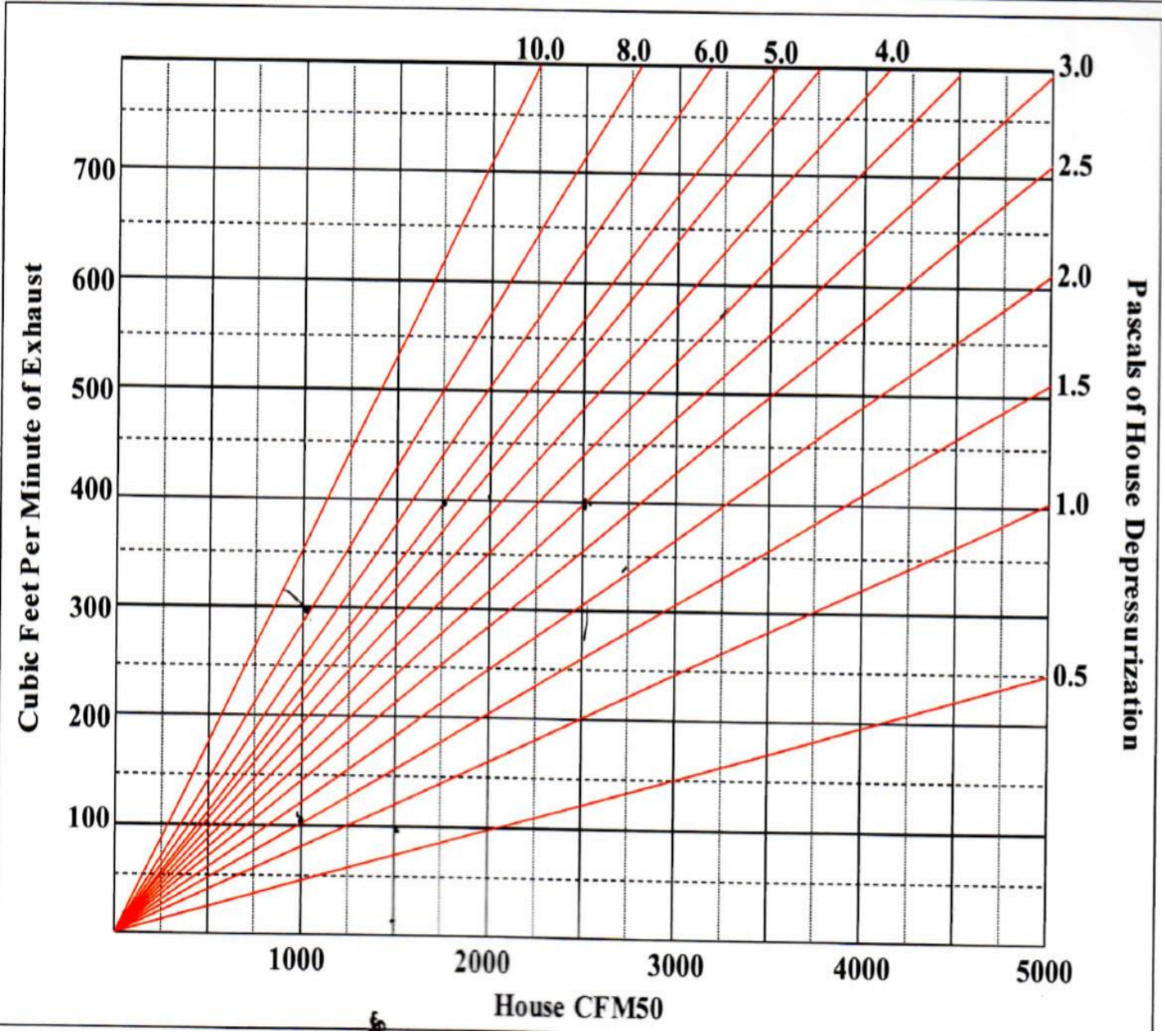
https://www.cmhc-schl.gc.ca/en/inpr/su/regrgu/regrgu_002.cfm

Spillage-susceptible Appliances

1. Natural draft furnaces
2. Natural draft water heaters
3. Fireplaces
4. Wood stoves
5. Power/Induced Draft Appliances

Depressurizing appliances

1. Downdraft cooktops
2. Exhaust fans
3. Central vacuums
4. Dryers
5. Range hoods
6. Duct Leakage



Dryers = 125-300cfm

Bathroom = 50-150cfm

Kitchen=100-400cfm

Woodstoves=100-300 cfm

Fire Places = 300+CFM

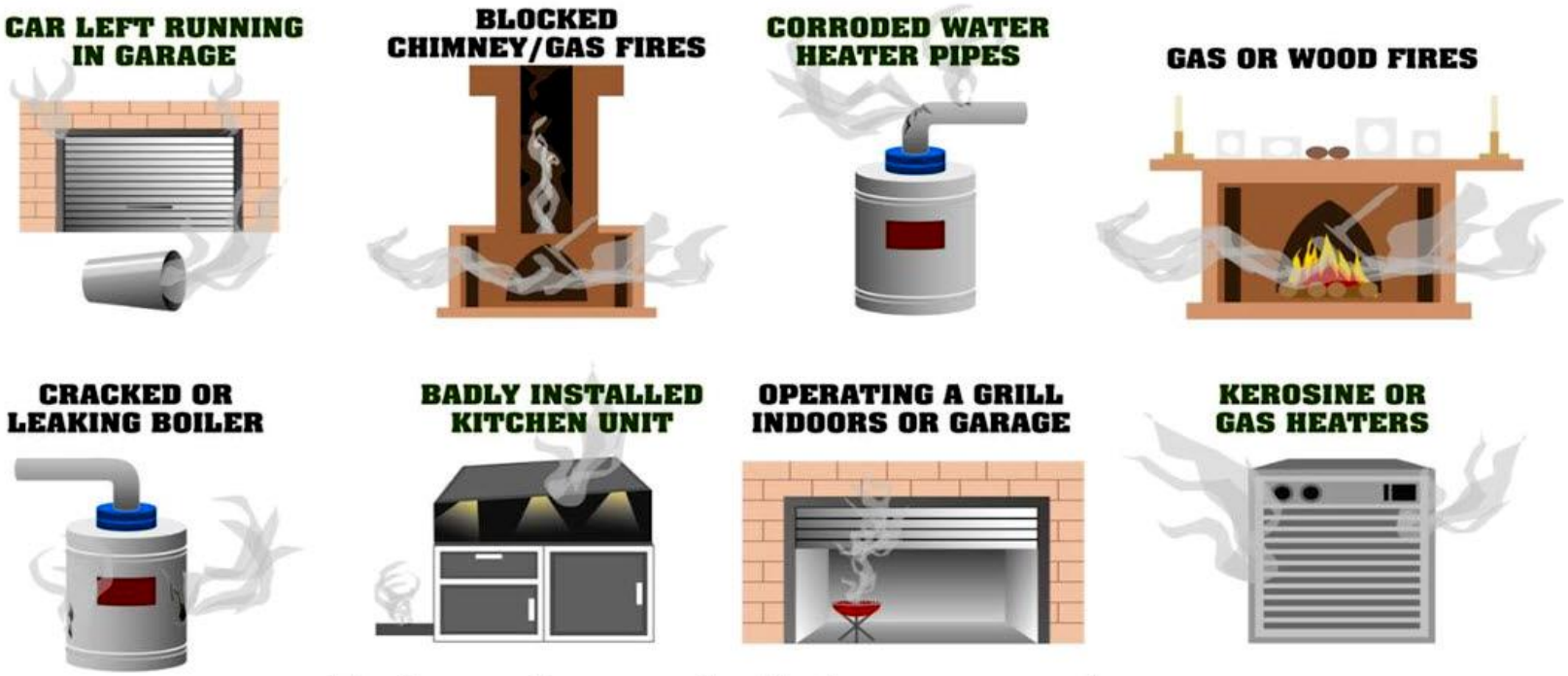
Duct Leakage = ?

Zone Pressure Imbalances = ?

Your House's CFM50#

????

Carbon Monoxide Sources



Source: http://en.wikipedia.org/wiki/carbon_monoxide_poisoning

Ovens and Ventilation

Berkeley Lab's Tips for Buying and Using Range Hoods

- **Turn on the hood** every time you cook, and set the fan to the highest setting that the noise is tolerable.
- Make sure it vents to the outdoors. If it doesn't, the hood will simply recirculate air in the kitchen.
- If your range hood does not extend over the front burners, cooking on the back burners could make the hood up to twice as effective at removing pollutants.
- If buying a new hood, it should cover your front burners and have a setting that moves at least **200 cubic feet** of air per minute.
- **If having a range hood is not possible, opening a window while cooking does help.**

http://newscenter.lbl.gov/2013/07/23/kitchens-can-produce-hazardous-levels-of-indoor-pollutants/

Formaldehyde exposure by inhalation happens through **3 main sources**: thermal or chemical decomposition of formaldehyde-based resins, emission from aqueous formaldehyde solutions (i.e. embalming fluids), and the production of formaldehyde resulting from the combustion of a variety of organic compounds (for example, exhaust gases).

https://en.wikipedia.org/wiki/Formaldehyde

TABLE 1.4-2. EMISSION FACTORS FOR CRITERIA POLLUTANTS AND GREENHOUSE GASES FROM NATURAL GAS COMBUSTION[a]

Pollutant	Emission Factor ($lb/10^6$ scf)	Emission Factor Rating
CO_2[b]	120,000	A
Lead	0.0005	D
N_2O (Uncontrolled)	2.2	E
N_2O (Controlled-low-NO_X burner)	0.64	E
PM (Total)[c]	7.6	D
PM (Condensable)[c]	5.7	D
PM (Filterable)[c]	1.9	B
SO_2[d]	0.6	A
TOC	11	B
Methane	2.3	B
VOC	5.5	C

a) Reference 11. Units are in pounds of pollutant per million standard cubic feet of natural gas fired. Data are for all natural gas combustion sources. To convert from lb/106 scf to kg/106 m3 , multiply by 16. To convert from lb/106 scf to 1b/MMBtu, divide by 1,020. The emission factors in this table may be converted to other natural gas heating values by multiplying the given emission factor by the ratio of the specified heating value to this average heating value. TOC = Total Organic Compounds. VOC = Volatile Organic Compounds.

b) Based on approximately 100% conversion of fuel carbon to CO2. CO2[lb/106 scf] = (3.67) (CON) (C)(D), where CON = fractional conversion of fuel carbon to CO2, C = carbon content of fuel by weight (0.76), and D = density of fuel, 4.2x104 lb/106 scf.

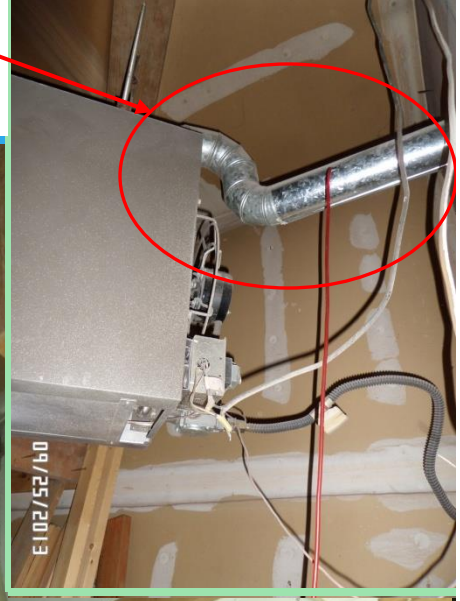
c) All PM (total, condensable, and filterable) is assumed to be less than 1.0 micrometer in diameter. Therefore, the PM emission factors presented here may be used to estimate PM10, PM2.5 or PM1 emissions. Total PM is the sum of the filterable PM and condensable PM. Condensable PM is the particulate matter collected using EPA Method 202 (or equivalent). Filterable PM is the particulate matter collected on, or prior to, the filter of an EPA Method 5 (or equivalent) sampling train.

d) Based on 100% conversion of fuel sulfur to SO2. Assumes sulfur content is natural gas of 2,000 grains/106 scf. The SO2 emission factor in this table can be converted to other natural gas sulfur contents by multiplying the SO2 emission factor by the ratio of the site-specific sulfur content (grains/106 scf) to 2,000 grains/106 scf.

e) The rate of VOC emissions from boilers and furnaces also depends on combustion efficiency. VOC emissions are minimized by combustion practices that promote high combustion temperatures, long residence times at those temperatures, and turbulent mixing of fuel and combustion air. Trace amounts of VOC species in the natural gas fuel (e.g., formaldehyde and benzene) may also contribute to VOC emissions if they are not completely combusted in the boiler.

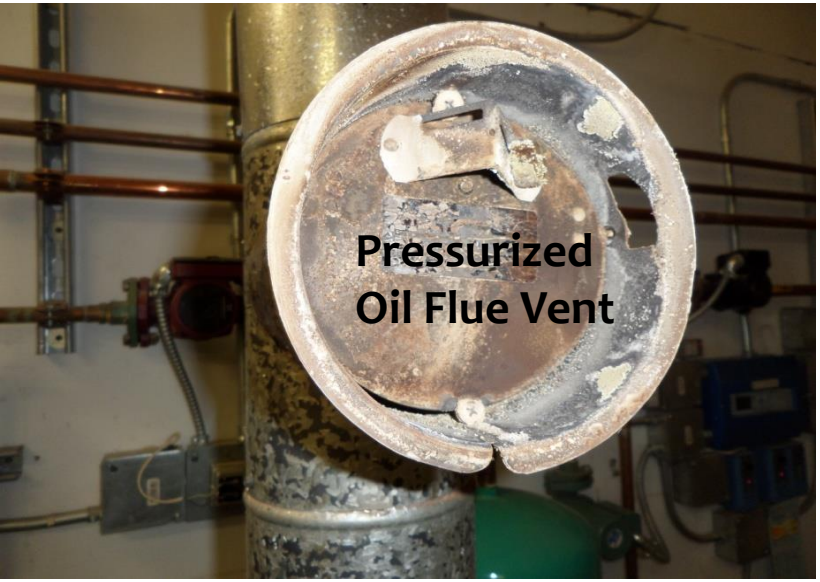
f) Source: https://www3.epa.gov/ttnchie1/ap42/ch01/final/c01s04.pdf

Hot flue gases don't go down very well.



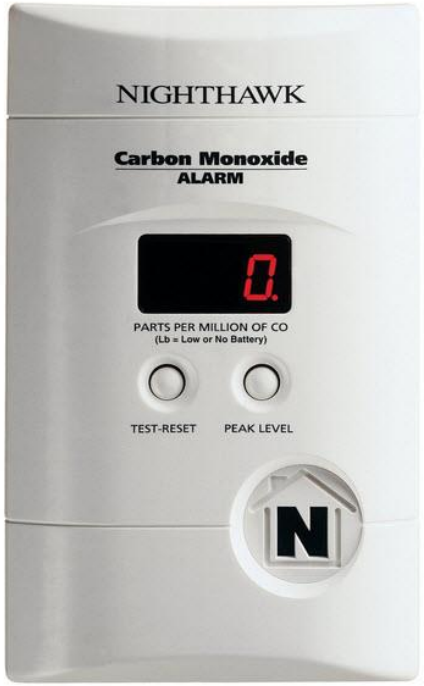
Improperly vented flues and older <u>exposed</u> chimneys are some of the most concerning issues. It has to at least be to code in order to <u>hope</u> that everything is venting properly.

Any system is capable of back draft conditions or spillage and can be just as dangerous as a natural aspirating appliances.



Positive pressurized flue & combustion chamber w/elevated CO levels present in home.

This was in an Anchorage Home venting a gas fired Boiler. It was removed by a Homeowner that had taken advantage of the Alaska Rebate Program and got an Energy Audit.



How do **YOU** know your home is safe?

Where to place **YOUR** Digital CO detectors?

How do **YOU** check peak CO numbers?

How often should **YOU** check it?

How often should **YOU** have Your Combustion appliances inspected/tested?

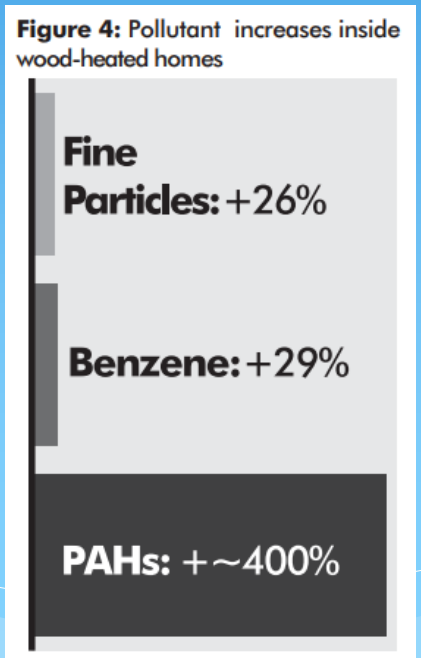
When should **YOU** Call **ATI**?

When should **YOU** Call **911**?

Wood Stove/Solid Fuel

- Depressurization limits range from -5pa to -18pa
- The only Combustion appliances that does not have a regulated flame and steady state combustion.
- CO levels inside of fire box at a low fire condition can be > 3000ppm

"Houses using wood heat have higher levels of fine particles, benzene, PAHs, and other chemicals. For example, a study showed that average fine particle levels were up to 26% higher in wood-burning houses compared to non-wood burning houses.[17] Benzene levels were 29% higher.[19] Average levels of cancer-causing PAHs were 300 to 500% higher.[20]"



https://fortress.wa.gov/ecy/publications/documents/91br023.pdf

17 Molnár P, Gustafson P, Johannesson S, Boman J, Barregard L, Sällsten G. 2005. Domestic wood burning and PM2.5 trace elements: Personal exposures, indoor and outdoor levels. Atmospheric Environment 39(14): 2643-2653

19 Gustafson P, Barregard L, Strandberg B, Sällsten G. 2007. The impact of domestic wood burning on personal, indoor and outdoor levels of 1,3-butadiene, benzene, formaldehyde and acetaldehyde. J Environ Monit. 9(1):23-32

20 Gustafson P, Ostman C, Sällsten G. 2008. Environ Sci Technol. 42(14):5074-80. Indoor levels of polycyclic aromatic hydrocarbons in homes with or without wood burning for heating

Chemicals in Smoke

* **"In addition to the chemicals listed in the table, wood smoke also contains a large amount of unreacted air, carbon dioxide, and water. It contains a variable amount of mold spores. VOCs are volatile organic compounds. Aldehydes found in wood smoke include formaldehyde, acrolein, propionaldehyde, butyraldehyde, acetaldehyde, and furfural. Alkyl benzenes found in wood smoke include toluene. Oxygenated monoaromatics include guaiacol, phenol, syringol and catechol. Numerous PAHs or polycyclic aromatic hydrocarbons are found in smoke. Many trace elements are released.**
* ***Reference: 1993 EPA Report, A Summary of the Emissions Characterization and Noncancer Respiratory Effects of Wood Smoke, EPA-453/R-93-036"***

https://www.thoughtco.com/smoke-chemistry-607309

Chemical	g/kg Wood
carbon monoxide	80-370
methane	14-25
VOCs* (C2-C7)	7-27
aldehydes	0.6-5.4
substituted furans	0.15-1.7
benzene	0.6-4.0
alkyl benzenes	1-6
acetic acid	1.8-2.4
formic acid	0.06-0.08
nitrogen oxides	0.2-0.9
sulfur dioxide	0.16-0.24
methyl chloride	0.01-0.04
naphthalene	0.24-1.6
substituted napthalenes	0.3-2.1
oxygenated monoaromatics	1-7
total particle mass	7-30
particulate organic carbon	2-20
oxygenated PAHs	0.15-1
Individual PAHs	10^{-5}-10^{-2}
chlorinated dioxins	$1x10^{-5}$-$4x10^{-5}$
normal alkanes (C24-C30)	$1x10^{-3}$-$6x10^{-3}$
sodium	$3x10^{-3}$-$2.8x10^{-2}$
magnesium	$2x10^{-4}$-$3x10^{-3}$
aluminum	$1x10^{-4}$-$2.4x10^{-2}$
silicon	$3x10^{-4}$-$3.1x10^{-2}$
sulfur	$1x10^{-3}$-$2.9x10^{-2}$
chlorine	$7x10^{-4}$-$2.1x10^{-2}$
potassium	$3x10^{-3}$-$8.6x10^{-2}$
calcium	$9x10^{-4}$-$1.8x10^{-2}$
titanium	$4x10^{-5}$-$3x10^{-3}$
vanadium	$2x10^{-5}$-$4x10^{-3}$
chromium	$2x10^{-5}$-$3x10^{-3}$
manganese	$7x10^{-5}$-$4x10^{-3}$
iron	$3x10^{-4}$-$5x10^{-3}$
nickel	$1x10^{-6}$-$1x10^{-3}$
copper	$2x10^{-4}$-$9x10^{-4}$
zinc	$7x10^{-4}$-$8x10^{-3}$
bromine	$7x10^{-5}$-$9x10^{-4}$
lead	$1x10^{-4}$-$3x10^{-3}$

TABLE 12-1 Minimum Efficiency Reporting Value (MERV) Parameters

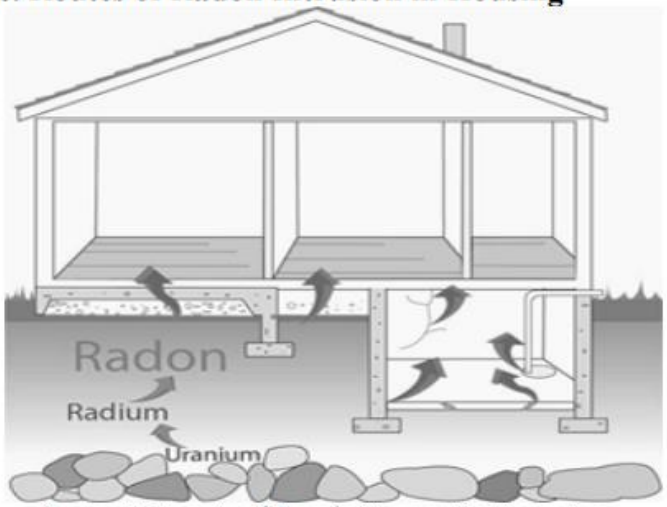
Standard 52.2 Minimum Efficiency Reporting Value (MERV)	Composite Average Particle Size Efficiency, % in Size Range, µm			Average Arrestance, %
	Range 1 0.30 to 1.0	Range 2 1.0 to 3.0	Range 3 3.0 to 10.0	
1	N/A	N/A	$E_3 < 20$	$A_{avg} < 65$
2	N/A	N/A	$E_3 < 20$	$65 \le A_{avg}$
3	N/A	N/A	$E_3 < 20$	$70 \le A_{avg}$
4	N/A	N/A	$E_3 < 20$	$75 \le A_{avg}$
5	N/A	N/A	$20 \le E_3$	N/A
6	N/A	N/A	$35 \le E_3$	N/A
7	N/A	N/A	$50 \le E_3$	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	$50 \le E_2$	$80 \le E_3$	N/A
11	$20 \le E_1$	$65 \le E_2$	$85 \le E_3$	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	$75 \le E_1$	$90 \le E_2$	$95 \le E_3$	N/A
15	$85 \le E_1$	$90 \le E_2$	$95 \le E_3$	N/A
16	$95 \le E_1$	$95 \le E_2$	$95 \le E_3$	N/A

Note: The minimum final resistance shall be at least twice the initial resistance. Refer to Section 10.7.1.1 [45]

http://blog.filtersnap.com/merv-vs-mpr-vs-fpr-the-definitive-guide/

RADON in AK

Figure. Routes of Radon Intrusion in Housing



Source: University of Nevada Cooperative Extension, Nevada Radon Education Program.

Background Radon is an odorless, colorless, radioactive gas that is generated by the decay of naturally occurring uranium in the earth's crust. When it decays, radon primarily emits alpha particles. As we breathe, these particles are deposited on the cells lining the airways where they can damage DNA and cause cancer. Radon is the second leading cause of lung cancer after tobacco smoke and the leading cause of lung cancer in nonsmokers in the United States.1

Table. Distribution of Alpha Track Measured Radon Levels ≥4.0 pCi/L in Alaska — 1990–2014*

Community	Zip Code	% ≥4 pCi/L	# of samples	Median [Radon]	Maximum [Radon]
ANC-Downtown	99513	18%	17	1.7	5.8
ANC-Hillside	99507	7%	15	1.6	4.4
ANC-Midtown	99503	5%	44	0.7	8.8
ANC-Trnagn Arm	99516	24%	17	1.4	13.1
DeltaJn-East	99737	67%	15	4.8	15
DeltaJn/Ft Greely	99731	10%	51	1.6	8.1
DeltaJn/Healy Lk	99706	19%	15	3.3	21.6
Eagle River	99577	8%	13	1	5.1
FAI-College	99708	49%	276	3.7	1355
FAI-College	99775	24%	41	1.8	148.1
FAI-Downtown	99710	43%	53	3.5	95
FAI-Downtown	99701	35%	31	2.1	48.1
FAI-Goldstream	99709	40%	334	3.3	205.7
FAI-Post Office	99707	38%	37	2.5	32.4
FAI-Two Rivers	99712	59%	210	4.8	104.3
Fortymile Country	99780	58%	32	4.1	13.1
Healy/DnaliNatlPk	99743	62%	34	5.6	33.5
Healy	99755	29%	14	2.8	8.8
Homer	99603	27%	11	2	4.2
Juneau	99801	2%	41	0.3	6.3
Juneau	99811	2%	1412	0.6	13.8
Kodiak	99619	40%	25	3	8.9
Nome	99762	58%	12	5.1	13.6
North Pole	99705	20%	40	1.7	12.7
Palmer	99645	28%	46	2.2	22.7
Salcha	99702	11%	79	2.3	25.3
Soldotna	99669	20%	10	2.4	6.8
Wasilla	99654	32%	25	2.4	9

**Note: only zip codes having >10 radon test results are presented. Some people living in rural areas might have mailed radon kits from a post office that is near but not in their community.*
FAI=Fairbanks; ANC=Anchorage

http://www.epi.alaska.gov/bulletins/docs/b2015_25.pdf

RADON Recommendations

* **1. All Alaska residents should test their homes for radon.[1] Short-term charcoal test kits are available from hardware, "big box" building, and safety product vendor stores. Long-term alpha track kits can be purchased from any UAF Cooperative Extension office or online from various vendors.[4] Some home** inspectors will perform testing **over a 72-hour period.**

* 2. Home owners should consider radon exposure reduction strategies if radon levels are ≥4 pCi/L. The primary method used is a vent pipe system and fan, which pulls radon from beneath the house and vents it to the outside.[1] Sealing foundation cracks and other openings are also helpful strategies.[1]

* 3. Health care providers should inform smokers that their risk for developing lung cancer is even higher if their homes have elevated radon levels.[1]

* 4. Home buyers and renters should ask about radon levels before they buy or rent a home.

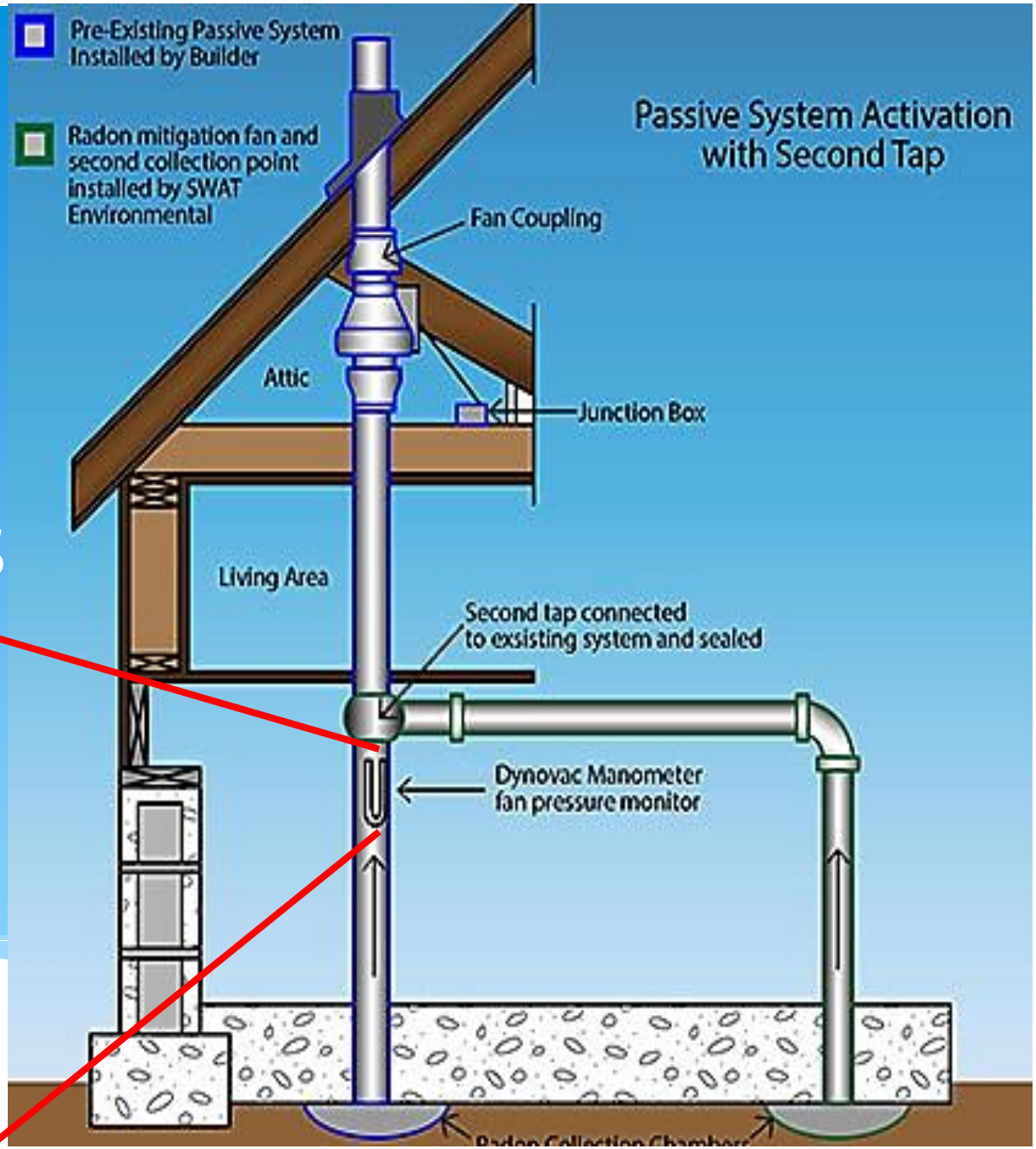
* 5. Call the UAF Cooperative Extension (800-478-8324) or the Section of Epidemiology (907-269-8000) with any questions related to radon.

References

* 1. EPA. A citizen's guide to radon. Available at: http://www.epa.gov/radon/pdfs/citizensguide.pdf
* 2. EPA. Consumer's guide to radon reduction. Available at: http://www.epa.gov/radon/pubs/consguid.html#testmean
* 3. EPA. State Indoor Radon Grant (SIRG) Program. Available at: http://www.epa.gov/radon/sirgprogram.html
* 4. UAF. Cooperative Extension Service. Energy and Housing Program. Radon. Available at: http://www.uaf.edu/ces/energy/radon/

http://www.epi.alaska.gov/bulletins/docs/b2015_25.pdf

RADON System Components



http://swat-radon.com/second-tap-passive-radon-system-activation/

Educational Ventilation Codes

IECC 2012 R303.3 Maintenance information. Maintenance instructions shall be furnished

ASHREA 62.2 Section 6.2: Instructions and Labeling. . . . . Shall be provided to the owner and the occupant of the dwelling unit.

Definition of Risk Management: The identification, analysis, assessment, control, and avoidance, minimization, or elimination of unacceptable risks.

Education and awareness are the low hanging fruit of Risk Management

How Do We Measure IAQ

What Should we Measure?

- Relative Humidity (RH%)
- Carbon Monoxide (CO)
- Carbon Dioxide (CO_2)
- Volatile Organic Compounds (VOC)
- Particulate Mater 2.5um ($PM_{2.5}$)
- Radon

Low Cost Devices Evaluated ~ $200-300

AirBeam

PM, T, RH

AirVisual Node

PM2.5, PM10, T, RH, CO2

AirQualityEgg V2

PM, T, RH

AWAIR

PM, T, RH, CO2, VOC

Dylos DC1700

Counts (Small, Large)

Foobot

PM, T, RH, CO2, VOC

PurpleAir V2

PM1, PM2.5, PM10, T, RH

Speck V2

Count, PM, T, RH

Building AMERICA U.S. Department of Energy

BERKELEY LAB

Thank You

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