Track 1: What is Combustion Safety

(1:15pm – 2:30pm)

Alaska Housing FINANCE CORPORATION

BPI CONTINUING EDUCATION

Combustion Safety and Home Ventilation Requirements 1.25 CEU's

First and Last Name	Email address	Endorsement type	BPI #	State I.D. #

Be sure to provide BPI and State Endorsement information to Receive CEU credit

Alaska Housing
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Residential Combustion Safety

Recognize potential safety concerns

Determine operation is within manufacturer parameters

Identify opportunities for improvement

Overview

Combustion safety has a great effect on the health and safety of a structures occupants.

Safe operation of combustion appliances is affected by:

Ventilation systems

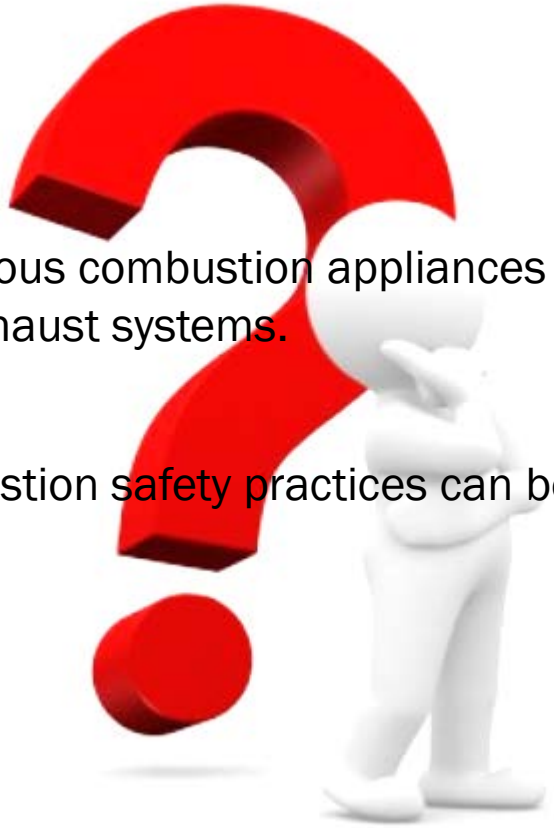
External forces

Occupant habits

Air barrier quality

Commissioning parameters

Objectives



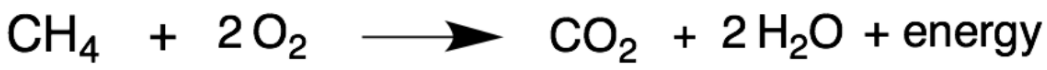
Understand how various combustion appliances are or may be affected by fans and other exhaust systems.

Consider how combustion safety practices can be used to enhance a systems operation.

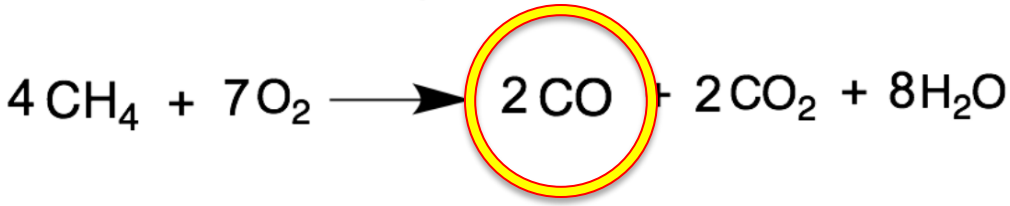

YEAH, IF YOU COULD GO AHEAD
AND PUT YOUR PHONE ON SILENT
THAT'D BE GREAT...

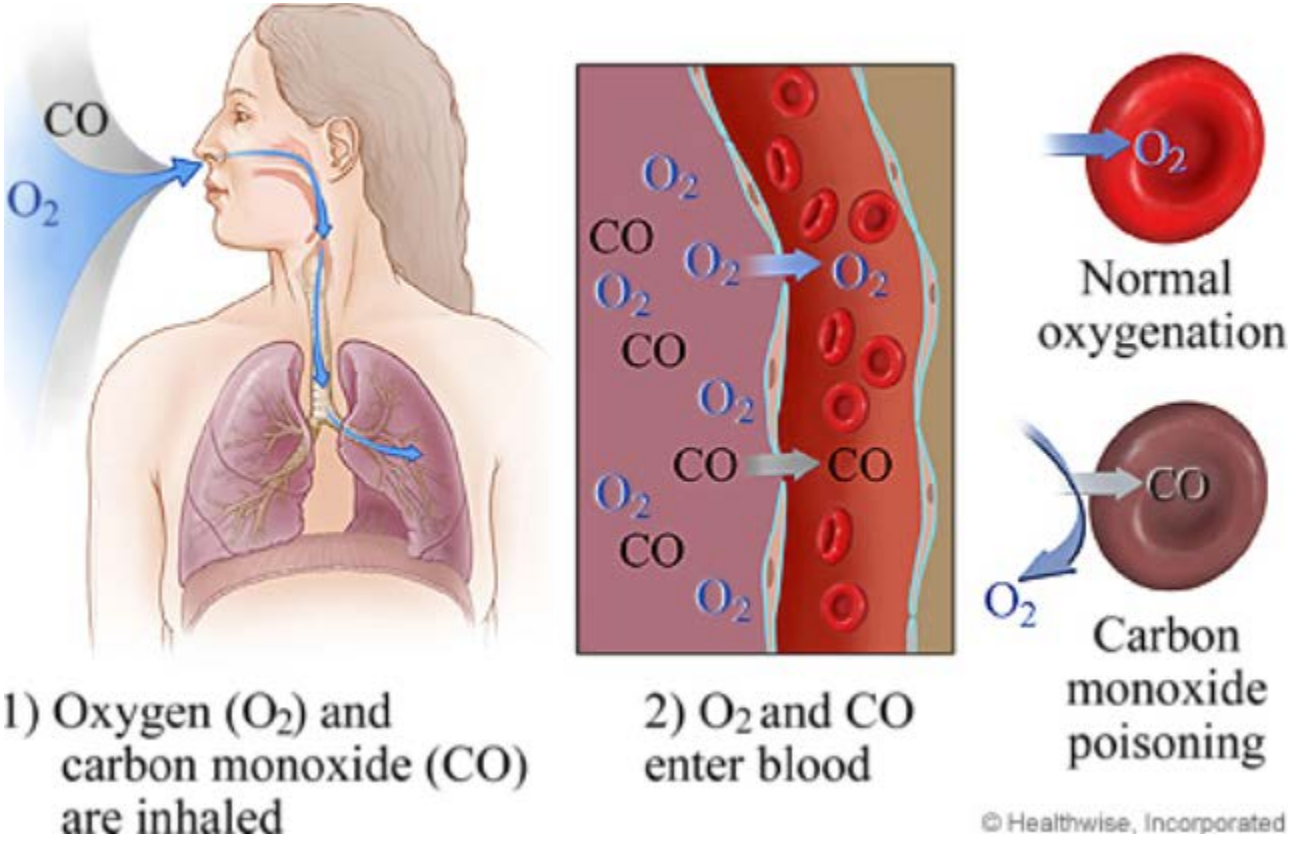
Why is combustion safety a concern?

Complete Combustion



Incomplete Combustion



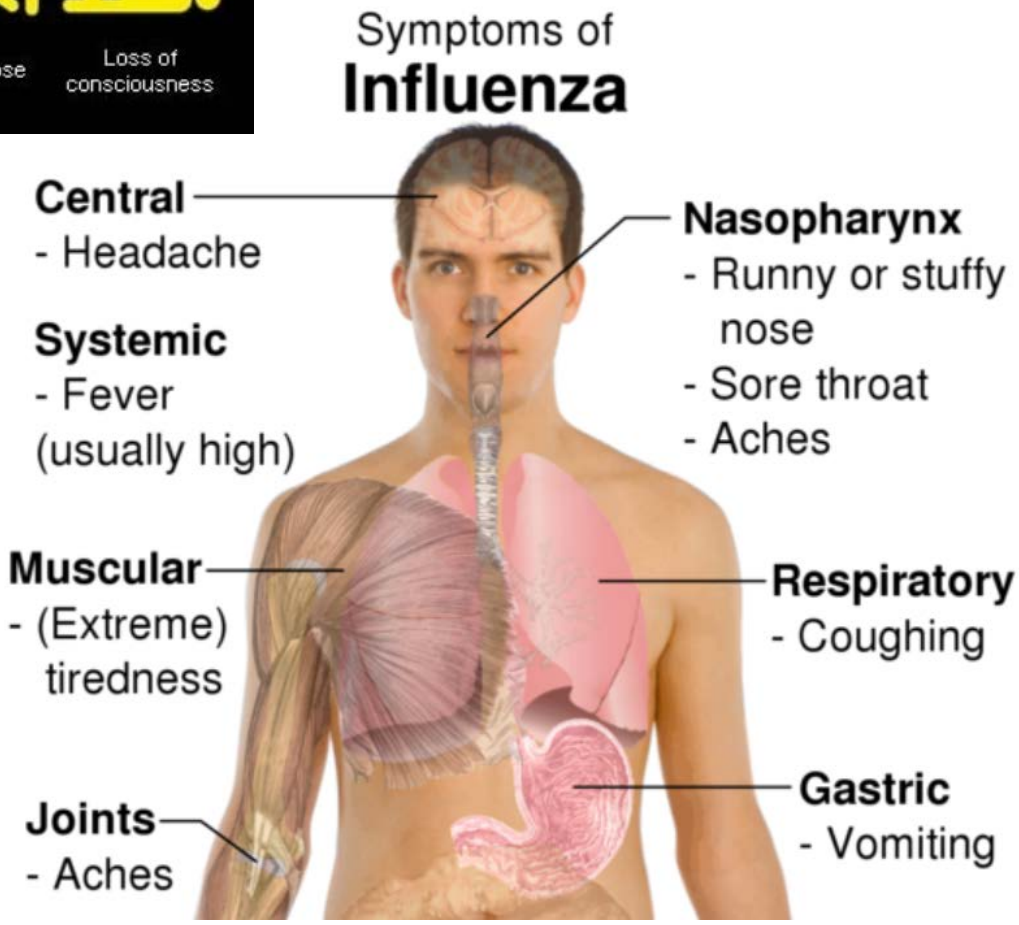


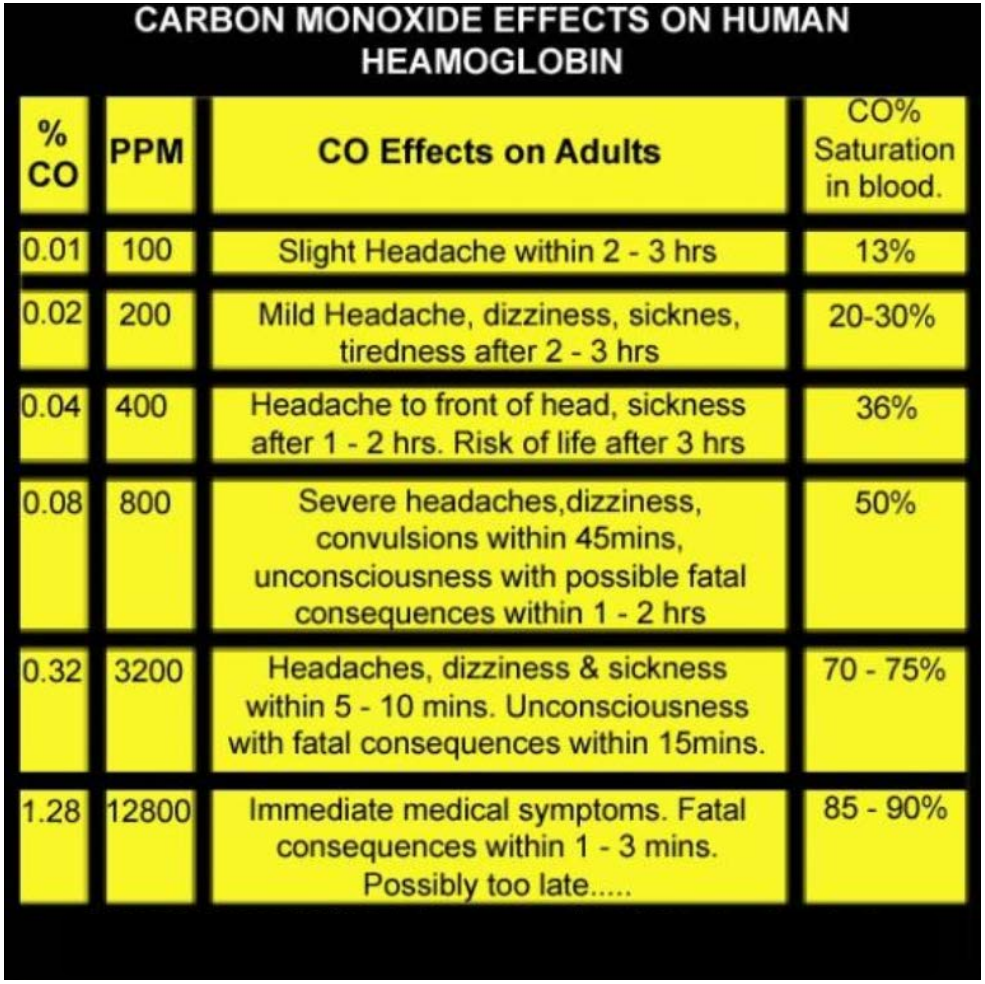
CO bonds with hemoglobin in the blood forming carboxyhemoglobin (COHb).

This bond results in less oxygen being transported to the body, and is 250 times stronger than the bond between oxygen and hemoglobin.


Signs of carbon monoxide poisoning
Headaches
Nausea
Dizziness
Breathlessness
Collapse
Loss of consciousness


Signs of carbon monoxide poisoning
Headaches
Nausea
Dizziness
Breathlessness
Collapse
Loss of consciousness


Symptoms of
Influenza
Central
- Headache
Systemic
- Fever
(usually high)
Muscular
- (Extreme)
tiredness
Joints
- Aches
Nasopharynx
- Runny or stuffy
nose
- Sore throat
- Aches
Respiratory
- Coughing
Gastric
- Vomiting

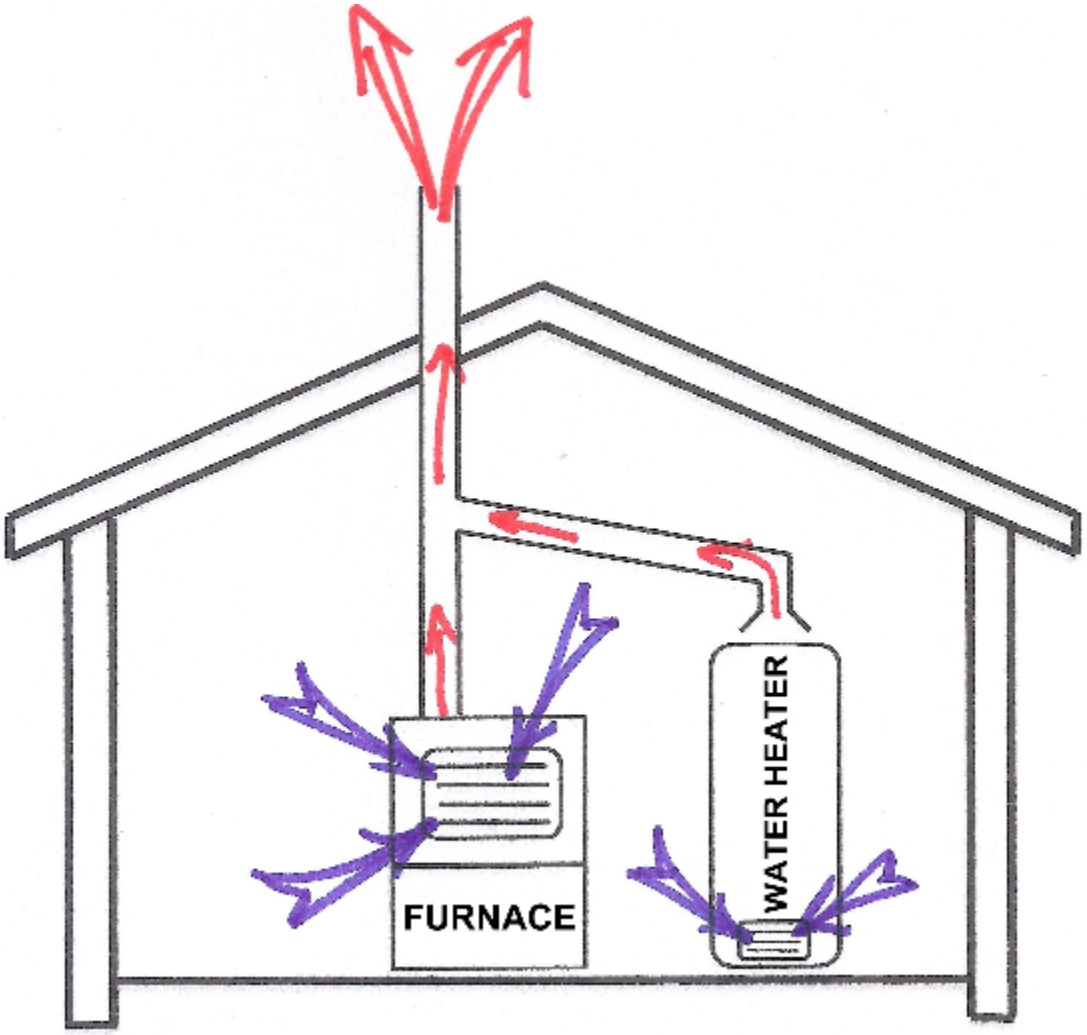


CARBON MONOXIDE EFFECTS ON HUMAN HEAMOGLOBIN

% CO	PPM	CO Effects on Adults	CO% Saturation in blood.
0.01	100	Slight Headache within 2 - 3 hrs	13%
0.02	200	Mild Headache, dizziness, sicknes, tiredness after 2 - 3 hrs	20-30%
0.04	400	Headache to front of head, sickness after 1 - 2 hrs. Risk of life after 3 hrs	36%
0.08	800	Severe headaches,dizziness, convulsions within 45mins, unconsciousness with possible fatal consequences within 1 - 2 hrs	50%
0.32	3200	Headaches, dizziness & sickness within 5 - 10 mins. Unconsciousness with fatal consequences within 15mins.	70 - 75%
1.28	12800	Immediate medical symptoms. Fatal consequences within 1 - 3 mins. Possibly too late.....	85 - 90%

Carbon Monoxide Half-Life

For normal air composition, CO absorbed into the blood reduces saturation by 50% every 4-6 Hours.



What should happen?

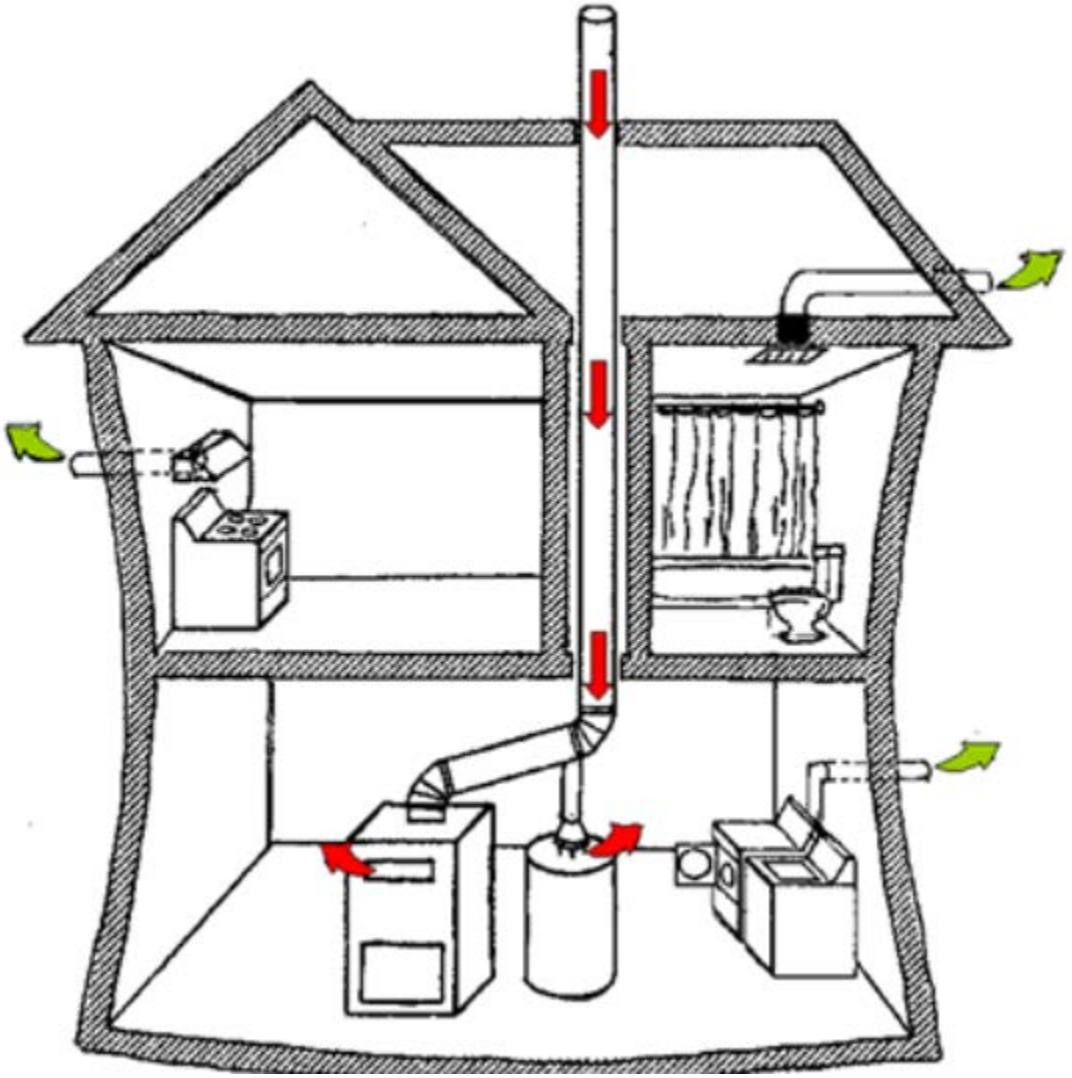
House should be warm.

Exhaust should exit the building without affecting the occupants.

System should be able to continue operating safely.

What can happen?

Not what we want!



Causes of Dangerous Combustion Appliances

Carbon Monoxide Production

Exhaust Spillage

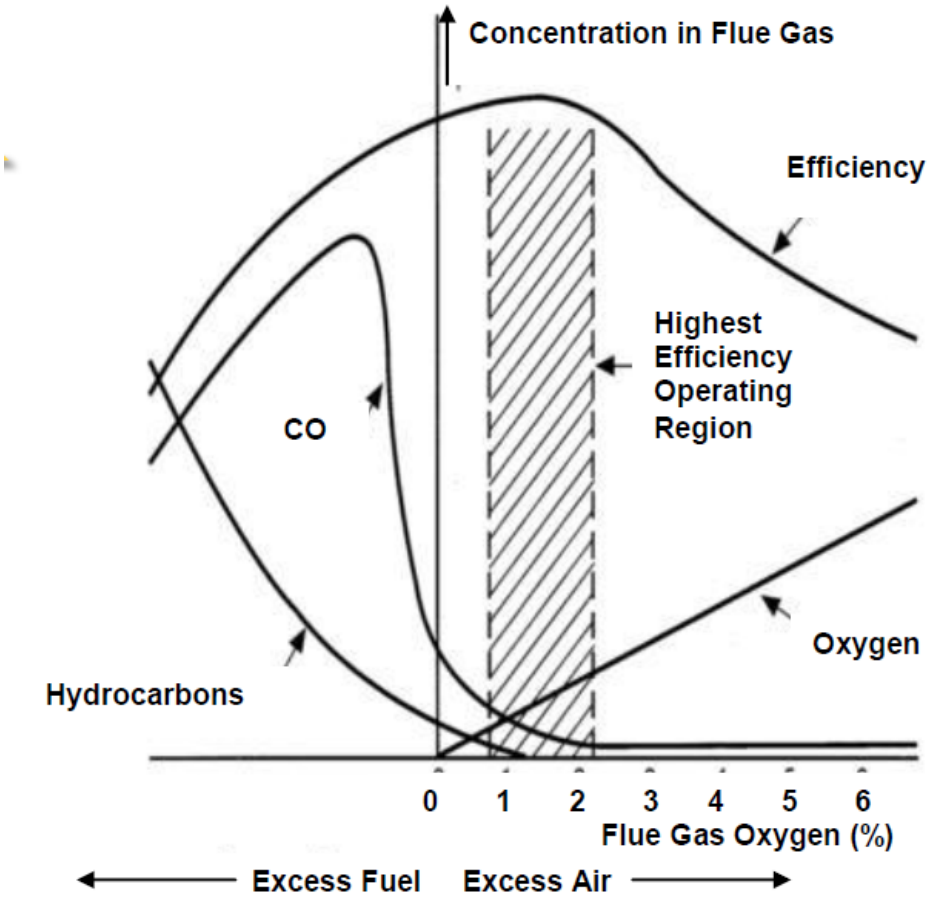
Exhaust Vent Leakage/Entrainment

Excessive Depressurization

Fuel Safety

Environment

Incomplete Combustion



Heating System Basics

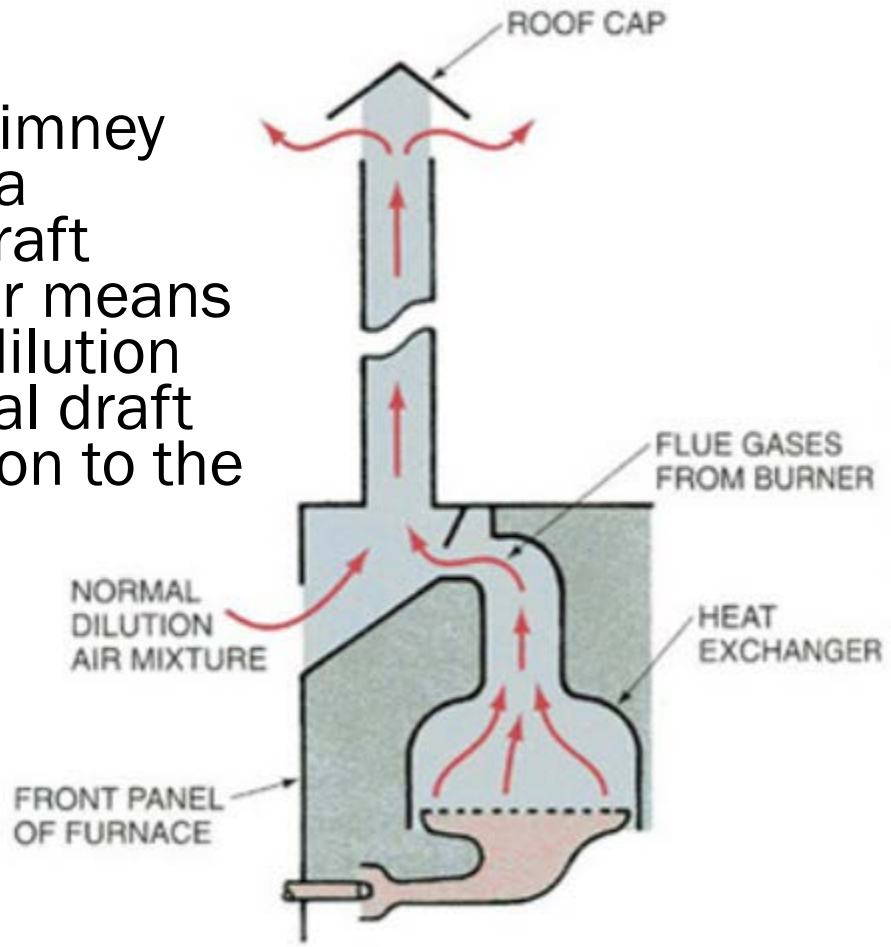
GAS APPLIANCE VENT CATEGORIES

Appliance Category	Vent Pressure	Condensing or Non-Condensing?	Typical Flue Pipe Material
I	Non-Positive	Non	B-Vent
II	Non-Positive	Condensing	Special per Manufacturer
III	Positive	Non	Stainless Steel
IV	Positive	Condensing	Plastic

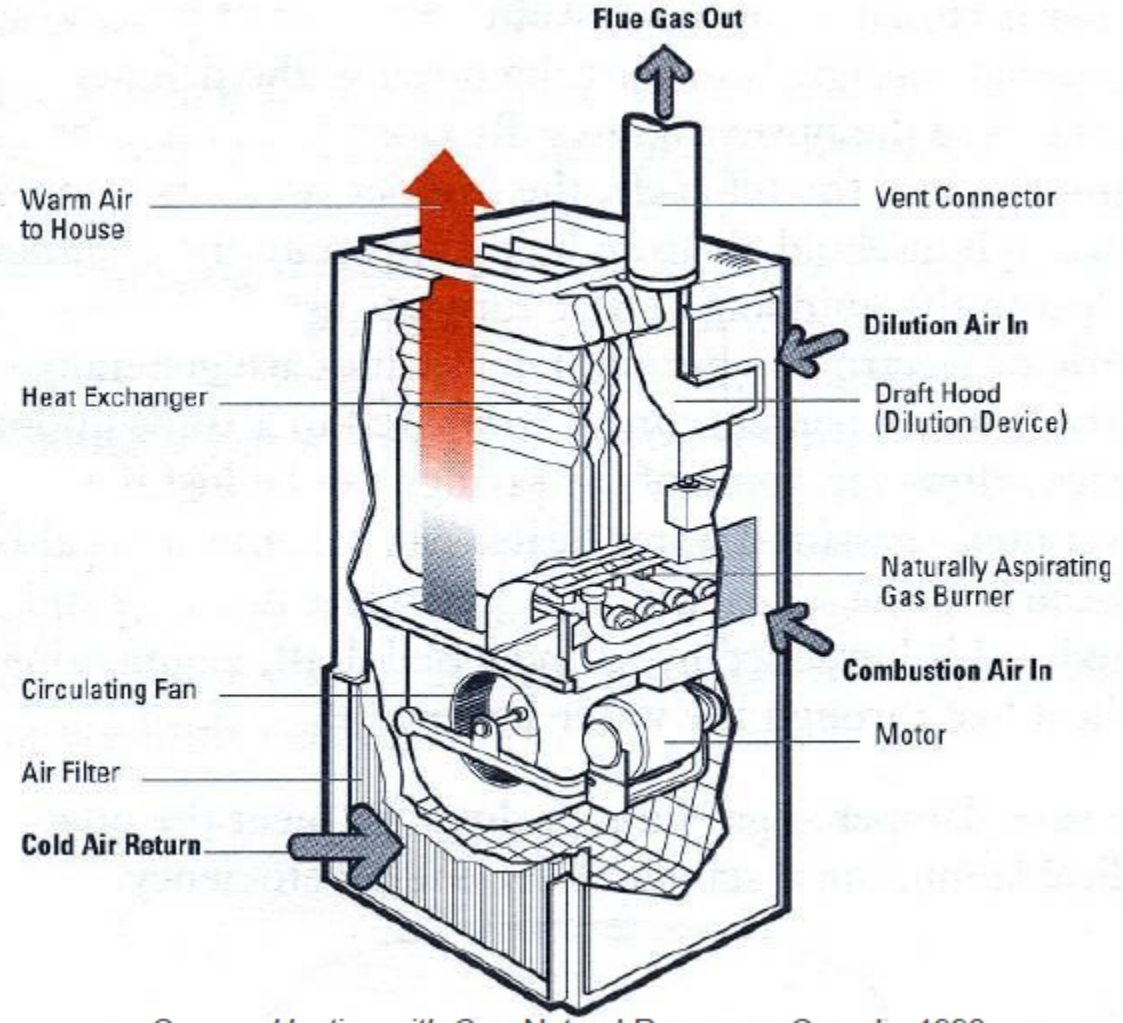
	Flue Negative Pressure	Flue Positive Pressure
Non- Condensing	**Category I Vented Appliance** An appliance that operates with a nonpositive vent static pressure and with a vent gas temperature that avoids excessive condensate production in the vent.	**Category III Vented Appliance** An appliance that operates with a positive vent static pressure and with a vent gas temperature that avoids excessive condensate production in the vent.
Condensing	**Category II Vented Appliance** An appliance that operates with a nonpositive vent static pressure and with a vent gas temperature that can cause excessive condensate production in the vent.	**Category IV Vented Appliance** An appliance that operates with a positive vent static pressure and with a vent gas temperature that can cause excessive condensate production in the vent.

- **Category I**
- **Depressurization limit 5 Pa**

- Takes combustion air and chimney draft dilution air from within a building, is installed with a draft hood, draft regulator, or other means of allowing for regulation of dilution air, and depends upon natural draft to vent products of combustion to the outdoors.



Category I, non-positive, non-condensing.



Source: *Heating with Gas*, Natural Resources Canada, 1998.

Category I Gas Appliance – An appliance that operates with negative static pressure in the vent and a temperature that is high enough to avoid condensation in vent. *Comment: May be atmospheric or fan-assisted combustion; airtight vent connector is not required.*

Category I Fan-Assisted Gas Appliance – An appliance that operates with negative static pressure in the vent, a temperature that is high enough to avoid condensation in vent, and an integral fan to draw a controlled amount of combustion supply air through the combustion chamber. *Comment: Airtight vent connector is not required; induced combustion fan installed by manufacturer.*

- **Category II**
- **Depressurization limit 10 Pa**

- Takes combustion air from a building, but has a sealed, gas-tight, corrosion-resistant flue without any openings through which combustion gases can backdraft into the building.

Category II, non-positive, condensing

Category II Gas Appliance – An appliance that operates with negative static pressure in the vent and a temperature that is low enough to cause excessive condensation in the vent. *Comment: No or very little equipment in this category.*

- **Category III:**
- **Depressurization Limit 20 Pa**

- Takes combustion air directly from the outside through a connection sealed from the atmosphere in the building, has a sealed, gas-tight flue without any openings through which combustion gases can backdraft into the building.

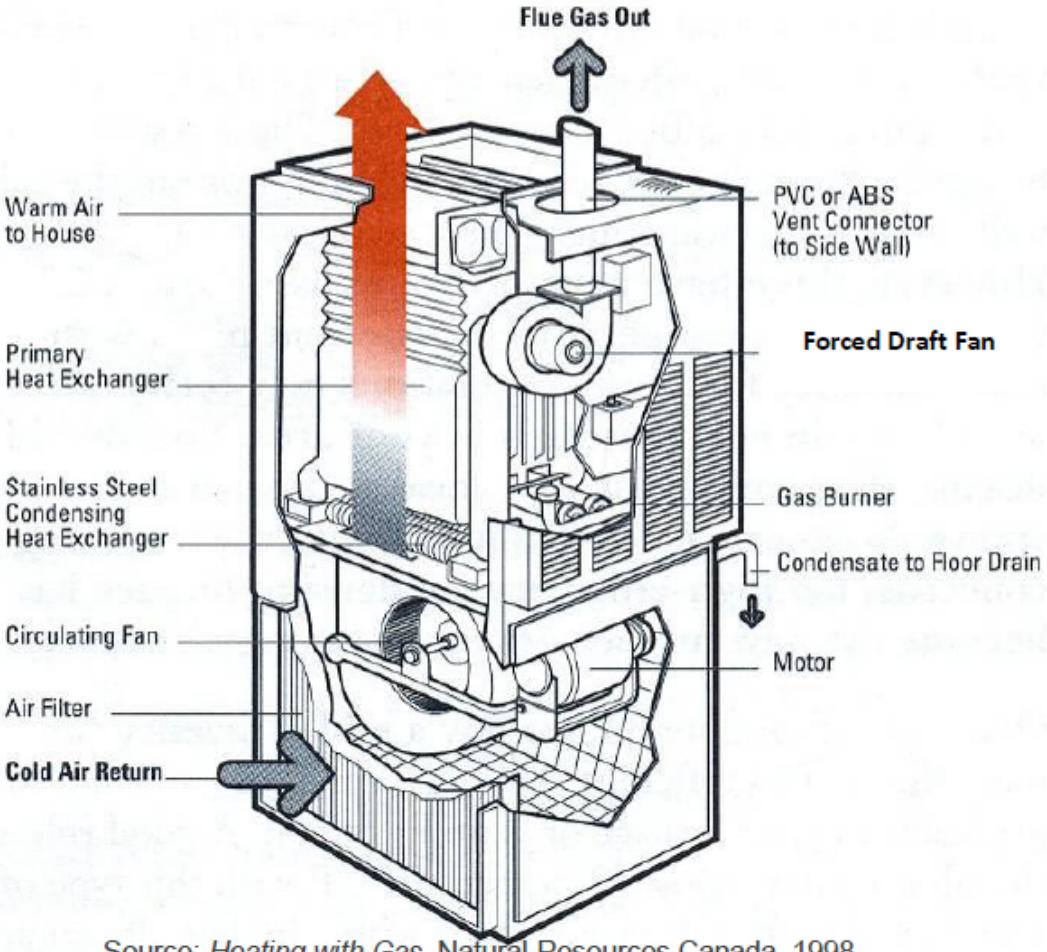
Category III, positive, non-condensing

Category III Gas Appliance – An appliance that operates with positive static pressure in the vent and a temperature that is high enough to avoid condensation in vent. *Comment: Airtight vent connector; vented through the wall; forced draft.*

- **Category IV:**
- **Depressurization limit 20 Pa**

- Takes combustion air directly from the outside through a connection sealed from the atmosphere in the building, has a sealed, gas-tight, corrosion-resistant flue without any openings through which combustion gases can backdraft into the building.

Category IV, positive, condensing



Source: *Heating with Gas*, Natural Resources Canada, 1998.

Category IV, positive, condensing

Category IV Gas Appliance - An appliance that operates with positive static pressure in the vent and a temperature that is low enough to cause excessive condensation in the vent. *Comment: Airtight vent connector; forced draft; often referred to as a "90-plus"or "condensing" unit.*

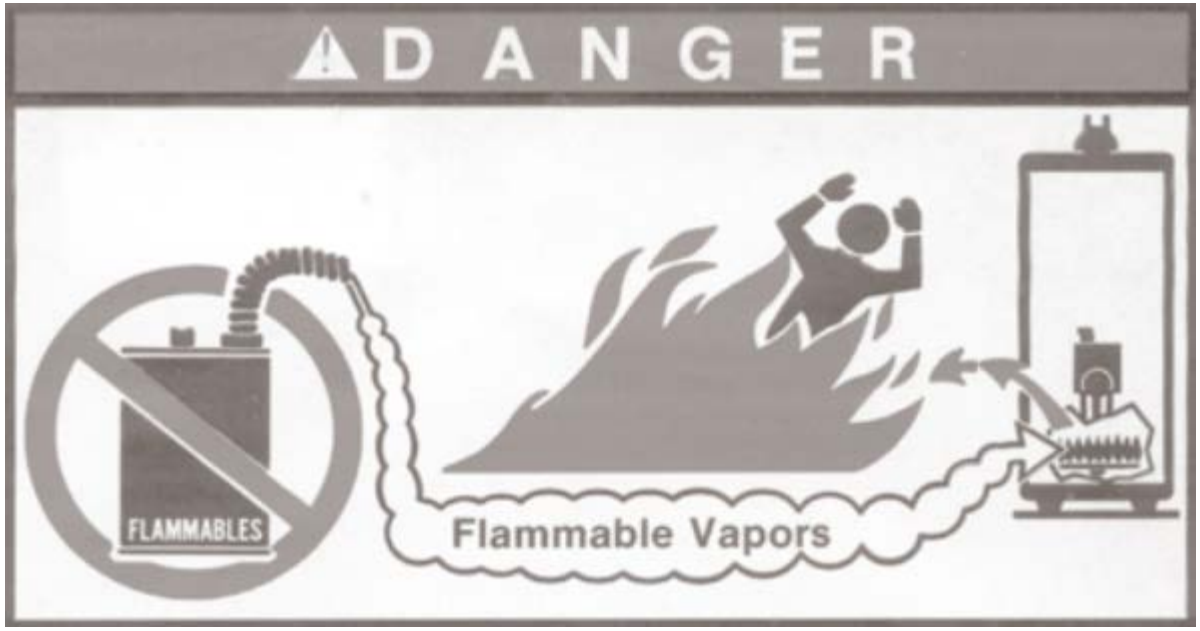
Exhaust vent leakage/entrainment

Entrainment:

BEES Application (Alaska Specific Amendment to ANSI/ASHRAE 62.2-2010):

6.8 Air Inlets. Replace the second sentence with "The intake shall be placed so that entering air is not obstructed by snow, plantings, or other material, and shall be located at least 18 inches above an adjacent finished grade." Add an additional exception: "(d) A ventilation system's supply and exhaust vents on the exterior of a building may be separated less than 10 feet as long as they are separated a minimum of 6 feet horizontally. *They may be separated less than this if they are part of a system engineered to prevent* ***entrainment*** *of the exhaust air. Care should be taken to locate an intake vent where it can be easily cleaned at regular intervals."*

Fuel Safety



Additional Costs: Fuel Oil

OIL SPILL COST BY DROPS

RATE OF LEAK	GALLONS PER YEAR LOST	DOLLAR PER YEAR LOST*	TONS OF CONTAMINATED SOIL**
Drop Every 10 Seconds	40	$160	150
Drop Every 5 Seconds	80	$320	300
Drop Every Second	410	$1,640	1,500
Three Drops Every Second	1,200	$4,800	4,500
Stream that Breaks into Drops	8,600	$34,400	32,000

(Drops are approximately 11/64 inch in diameter.)
*At $4.00 per gallon of heating oil
** Average 1000 ppm total petroleum hydrocarbons

Cost of Fuel Oil Leak

93.4 Point, Five Star Plus Home located in Fairbanks

Estimated Annual Fuel Use (Heating and Hot Water): 790 gallons of #2 Oil, $3,002/year

OIL SPILL COST BY DROPS

RATE OF LEAK	GALLONS PER YEAR LOST	DOLLAR PER YEAR LOST*	TONS OF CONTAMINATED SOIL**
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(Drops are approximately 11/64 inch in diameter.)
*At $4.00 per gallon of heating oil
** Average 1000 ppm total petroleum hydrocarbons

5% Loss	$152
10% Loss	$304
51.9% Loss	$1,558
151.9% Loss	$4,560
1,088.6% Loss	$32,680

Environmental hazards

Clearance to Combustibles

Oil and Wood	Gas
Single wall 18”	Single Wall 6”
Double Wall Super Six, Dura Vent 6”	Double Wall B-Vent *or* B-W Vent 1”
Manufactured Chimney 2” or Per Manufacturer Instructions	

Worst case depressurization

What is the greatest negative pressure that the home can exert on the combustion appliance zone (CAZ)?

Fan Operation	Create negative pressure in the CAZ.
Door Positions	Limit the available air.

Spillage, Draft and CO

Spillage

- Test at vent openings, i.e. dilution air openings, barometric damper, with smoke. (one minute spillage limit)

Draft

- Test in vent connection between last opening in vent connect and chimney.
- Oil burners – Test over fire in combustion chamber.

CO

- Test at appliance breech, between appliance and first opening in vent connect or directly above heat exchanger.
- Condensing gas appliances – Test at vent termination.

Combustion Safety Problems - Fixes

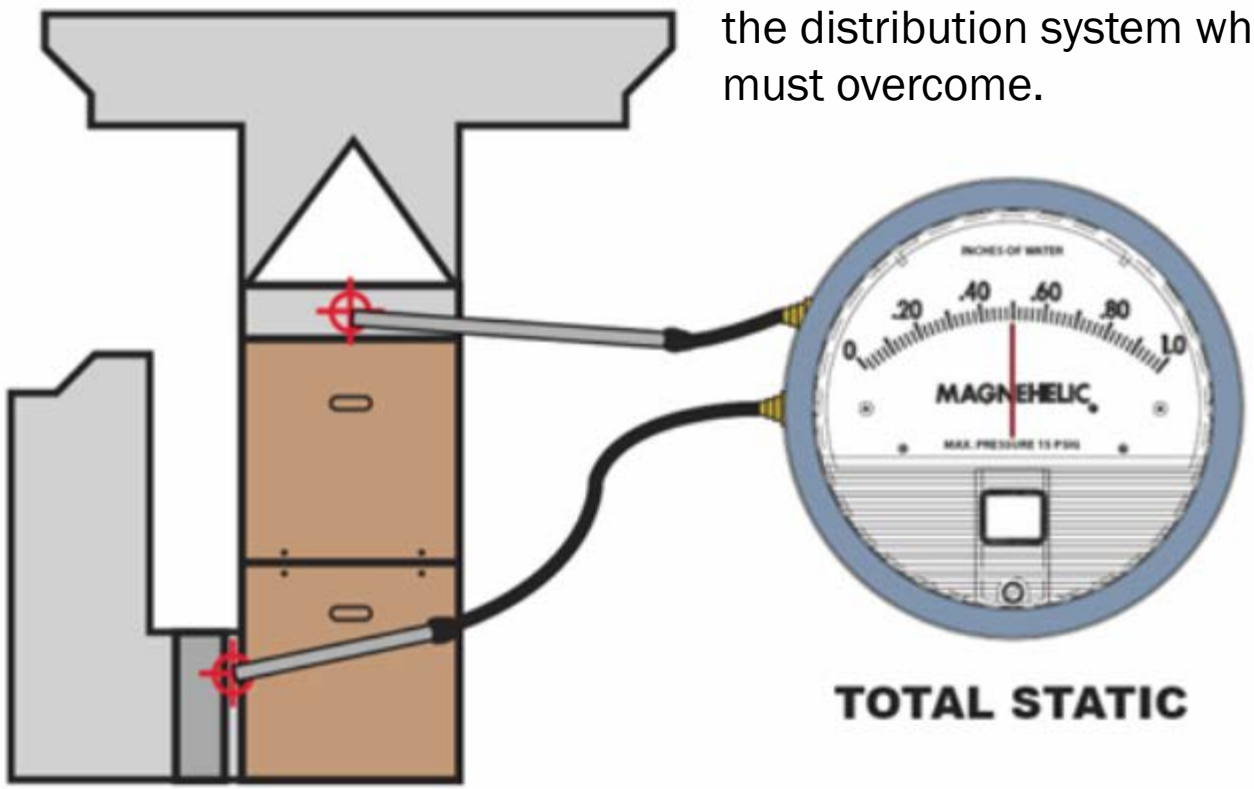
Solve excessive depressurization or inadequate draft:

- Repair chimney obstructions, disconnections, or leaks.
- Properly size the vent, connector, or liner.
- Install a metal chimney liner and/or a wind-rated chimney cap.
- Seal leaks in the return ducts of the CAZ.
- Balance supply and return air by adding new returns, or by adding passive return air openings to the main body of the house.
- Reduce capacity of large exhaust fans.
- Provide make-up air for dryers and exhaust fans.
- Provide combustion air inlet to CAZ.

Helping a system to continue safe operation?

Static Pressure (forced air)

Measurement of pressure created by the distribution system which the fan must overcome.

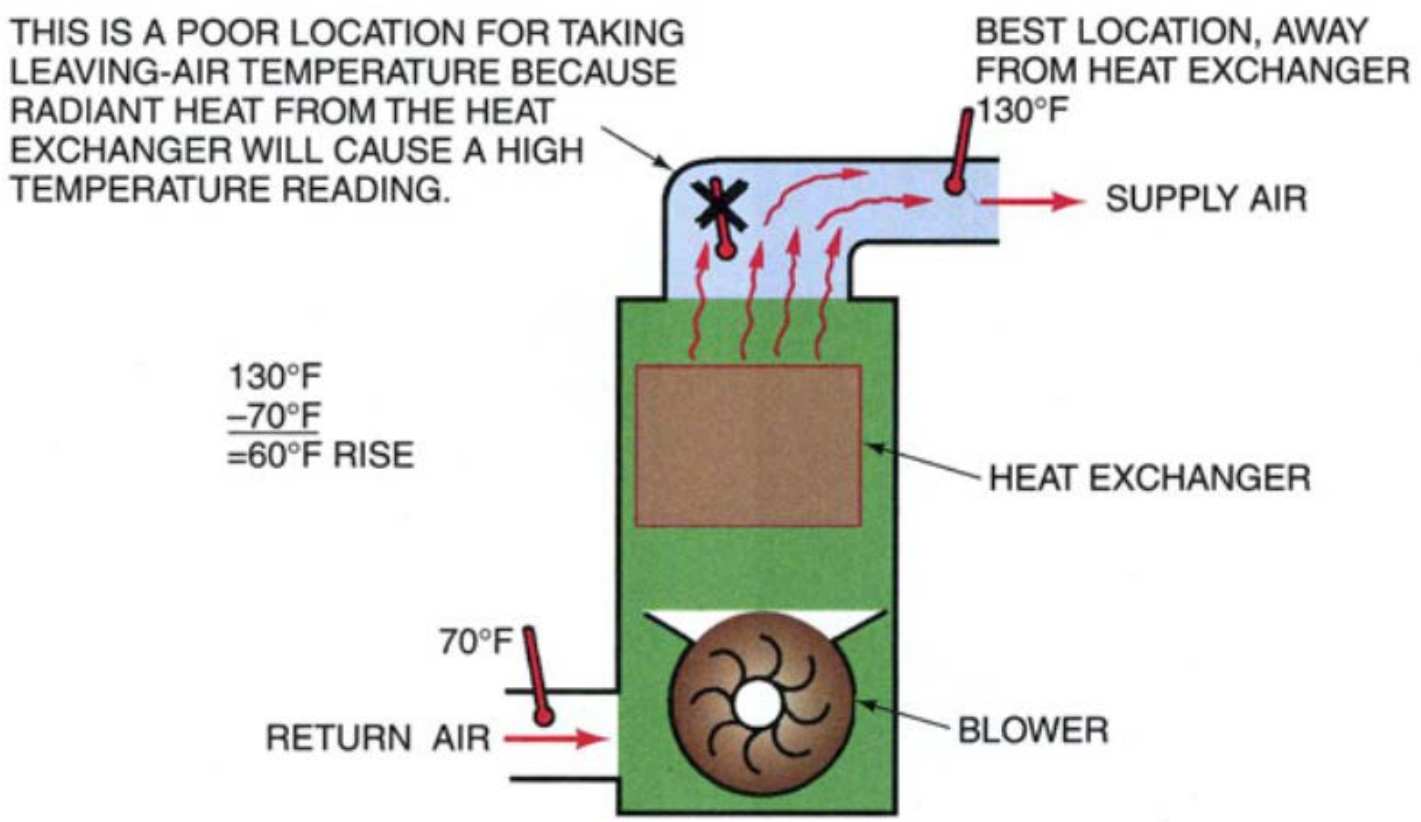


Effects of Static Pressures outside the Manufacturer Prescribed Values

Static Pressure that exceeds the rated pressure will cause the fan to move less air than designed and potentially fail to adequately heat the structure.

Static pressure directly effects the ability of the furnace to operate within the designed temperature rise.

Temperature Rise (forced air)

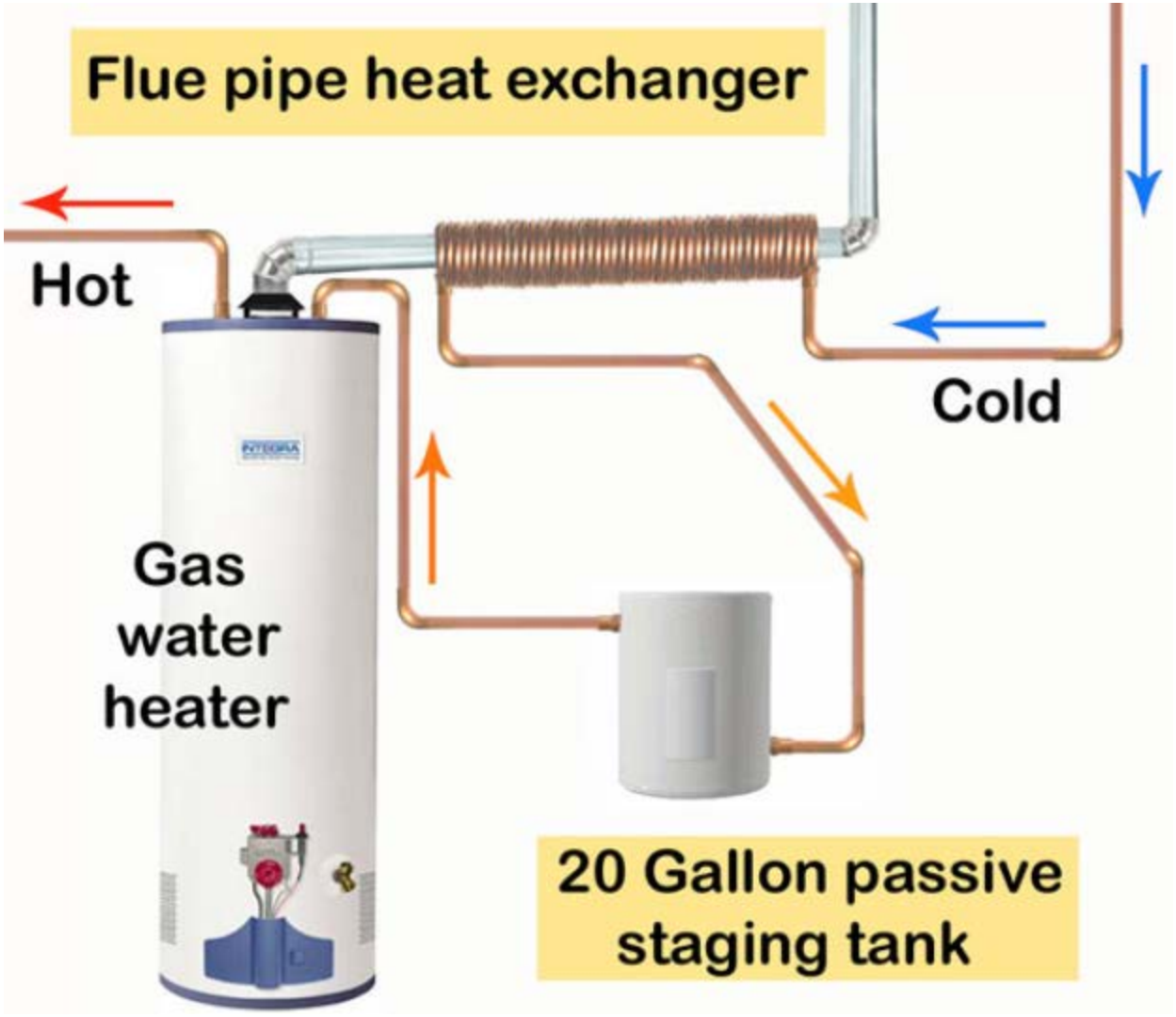


Effects of Temperature outside the Manufacturer Prescribed Values

Operation at temperature rise above the prescribed range may cause premature heat exchanger failure, temperature sensor shut-offs, and elevated heat loss through ducting.

Operation at a temperature rise below the prescribed range may cause the home to feel cold/drafty, cause the unit to run more frequently than necessary, and cause premature blower failure.

Knowledge Application


Flue pipe heat exchanger
Hot
Cold
Gas water heater
20 Gallon passive staging tank

Questions?

"A wise man can learn more from a foolish question than a fool can learn from a wise answer."

~Bruce Lee

Thank You!

Track 1: Guide to Home Ventilation

(2:45pm – 4:00pm)

Alaska Housing FINANCE CORPORATION

CONTINUING EDUCATION

Combustion Safety and Home Ventilation Requirements 1.25 CEU's

First and Last Name	Email address	Endorsement type	BPI #	State I.D. #

Be sure to provide BPI and State Endorsement information to Receive CEU credit

Residential Ventilation

Why ventilation is needed

Ventilation Equipment

Ventilation by location

ASHRAE 62.2-2010 (with AK-specific amendments)

Flow testing

Overview

Ventilation is necessary, and often required in residential buildings to decrease contaminants and introduce fresh air to provide high quality air.

Objectives

Discuss what we mean when we say Indoor Air Quality (IAQ).

Examine options for providing IAQ.

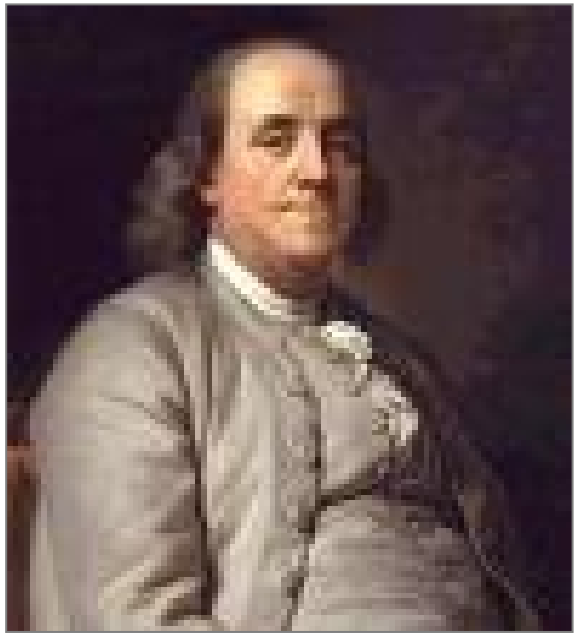
Review spot/whole house requirements for ventilation.

Explore flow testing.


YEAH, IF YOU COULD GO AHEAD
AND PUT YOUR PHONE ON SILENT
THAT'D BE GREAT...

"I am certain that no air is so unwholesome as air in a closed room that has been often breathed and not changed."

– Benjamin Franklin



Smithsonian National Portrait Gallery

Generally, we desire…

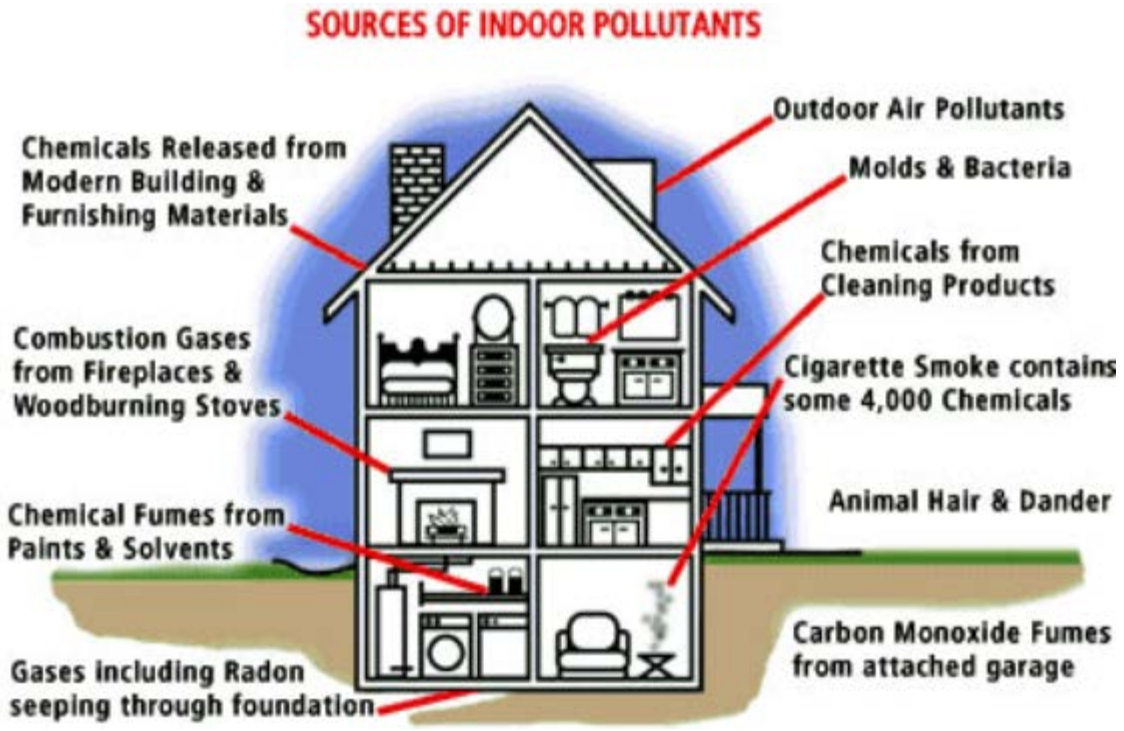
- Air perceived as fresh/pleasant
- No negative impact on our health
- No negative impact on productivity
- No negative impact on durability

Goals of Ventilation

- Fresh air IN
- Stale air OUT
- Manage Pressure

Not from garage,
attic, etc…

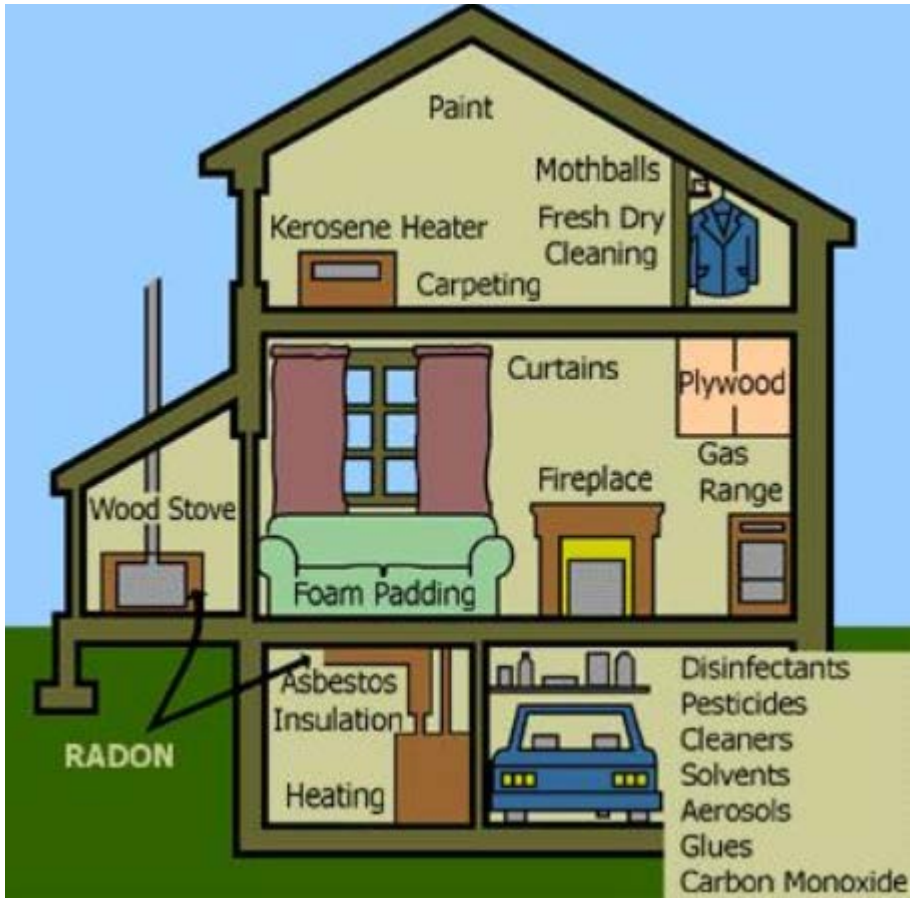
Causes and Sources of Unhealthy Air



Classes of Pollutants

- Combustion exhaust gases
- Volatile Organic Compounds (VOC)
- Biologicals
- Particulates
- Water
- Others (phthalate esters, PVC…)

Volatile Organic Compounds (VOC)



Biologicals

BACTERIA

VIRUSES

MOLD

Benzene in Alaska homes

- Highest in homes with tuck-under garages and no centralized ventilation
- Homes with garage furnaces = high benzene
- Homes with detached garages = low benzene

P. Kaluza

Where does water come from?

- Us: breathing, evaporating, sweating…
- Cooking
- Showers, baths
- Plumbing leaks


P. Cotter

Relative Humidity

- Amount of water vapor in air RELATIVE to how much water vapor that air can hold
- Depends on TEMPERATURE
- Should be controlled
  - Ventilation is one part of a control strategy

Dewpoint Temperature

- The temperature at which water vapor changes to liquid

- Dependent on temperature and amount of moisture in the air

Dew point on interior glass surface

Remove the source!

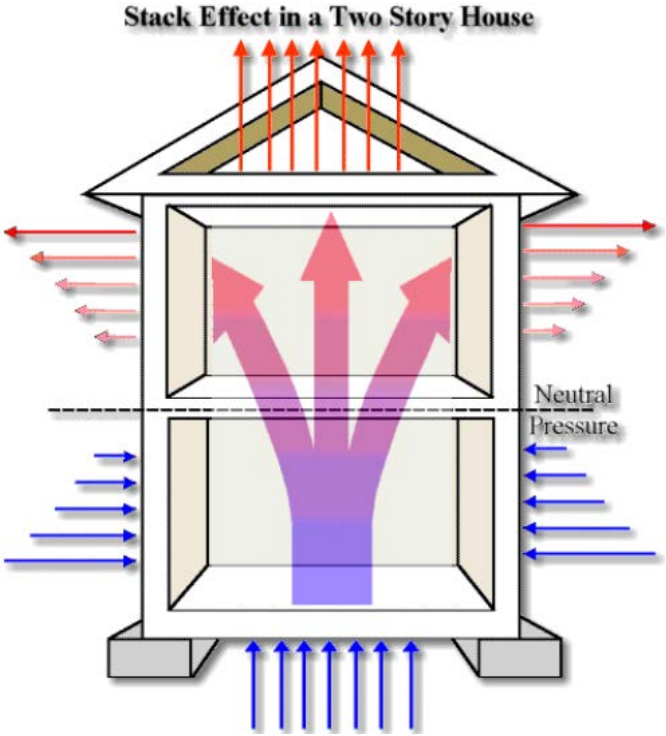
Ventilation

cfm out = cfm in
(exfiltration = infiltration)

Difference in pressure (naturally or through use of fan(s)) inside to outside; working for equilibrium

Introducing Fresh Air

Natural Ventilation: Also termed ‘stack effect’

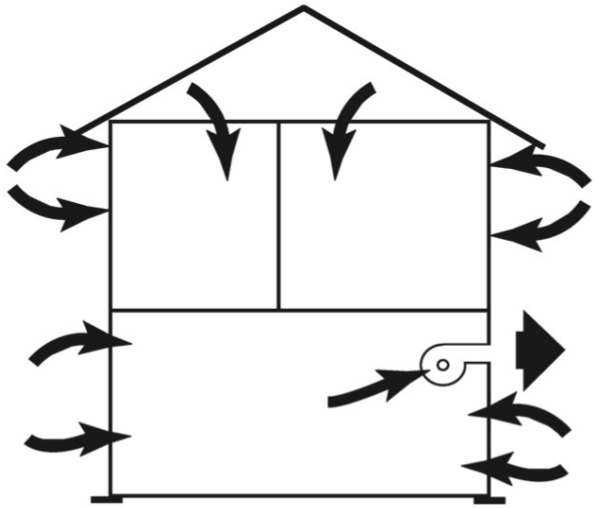


Fresh air is introduced into the home through existing penetrations in the buildings air barrier. The amount of ventilation is determined by the aggregate area of the penetrations and the difference in pressure from inside to outside.

Introducing Fresh Air

Mechanical Ventilation, exhaust only: Controlling the pressure difference

In an exhaust only system, a fan or system of fans creates a pressure difference from inside to outside to draw in outdoor air and exhaust indoor air.



Supply only Ventilation

4.2 System Type.

Add the following three sentences after the first one:

"Supply-only systems are not permitted in Alaska during the heating season. Balanced, heat-recovery ventilation systems as described in Appendix C2.1 that provide well distributed ventilation throughout the entire occupiable space are strongly recommended in Alaska.

If warm air holds more water than cold air,

AND

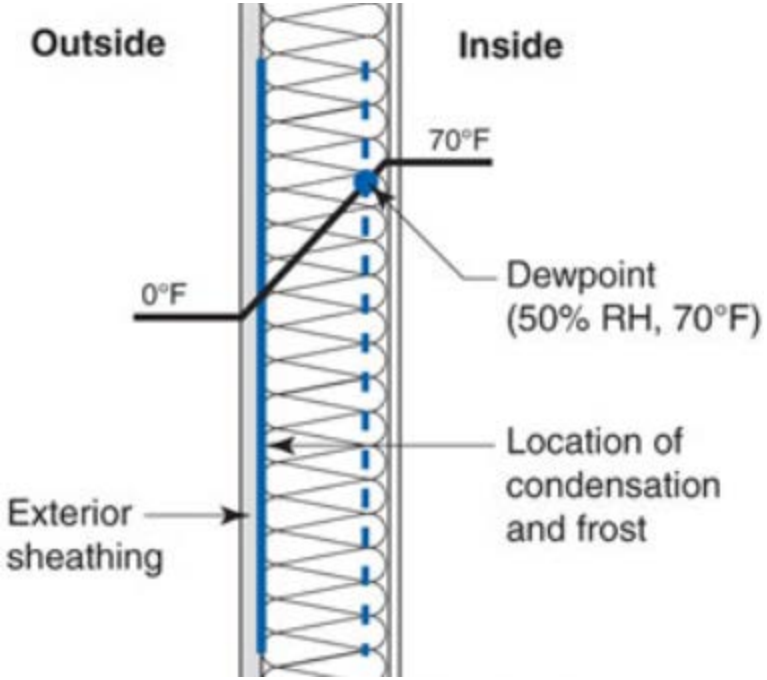
this warm air leaks through building assemblies,

AND

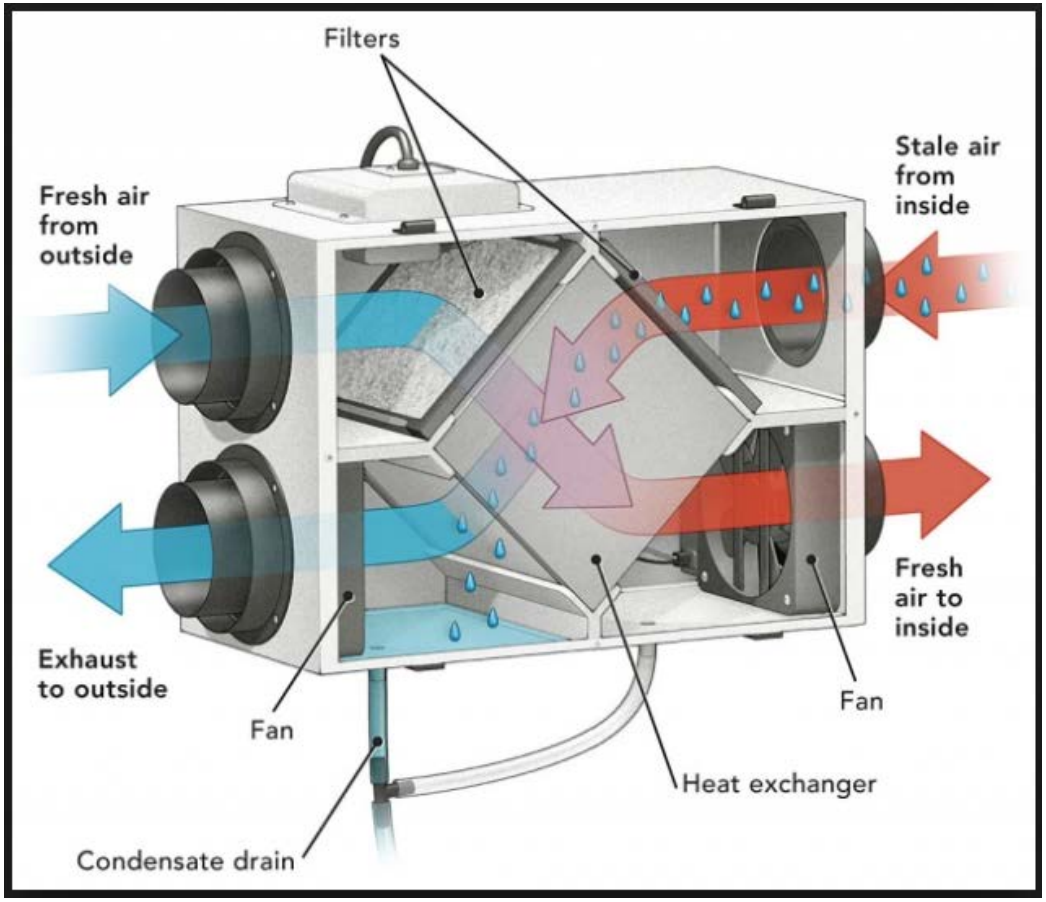
it hits cold surfaces,

THEN

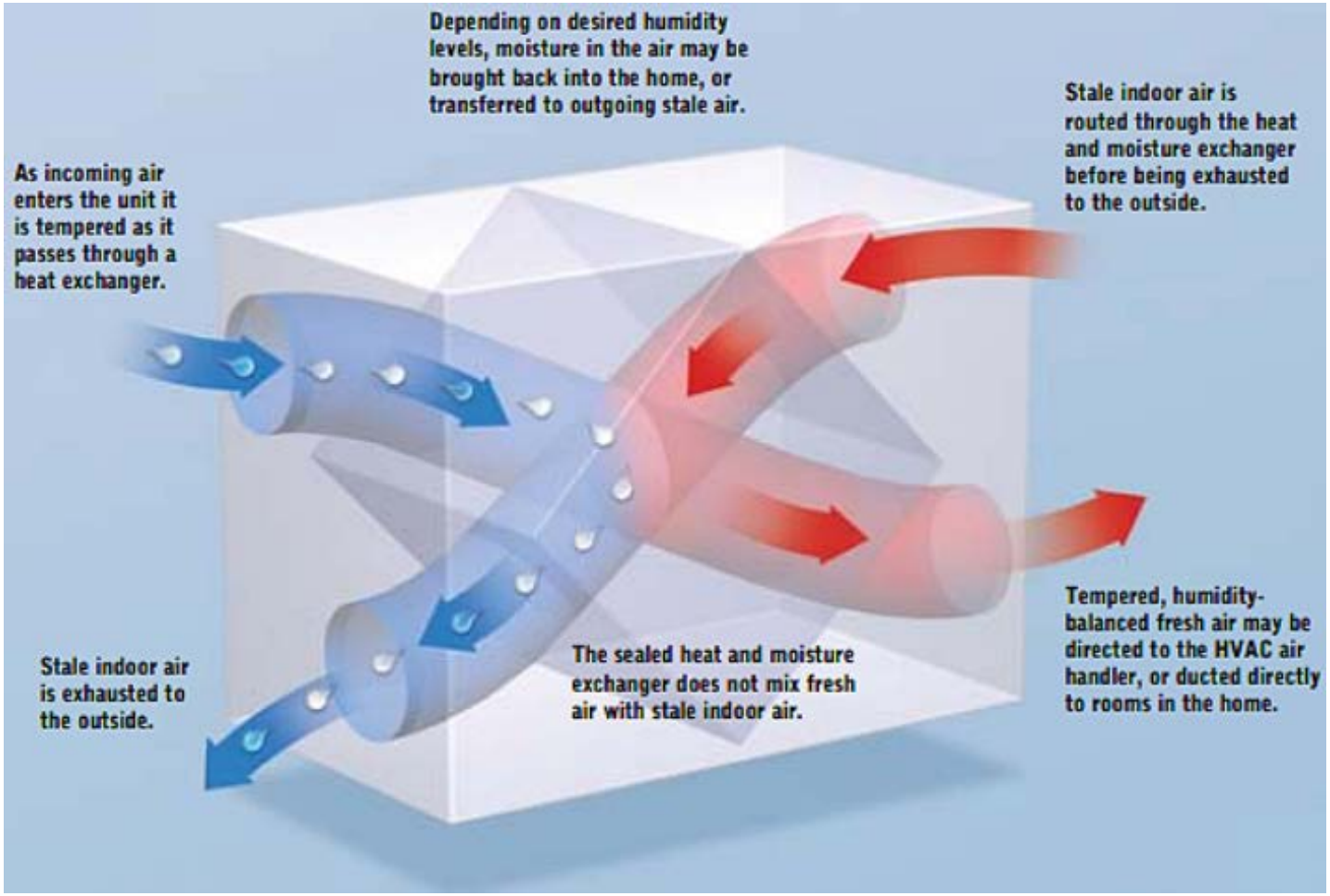
we have a moisture problem


Outside
Inside
70°F
0°F
Dewpoint
(50% RH, 70°F)
Location of
condensation
and frost
Exterior
sheathing

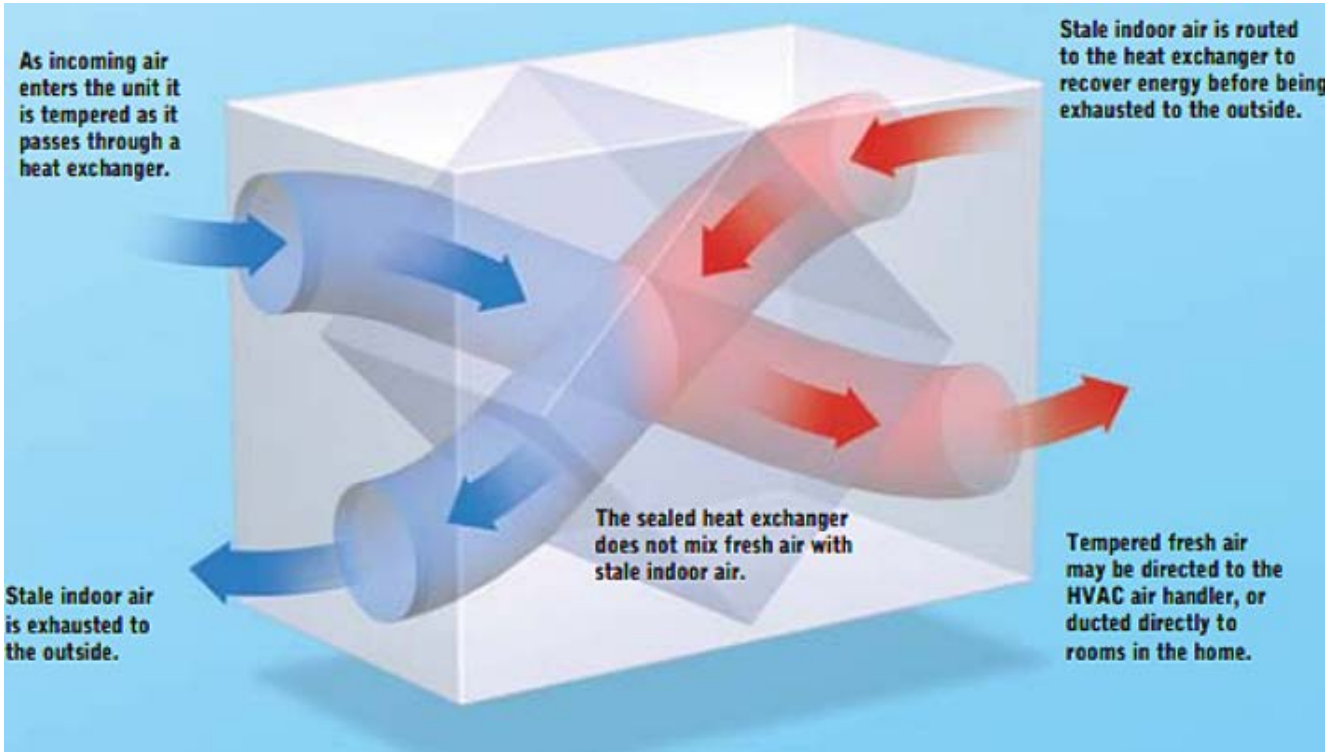
Mechanical Ventilation, a third option.



HRV vs ERV


Depending on desired humidity levels, moisture in the air may be brought back into the home, or transferred to outgoing stale air.
Stale indoor air is routed through the heat and moisture exchanger before being exhausted to the outside.
As incoming air enters the unit it is tempered as it passes through a heat exchanger.
Tempered, humidity-balanced fresh air may be directed to the HVAC air handler, or ducted directly to rooms in the home.
The sealed heat and moisture exchanger does not mix fresh air with stale indoor air.
Stale indoor air is exhausted to the outside.

HRV vs ERV


As incoming air enters the unit it is tempered as it passes through a heat exchanger.
Stale indoor air is routed to the heat exchanger to recover energy before being exhausted to the outside.
The sealed heat exchanger does not mix fresh air with stale indoor air.
Stale indoor air is exhausted to the outside.
Tempered fresh air may be directed to the HVAC air handler, or ducted directly to rooms in the home.

HRV vs ERV

While both designed are designed to be ducted, whole-house solutions, an ERV is designed for warmer climates to allow moisture from the intake air to be ‘handed-off’ to exhaust air to decrease indoor humidity.

Exhaust Only – Pros/Cons

- Pros
  - Low initial cost
  - Simple, generally
  - Low maintenance
  - Many controls
- Cons
  - Potential for dangerous depressurization
  - No heat recovery
  - Incoming air may get contaminated

HRV – Pros/Cons

- Pros
  - Continuous
  - Heat recovery for efficiency
  - Balanced (installed properly)
  - Many controls
- Cons
  - High initial cost
  - Some maintenance required
  - Retrofits can be challenging

Ventilation System Efficacy

(cfm/watt)

TABLE R403.5.1 MECHANICAL VENTILATION SYSTEM FAN EFFICACY

FAN LOCATION	AIR FLOW RATE MINIMUM (CFM)	MINIMUM EFFICACY (CFM/WATT)	AIR FLOW RATE MAXIMUM (CFM)
Range hoods	Any	2.8 cfm/watt	Any
In-line fan	Any	2.8 cfm/watt	Any
Bathroom, utility room	10	1.4 cfm/watt	< 90
Bathroom, utility room	90	2.8 cfm/watt	Any

Size and Flow

- Fans are sized by their flow rate in cubic feet per minute (cfm)
  - Ex. Bath fan might be 50cfm
- Many fans have adjustable flow rates to meet different needs and situations
- True flow depends on other factors, too

BEES Requirement

R403.5 Mechanical ventilation (Mandatory).
The building shall be provided with ventilation that meets the requirements of the ANSI/ASHRAE Standard 62.2-2010 as amended below. Outdoor air intakes and exhausts shall have automatic or gravity dampers that close when the ventilation system is not operating or positive closure that can be operated by occupants. An exterior exhaust vent shall be located to minimize exhaust air rising into an attic vent.

Local (spot) ventilation

Kitchen: 100cfm if exhaust flow is less than 5 kitchen air changes per hour.

Bathroom: 50 cfm

Whole house ventilation

WHOLE HOUSE MECHANICAL VENTILATION SYSTEM.

An exhaust system, supply system, or combination thereof that is designed to mechanically exchange indoor air with outdoor air when operating continuously or through a programmed intermittent schedule to satisfy the whole house ventilation rates.

Ventilation in Alaska homes

$$cfm = 0.01A + 10(\#\ Bedrooms + 1)$$

OR

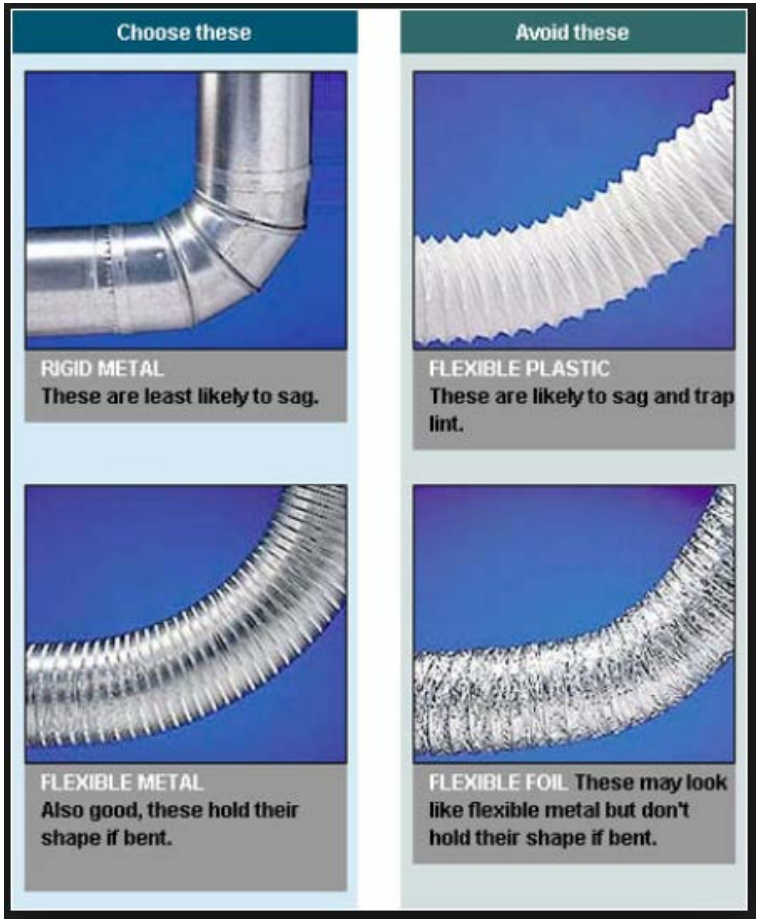
Ventilation in Alaska homes

Number of Bedrooms	0-1	2-3	4-5	6-7	>7
<1500 ft²	35	55	75	95	115
1501-3000	50	70	90	110	125
3001-4500	65	85	105	125	145
4501-6000	80	100	120	140	160
6001-7500	95	115	135	155	175
>7500 ft²	110	130	150	170	190

Measured flow to meet standard

Testing flow

Duct Considerations



Knowledge application

Questions?

"A wise man can learn more from a foolish question than a fool can learn from a wise answer."

~Bruce Lee

Thank You!