We will be starting soon!

Thanks for joining us

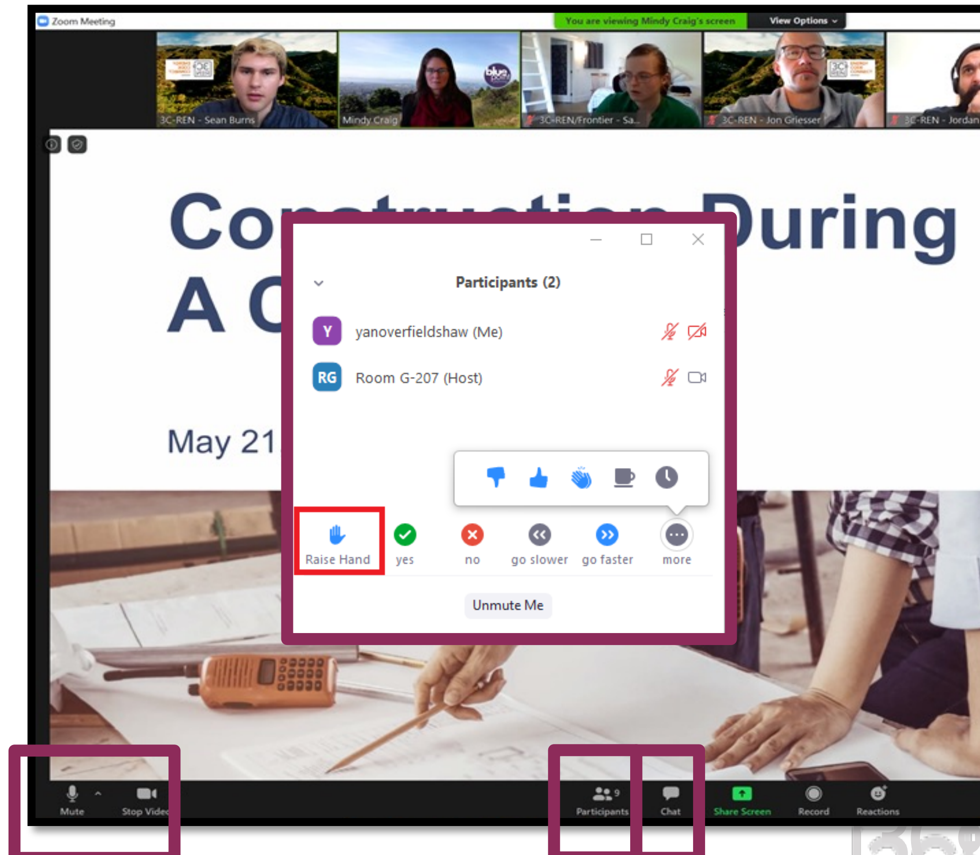
Introduction to Residential HVAC Systems

Russell King, ME – Coded Energy Inc.

January 30, 2024

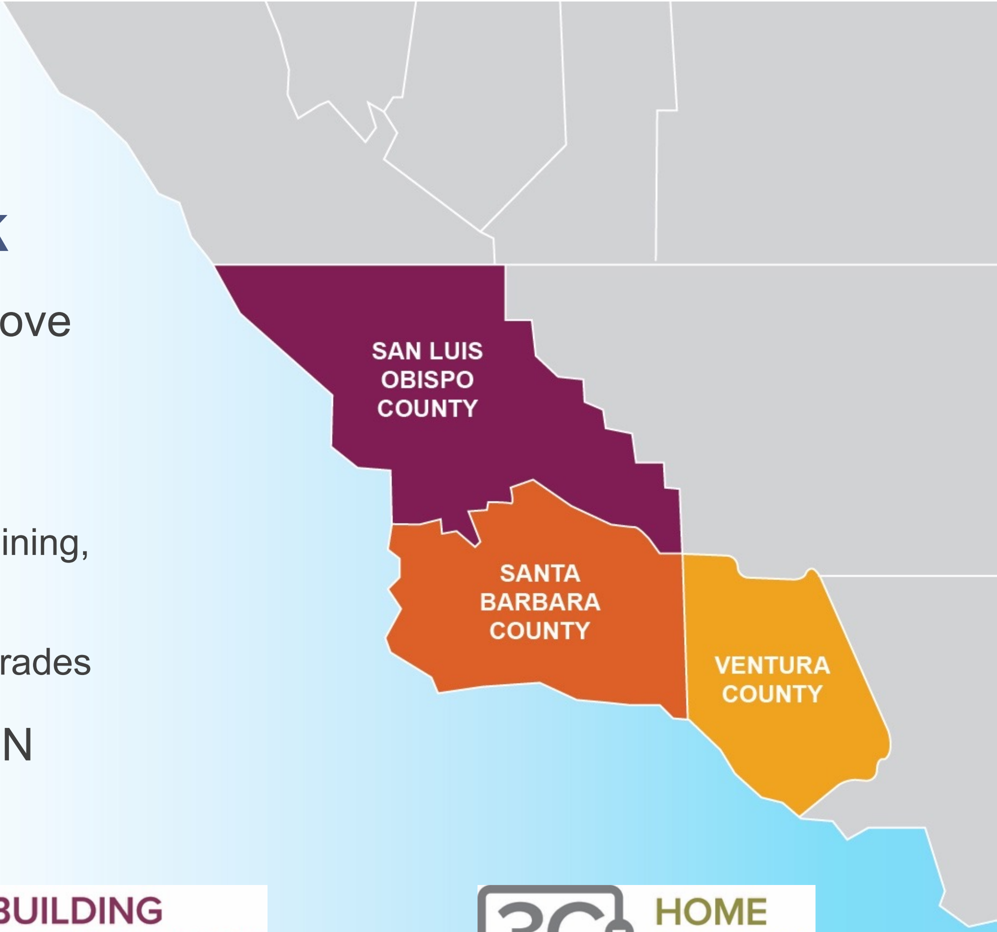
Zoom Orientation

- Please be sure your full name is displayed
- Please mute upon joining
- Use "Chat“ box to share questions or comments
- Under "Participant" select "Raise Hand" to share a question or comment verbally
- The session may be recorded and posted to 3C-REN's on-demand page. Feel free to ask questions via the chat and keep video off if you want to remain anonymous in the recording.



3C-REN: Tri-County Regional Energy Network

- Three counties working together to improve energy efficiency in the region
- Services for –
  - **Building Professionals:** industry events, training, and energy code compliance support
  - **Households:** free and discounted home upgrades
- Funded by ratepayer dollars that 3C-REN returns to the region



3C REN ENERGY CODE CONNECT

3C REN BUILDING PERFORMANCE TRAINING

3C REN HOME ENERGY SAVINGS

3C-REN ENERGY CODE CONNECT

- Serves all building professionals
- Three services –
  - **Energy Code Coach**
  - **Training and Support**
  - **Regional Forums**
- Makes the Energy Code easy to follow

Energy Code Coach:
3c-ren.org/codes
805.781.1201

Event Registration:
3c-ren.org/events

3C-REN BUILDING PERFORMANCE TRAINING

- Serves current and prospective building professionals
- Expert instruction:
  - **Technical skills**
  - **Soft skills**
- Helps workers to thrive in an evolving industry

Event Registration:
3c-ren.org/events

3C-REN HOME ENERGY SAVINGS

Multifamily (5+ units)

- No cost technical assistance
- Rebates up to $750/apartment plus additional rebates for specialty measures like heat pumps

Single Family (up to 4 units)

- Sign up to participate!
- Get paid for the metered energy savings of your customers

Enrollment:
3C-REN.org/contractor-participation

Introduction to Residential HVAC Systems

Presented By:

Russell King, M.E.

- This training is based on the book "HVAC 1.0 – Introduction to Residential HVAC Systems"
- © CalCERTS, Inc.

- This class is intended for people with little or no practical experience with residential HVAC systems.
- It is intended to put you on a more level playing field when dealing with people who know a LOT about HVAC . . . or think they do.

- The topics covered include:
  - Identification of System and Distribution Types,
  - Terminology,
  - Understanding Airflow,
  - Comfort Issues,
  - Design Strategies and
  - Efficiencies.

Terminology

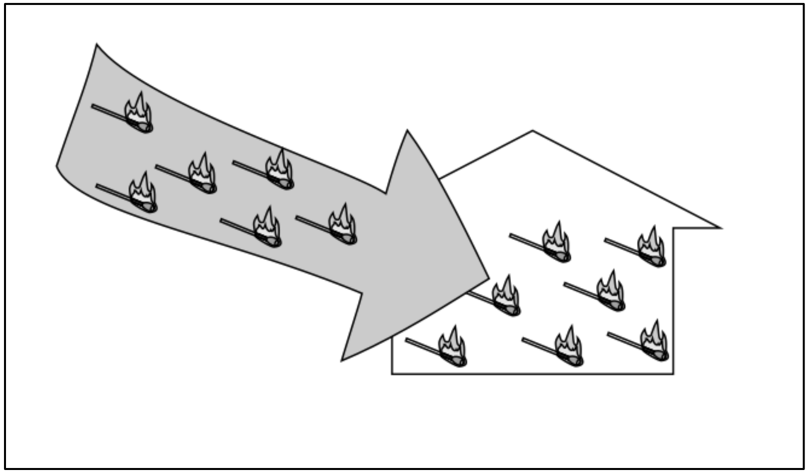
British Thermal Unit (BTU)

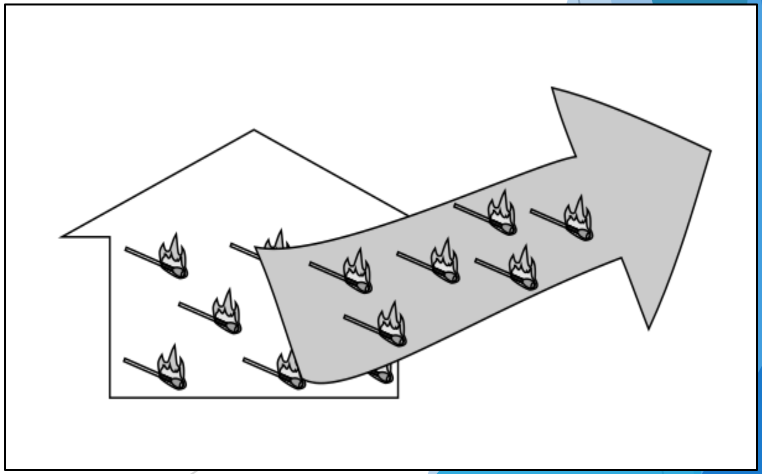
- A BTU is a unit of heat energy approximately equal to the amount of heat stored in one wooden kitchen match.
- Houses gain and loose heat at a certain rate (BTU's per hour).

Terminology

British Thermal Unit (BTU)

- When we heat a house we are *adding* BTU's to replace those that have been lost.
- When we cool a house we are *removing* BTU's that have been gained.





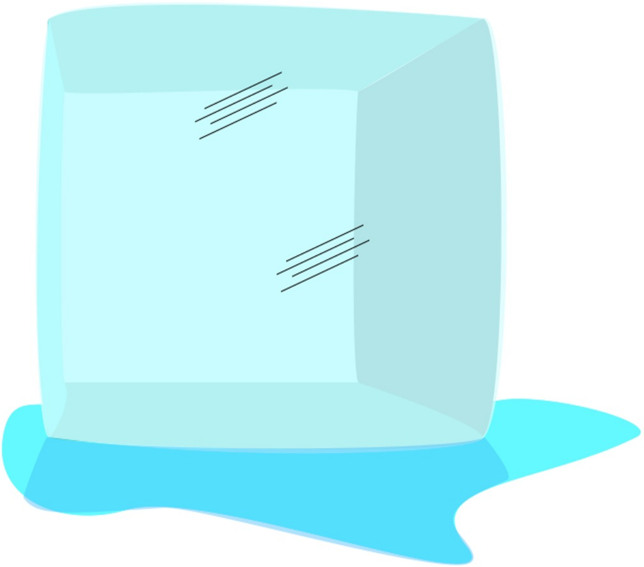
Terminology

- The rate (BTUs per hour) at which a home loses or gains heat under a certain set of conditions can be calculated.
- We refer to these as the home's heating or cooling "load".

Terminology

- To maintain a constant temperature in the home, we must replace BTU's (heat) or remove BTU's (cool) at the same rate.
- We refer to the ability to do this as the heating or cooling equipment's "capacity".

Terminology



Ton (of cooling)

- How much does a "Ton" of cooling weigh?
- Before refrigeration, people had to have blocks of ice delivered to keep food cold.
- When they first started to market refrigeration they would make claims such as, "This refrigeration system can replace having one ton of ice delivered per day!"
- Today a "ton" of cooling is defined as the ability to remove 12,000 BTU's per hour,

Terminology

Ton (of cooling)

- Residential air conditioning systems typically come in the following sizes:
  - 1½
  - 2
  - 2½
  - 3
  - 3½
  - 4 and
  - 5 tons.

Terminology

Ton (of cooling)

- Using the definition of a ton of cooling as 12,000 btu/hr, it would make sense that a 2 ton system would have a cooling capacity of . . .

$$2 \times 12{,}000 = 24{,}000 \text{ btu/hr,}$$

Terminology

Ton (of cooling)

- A 3½ ton system would have a cooling capacity of . . .

3.5 x 12,000 = 42,000 btu/hr, and so on.

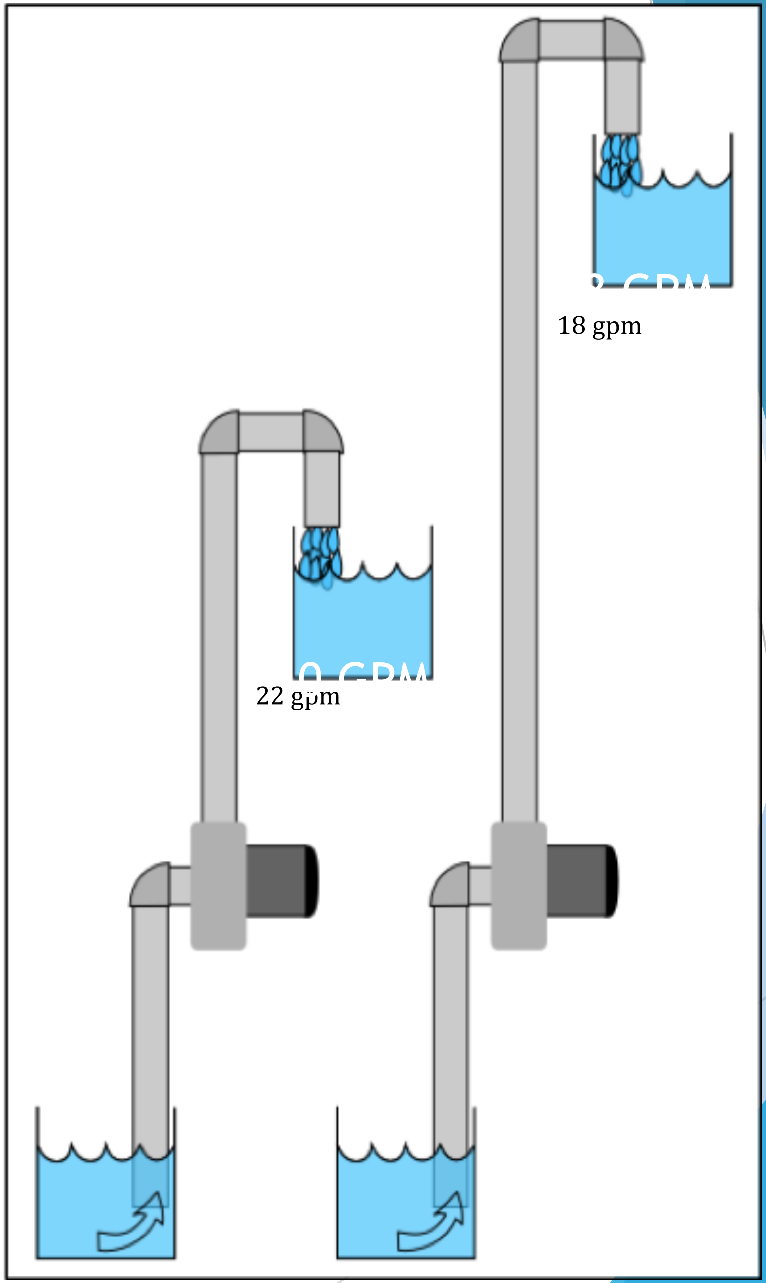
Terminology

Ton (of cooling)

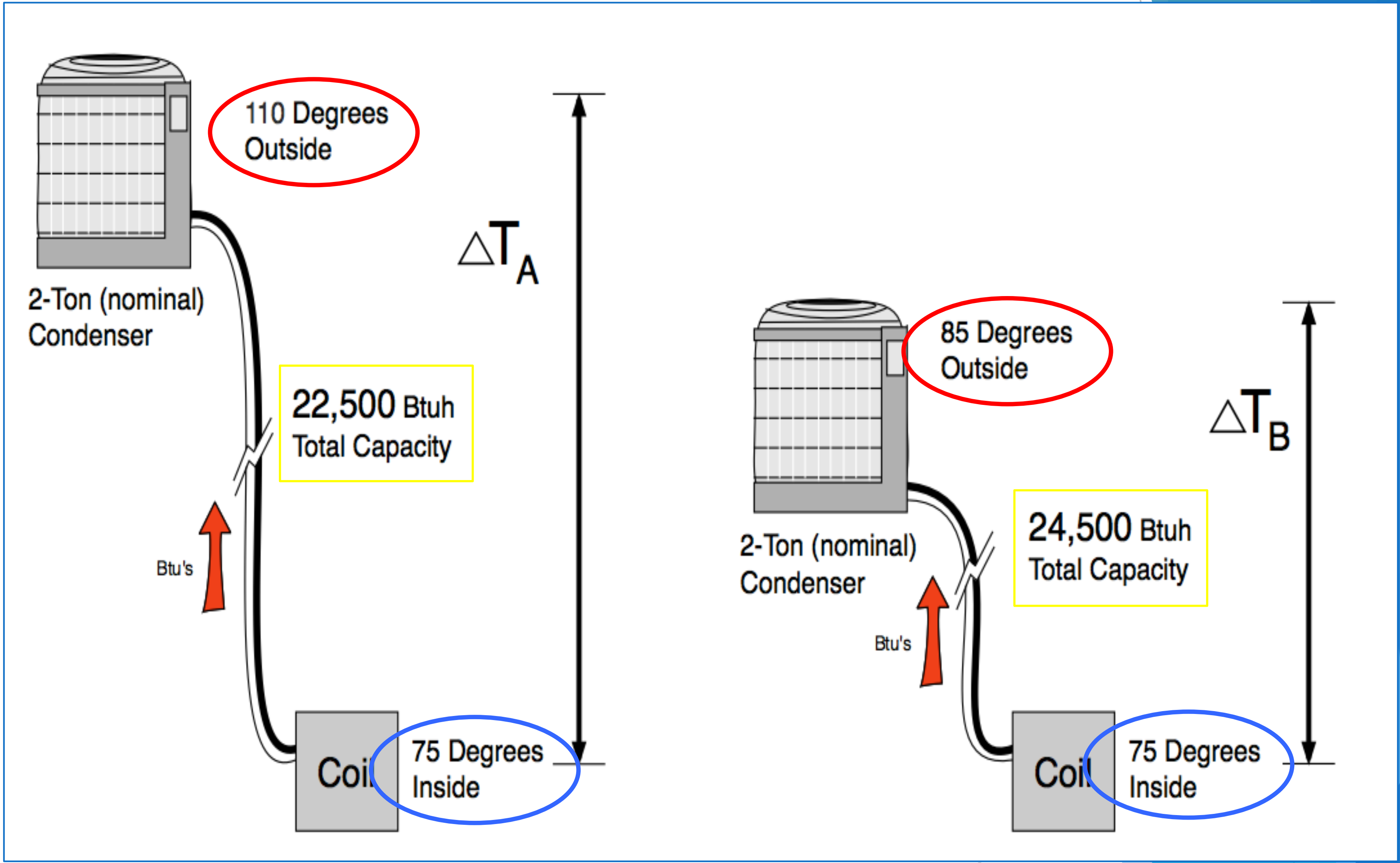
- Unfortunately, it is not that simple.
- Because air conditioners work by moving BTU’s from one place to another, their ability to do that at a certain rate (btu/hr) depends on the temperature at those two locations.
- It’s kind of like pumping water up a hill.

Terminology

If you use the same pump to pump water farther up a hill, it will not pump as much water.



Terminology



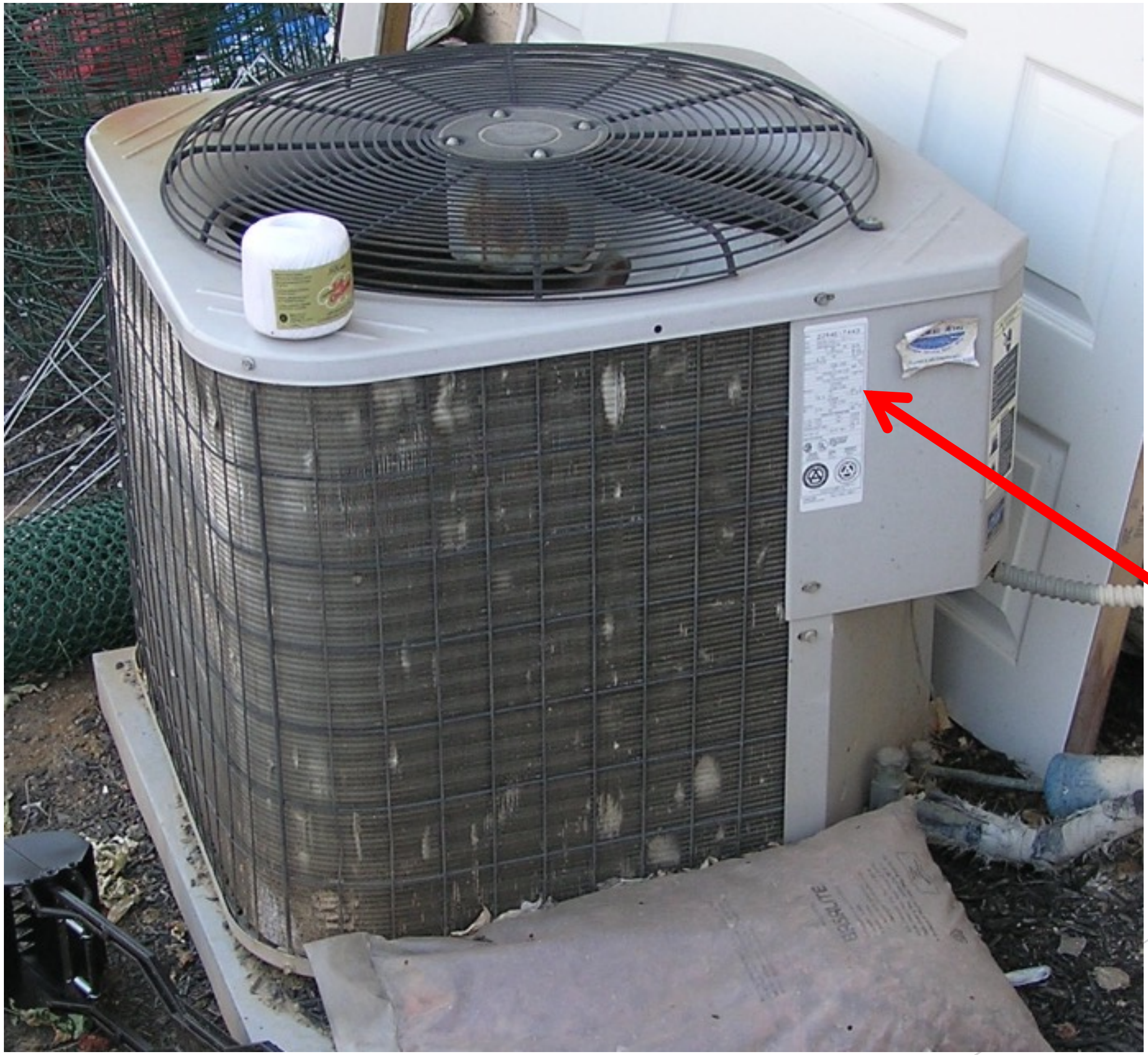
Terminology

Ton (of cooling)

- It's usually pretty easy to get the nominal tonnage from the equipment's model number using the following code: tons x 12.

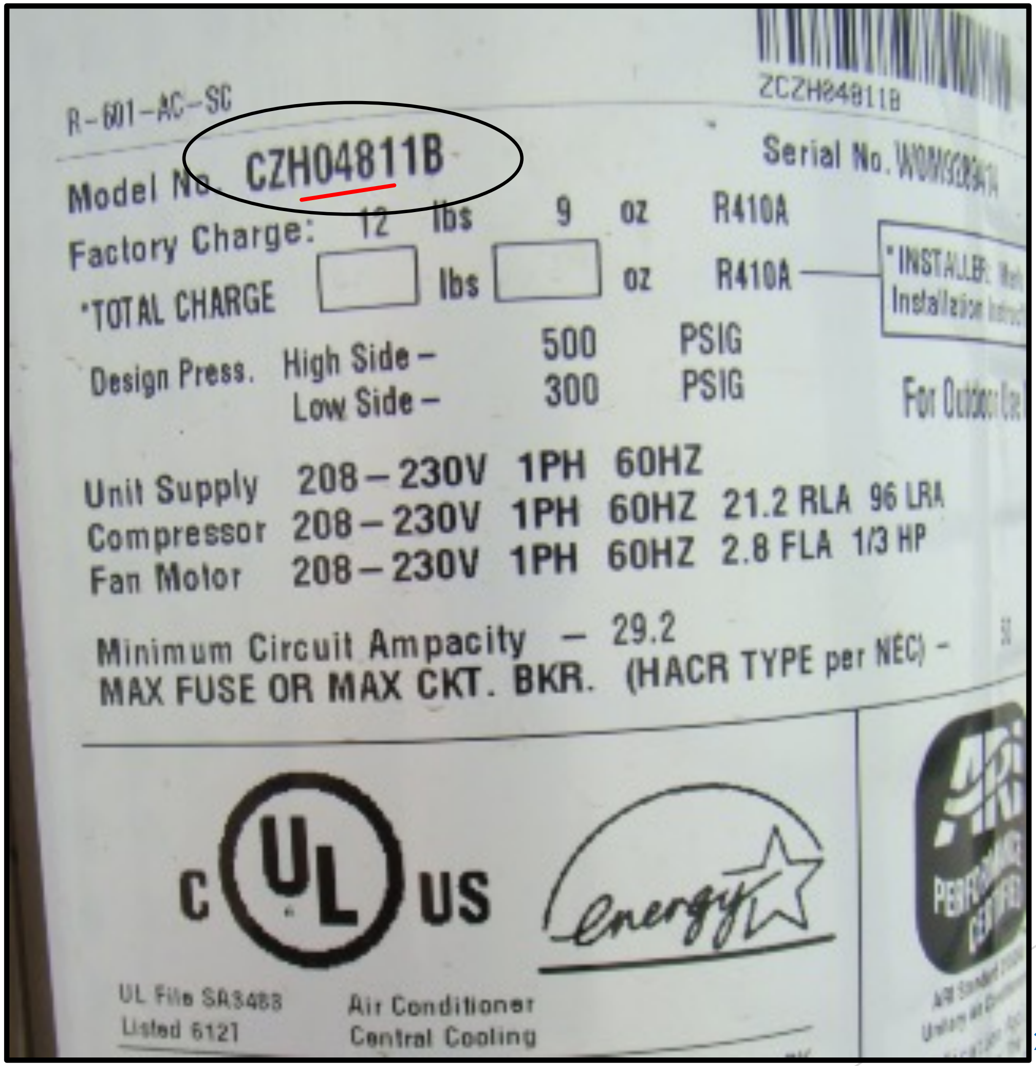
Tonnage	Code in Model Number
1½	18
2	24
2½	30
3	36
3½	42
4	48
5	60

Terminology

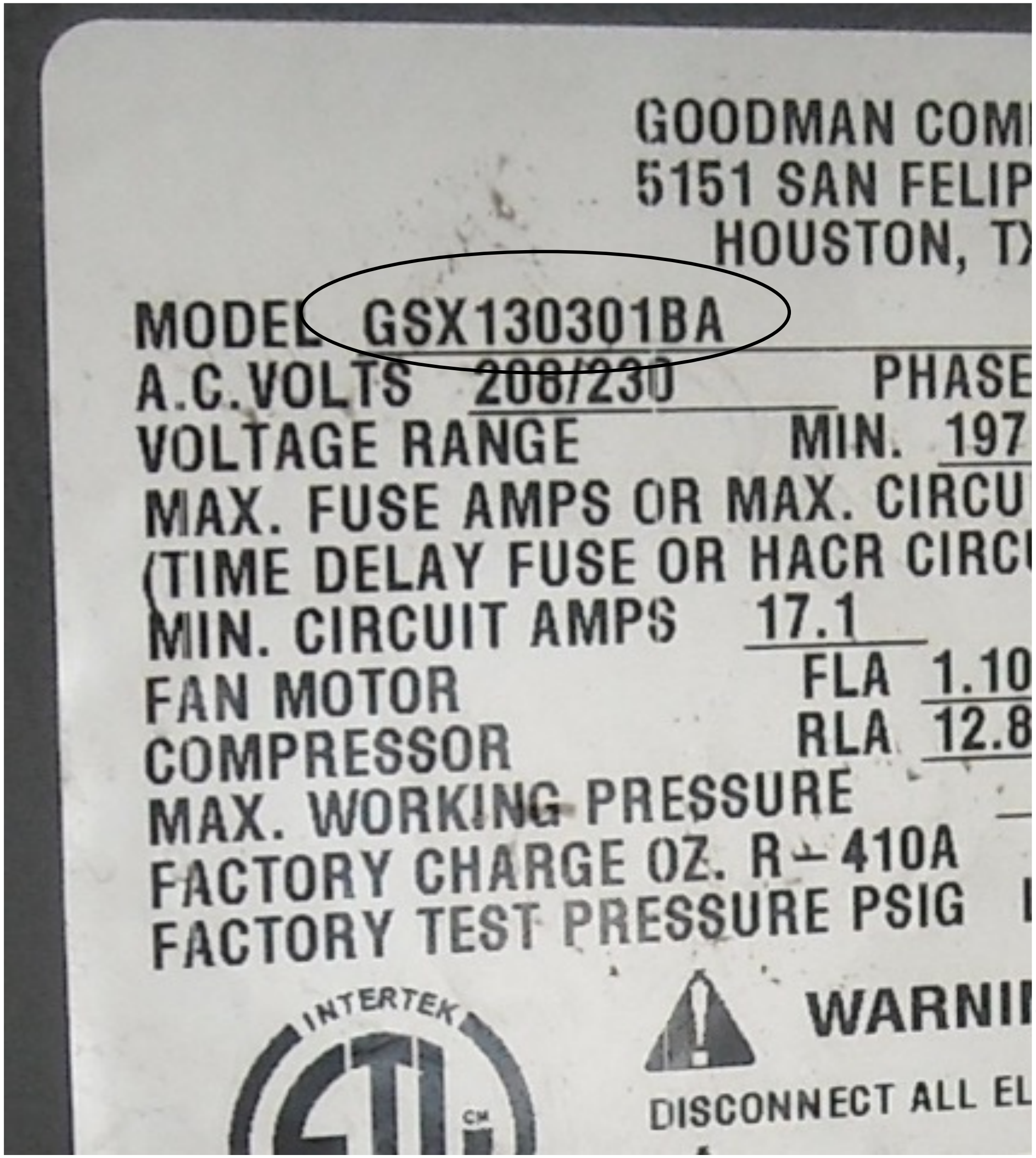


Manufacturer's Nameplate

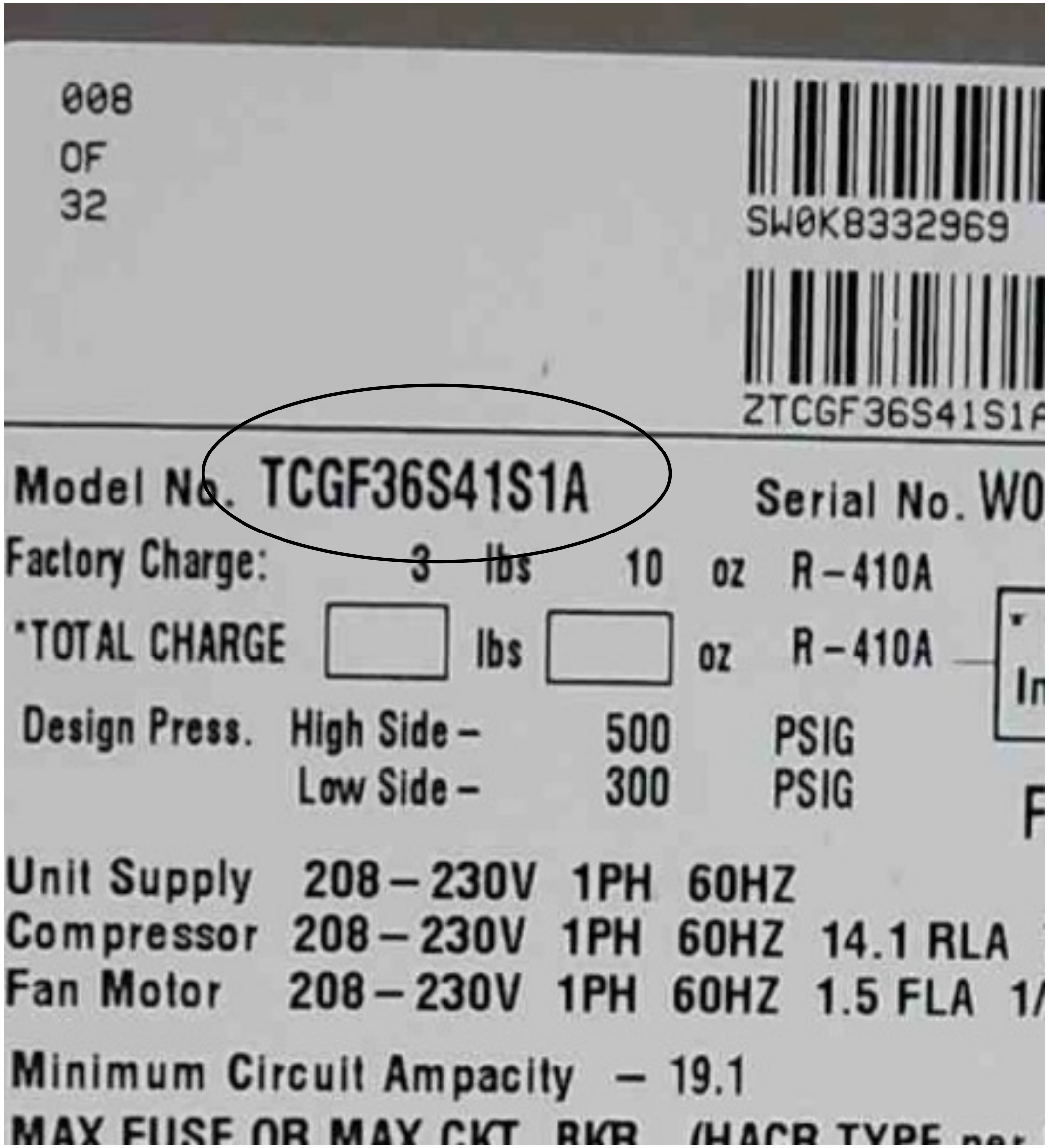
Terminology



Terminology



Terminology



Terminology

Ton (of cooling)

- Also be aware that air-conditioning coils and sometimes air handlers (a furnace is an airhandler) are also rated in nominal tons.
- The condenser defines the nominal tonnage of the system.
- It does not matter if you have a 4-ton coil and a 4-ton furnace attached to a 3-ton condenser.
- This would still be considered a “3-ton system”.

Terminology

SEER and **EER**

- These are two similar efficiency ratings used for residential sized air conditioners.
- SEER stands for Seasonal Energy Efficiency Ratio.
- EER is just Energy Efficiency Ratio.
- They are numbers derived from laboratory testing of equipment at specific conditions.

Terminology

SEER and **EER**

- As implied by the extra word "seasonal", the SEER rating of an air conditioner is measured over a "season".
- That is, it is tested at a variety of outdoor temperatures, which represent the changes in temperature that occurs throughout the season.
- EER is only tested at one fixed set of conditions.

Terminology

SEER and **EER**

- SEER ratings are always higher than EER ratings for a given piece of equipment.
- There is no simple formula to convert one to another, but approximately speaking:
  - EER = 0.875 x SEER.
- Never compare SEER of one piece of equipment to the EER of another.

Terminology

SEER and **EER**

- Both numbers represent efficiency in the sense of output divided by input.
- What you get out for what you put in.
- Higher is better.
- They represent how many BTU’s an air conditioner will remove for each unit of electricity consumed (watts per hour).

Terminology

SEER and **EER**

- You can pick an engine, transmission and body type in a car.
- Depending on what combination you pick, it will affect the miles per gallon.
- The same thing happens with an air conditioner, but with air conditioners the components can actually be different brands.
- The combination of condenser, coil and air handler will affect the SEER and EER.
- Manufacturers must test all possible combinations if they want that particular combination to be certified.

Terminology

AFUE

- This is also an efficiency rating.
- It stands for **Annual Fuel Utilization Efficiency**.
- It too represents output delivered for each unit of input used.
- Again, higher is better.
- AFUE is the efficiency rating of gas furnaces.
- The output is heat and the input is in gas.

Terminology

AFUE

- Because gas has a fixed amount of BTU's in it, AFUE can be simplified as
  - [BTU's of heat out] / [BTU's of gas in]
- Since it is just BTU's divided by BTU's, this makes it a simple percentage and easy to understand.
- An AFUE of 80 means that you get 80 BTU's of heat for every 100 BTU's of gas you put in.
- Most furnaces will list the input and output right on the nameplate, allowing you to calculate the AFUE yourself.
  - AFUE = (output / input) x 100.

Terminology

AFUE

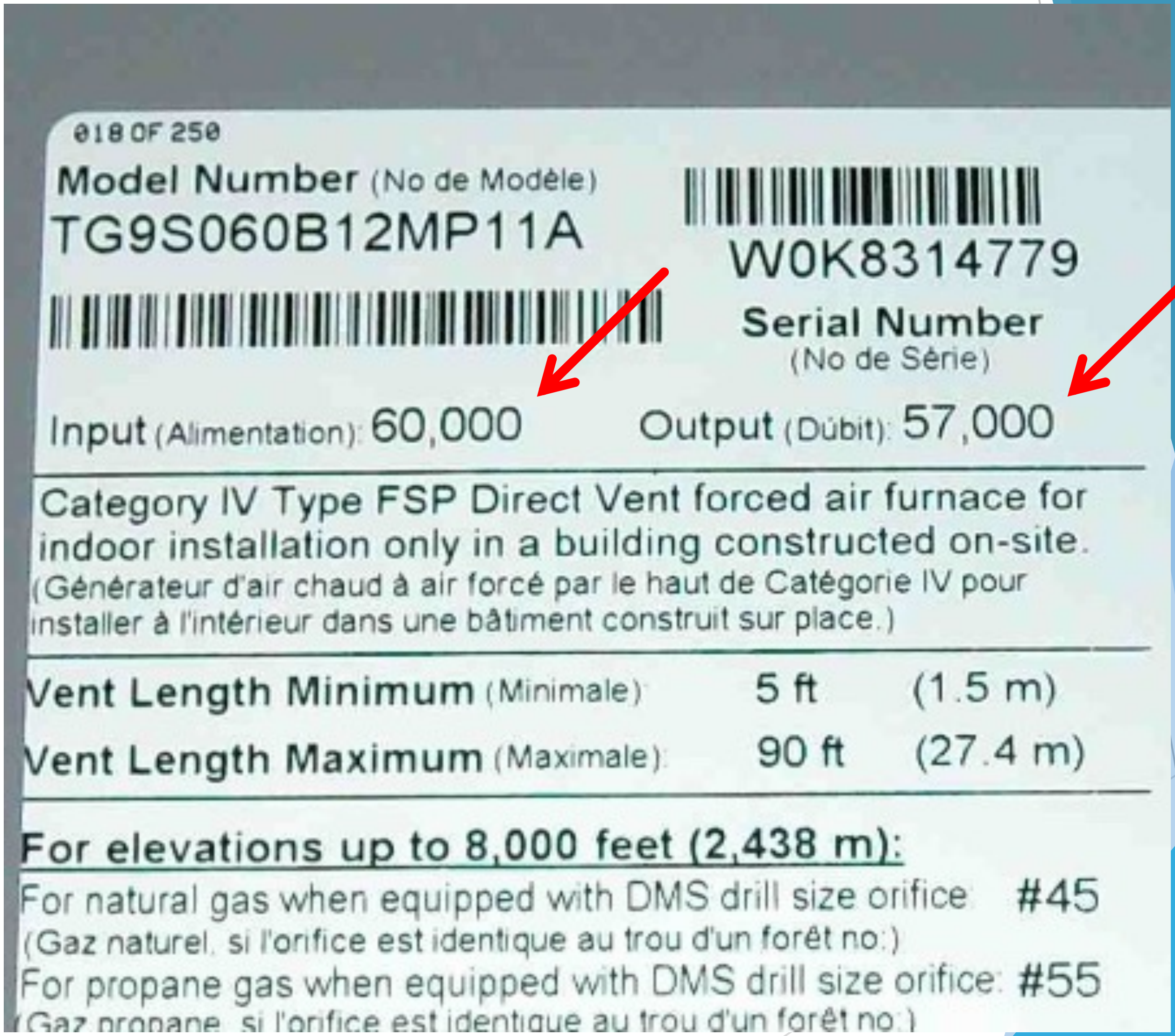
What's the AFUE of this Furnace?

AFUE = Output divided by Input x 100 (small number divided by large number)

60 / 75 = 0.8
0.8 x 100 = 80

Terminology

AFUE



What's the AFUE of this Furnace?

57 / 60 = 0.95

X 100 = 95

Terminology

HSPF

- This is the efficiency rating of a type of heater called a "heat pump" (to be discussed later).
- HSPF stands for **Heating Season Performance Factor** and it is also an output/input type of efficiency.
- Like air conditioners, it is tested at certain conditions.
- The HSPF is affected by the combination of condenser, coil and airhandler.
- The input is electricity in watt-hours, the output is BTU's.

Terminology

Cubic Feet per Minute (CFM)

- This is the unit used to quantify airflow.
- It is used in a lot of different areas related to HVAC. The following are common airflows measured in CFM:
  - Airflow in a duct
  - Airflow out of a registers
  - Airflow across a cooling coil
  - Air leakage into or out of ducts
  - Air leakage into or out of a house
  - Airflow delivered by a fan

Terminology

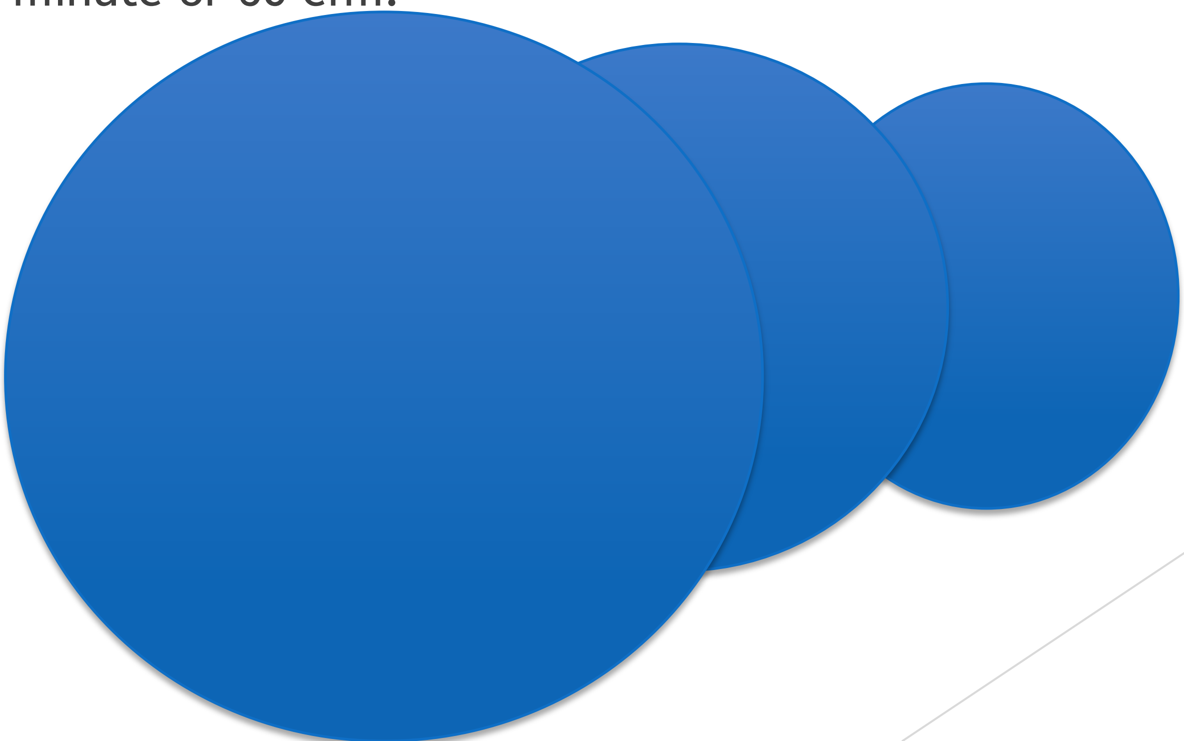
Cubic Feet per Minute (CFM)

- Similar to gallons per minute that pumps are rated in, it is called a unit of volumetric transfer rate.
- In other words it describes how fast a certain volume of air moves through or past a certain point over a period of time.
- It is a fairly intuitive number and easy to visualize.

Terminology

Cubic Feet per Minute (CFM)

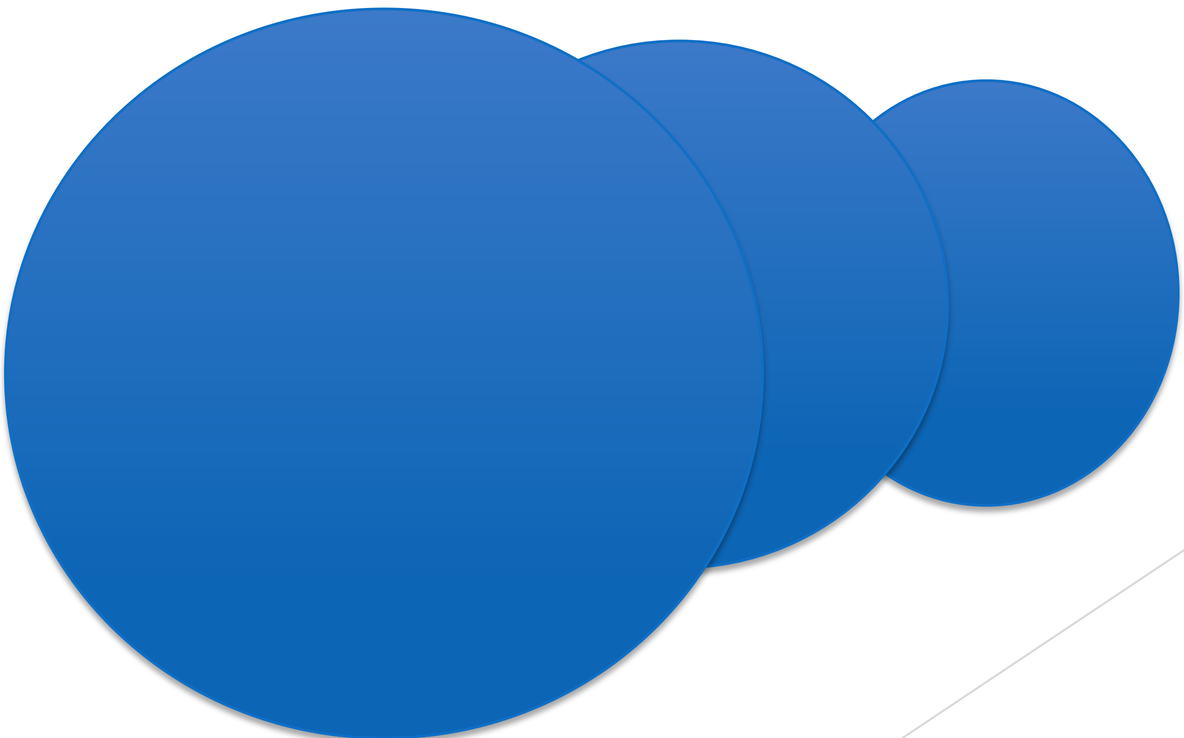
- A soap bubble about 15” across, about the size of a medium-sized beach ball, will have a volume of about 1 cubic foot.
- Let’s call this a “big ol’ bubble”.
- If one big ol’ bubble came out of a nozzle every second, that would be one cubic foot per second or 60 cubic feet per minute or 60 cfm.



Terminology

Cubic Feet per Minute (CFM)

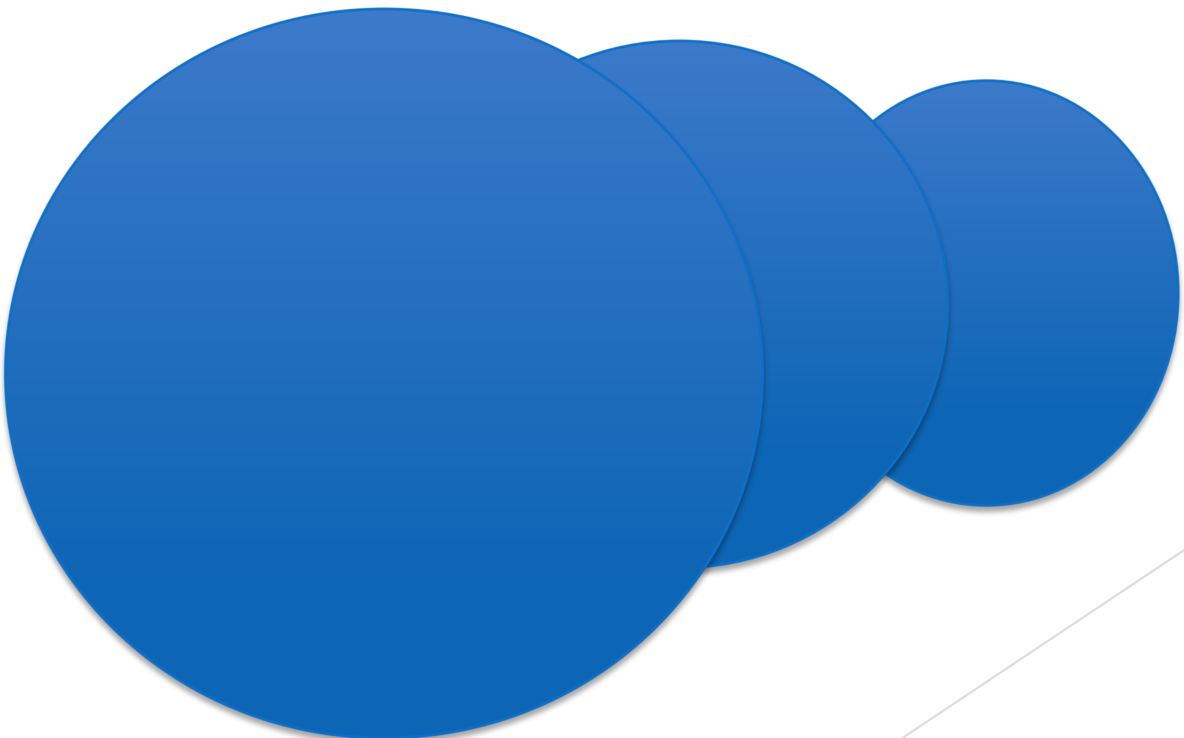
- A typical supply register in a bedroom supplies about 90 to 120 cfm, or about 1.5 to 2 big ol' bubbles per second.
- That's a pretty respectable amount of air.
- A medium size residential air conditioner (3-ton) should move about 1200 cfm, or 20 big ol' bubbles per second.
- That's a lot of big ol' bubbles!



Terminology

Cubic Feet per Minute (CFM)

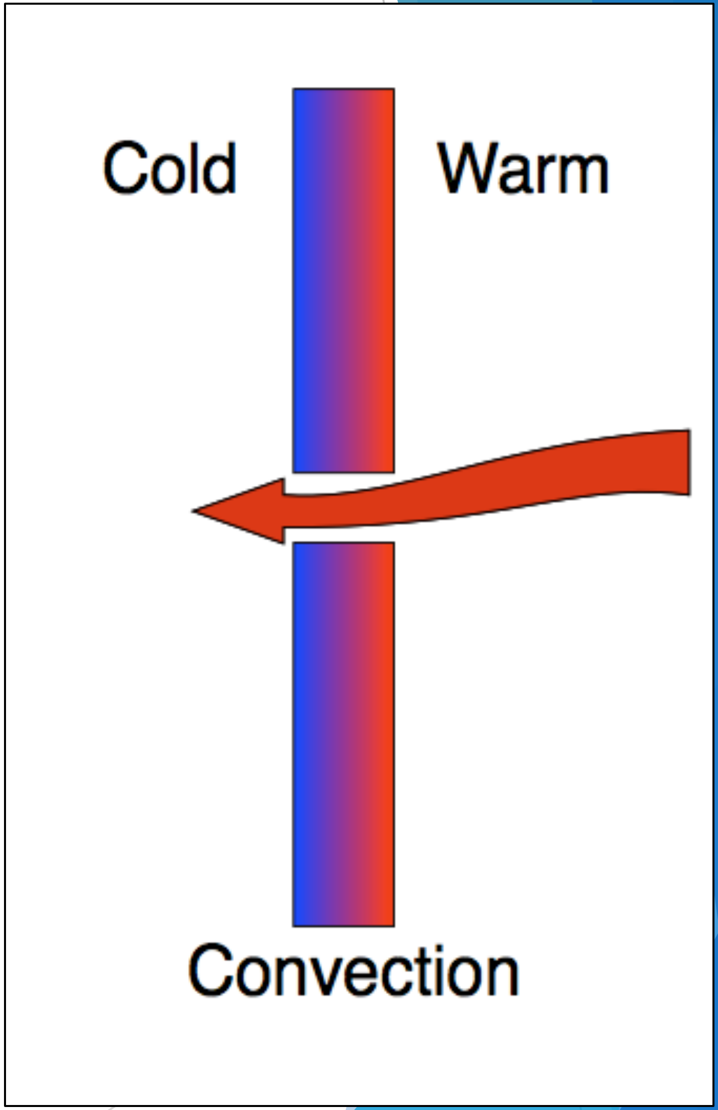
- Try to estimate airflow out of a supply register by putting your hand over it and imagining big ol' bubbles coming out per second, then multiply that by 60 to get cfm.
- With a flow hood to compare to and some practice, you can get pretty accurate doing this.



How Homes Lose and Gain Heat Appendix C (page 112)

Convection

- This is the transfer of heat (BTU's) by means of a moving fluid, usually air.



How Homes Lose and Gain Heat

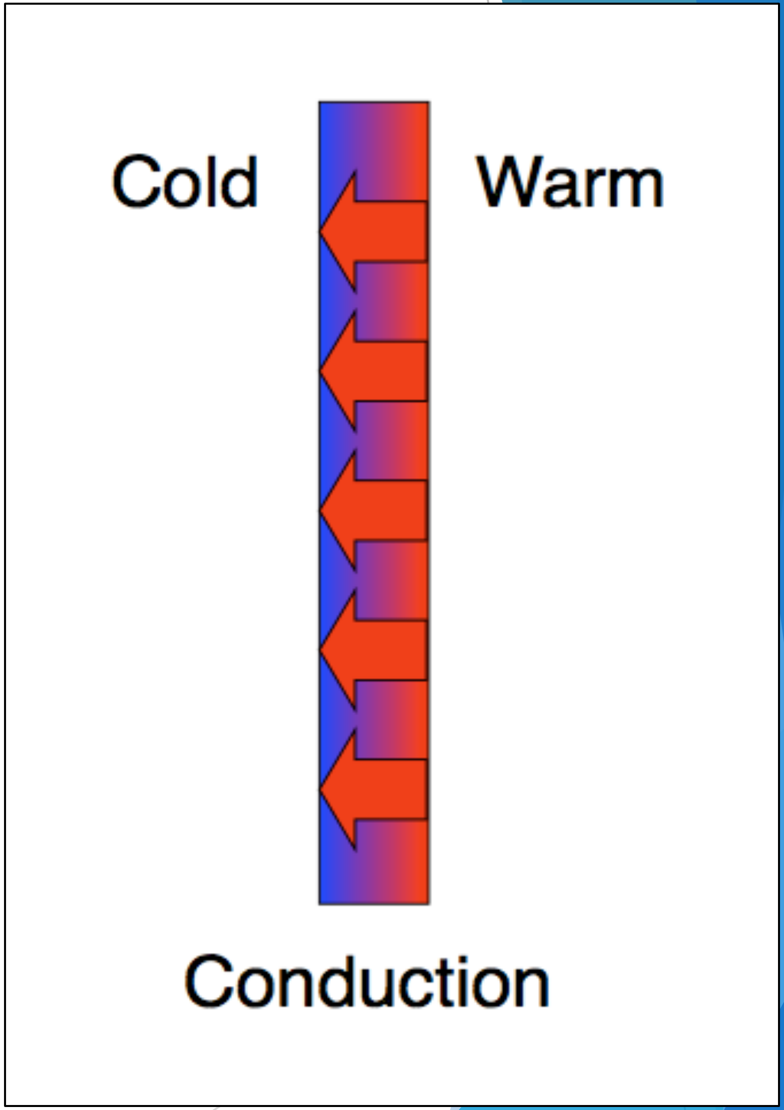
Convection

- Homes lose and gain a lot of heat by convection.
- Convection is a very important part of how we heat and cool our homes.
- Examples of convection:
  - Infiltration
  - Drafts
  - Ceiling fans cooling occupants
  - Stratification (hot air rising)
  - Forced air central heating and cooling

How Homes Lose and Gain Heat

Conduction

- This is the transfer of heat through a solid material.



How Homes Lose and Gain Heat

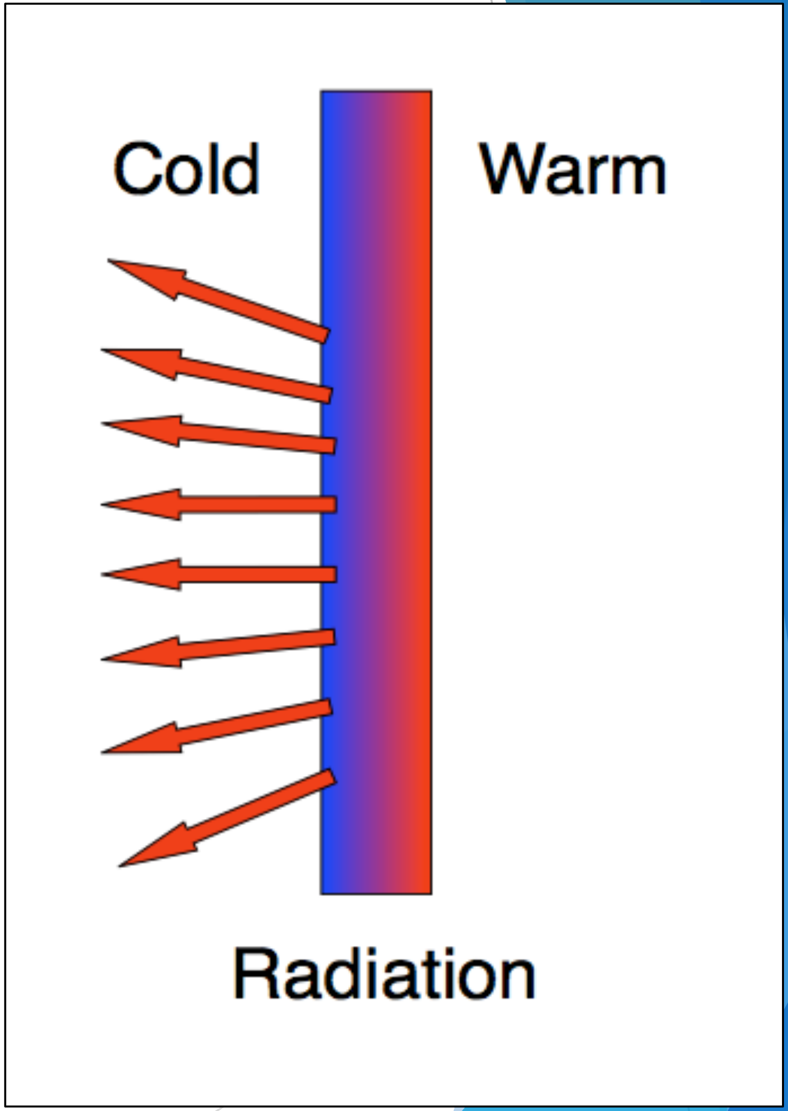
Conduction

- Occurs through any solid material that has a temperature difference across it.
- In a home this is usually the conditioned shell or thermal boundary of the home, which is made up of walls, floors, ceilings, windows and doors.
- Some of these conduct more heat per square foot than others.

How Homes Lose and Gain Heat

Radiation

- This is the transfer of heat by means or electromagnetic radiation (light waves), both visible and invisible.



How Homes Lose and Gain Heat

Radiation

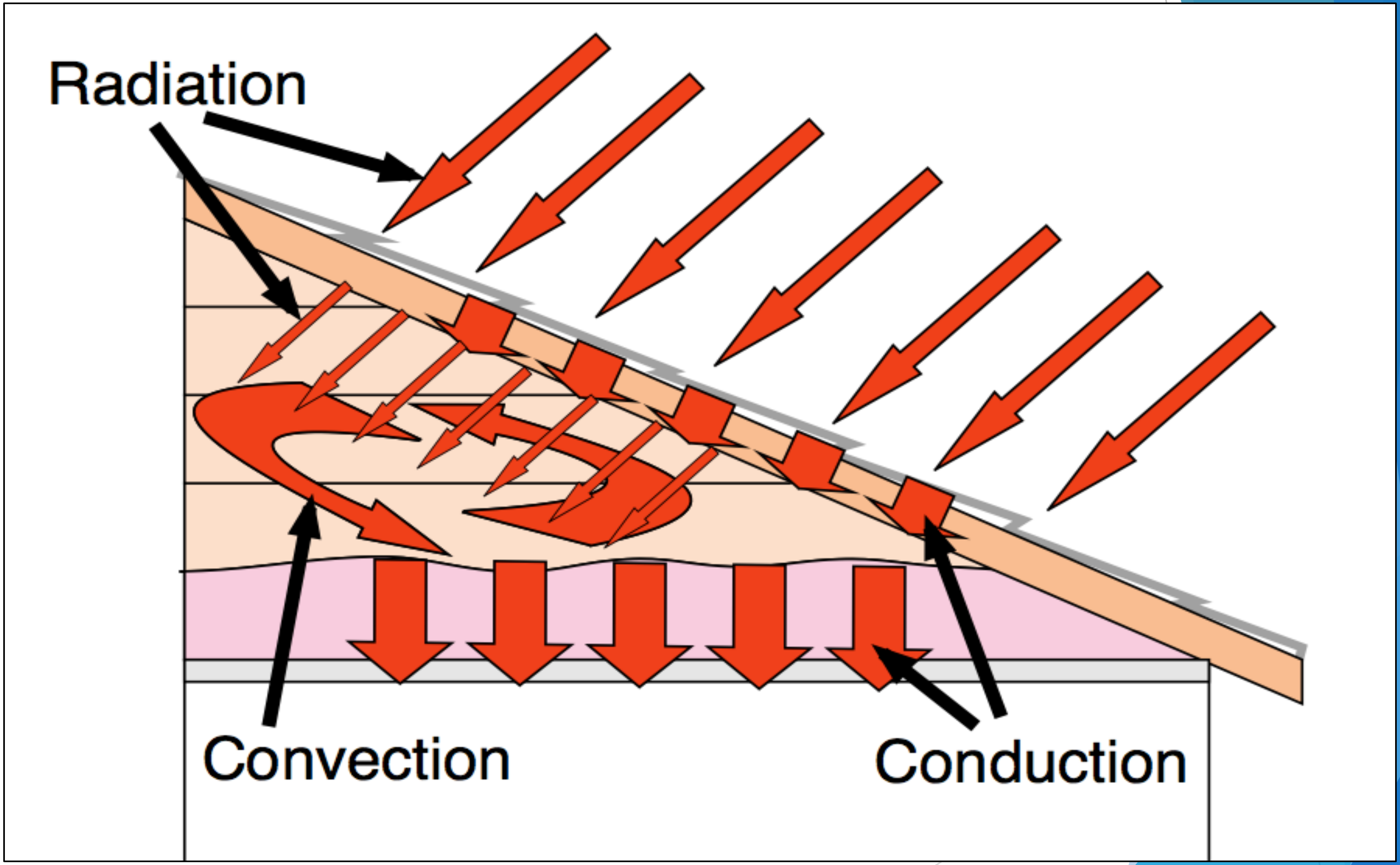
- The main source of radiant heat transfer in a home is solar gains, BTU's coming into the house by means of sunlight passing through windows.
- Homes can lose heat by radiation too.
- If you ever get a chance to look at a warm house on a cold night through an infrared camera, you can actually see where a house is losing energy by radiation.

How Homes Lose and Gain Heat

Sometimes it takes all three forms of heat transfer for a BTU to make it into a house.

1. The sun shines on the roof, heating it up.
2. This heat conducts through the roof to the attic side where it radiates into the attic.
3. The air in the attic circulates across it and gets hot.
4. The heat conducts through the insulation and ceiling into the conditioned space.

How Homes Lose and Gain Heat



Types of HVAC Systems (page 15)

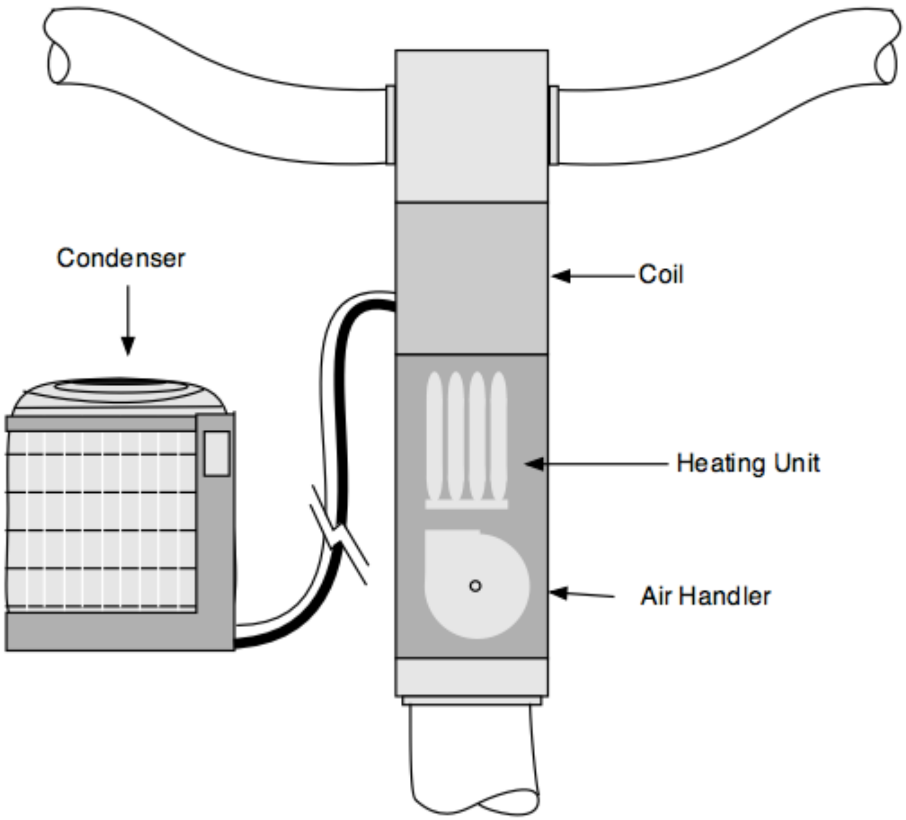
- There are many types of HVAC systems.
- They may or may not have air conditioning.

Split vs. Package

- There are two basic ***configurations*** of central forced air systems, *split systems* and *package units*.
- A central forced air heating and cooling system has three basic components: air handler, cooling unit and heating unit.
- A cooling unit has two basic parts: a condenser and an evaporator coil (usually just called “the coil”).
- So, let’s say there are four parts altogether.

Types of HVAC Systems

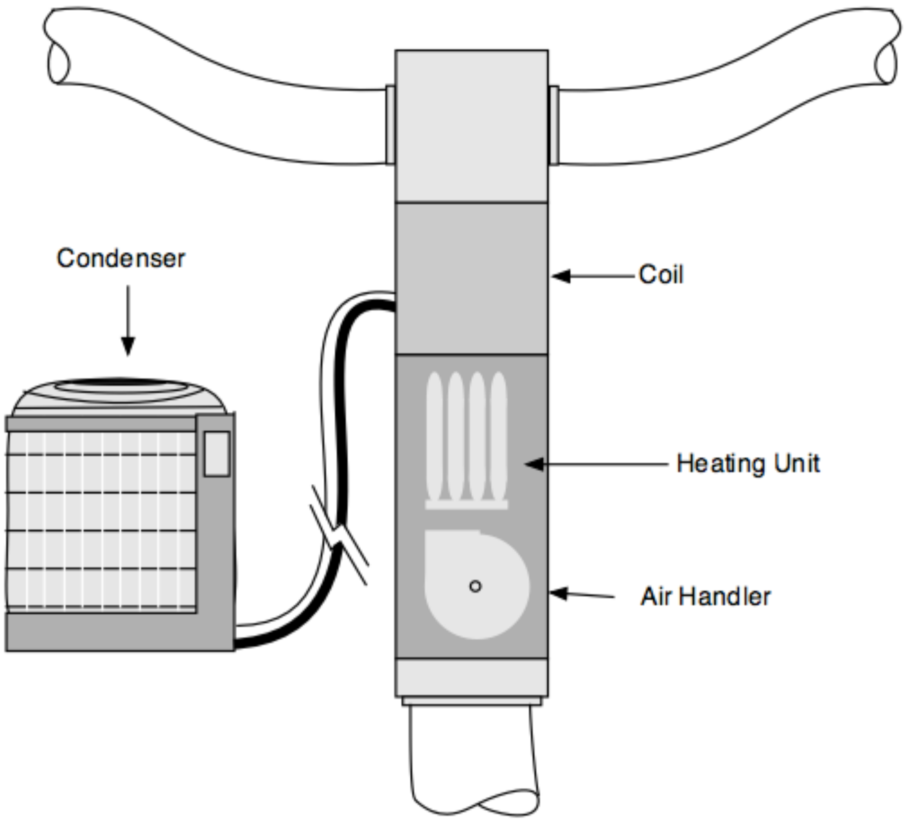
- In a split system these units are modular.
- An installer/contractor can pick and choose different sizes and even different brands, which are assembled into the final system.
- When using a gas furnace, the heating unit and airhandler are the same component.



A Typical Split System

Types of HVAC Systems

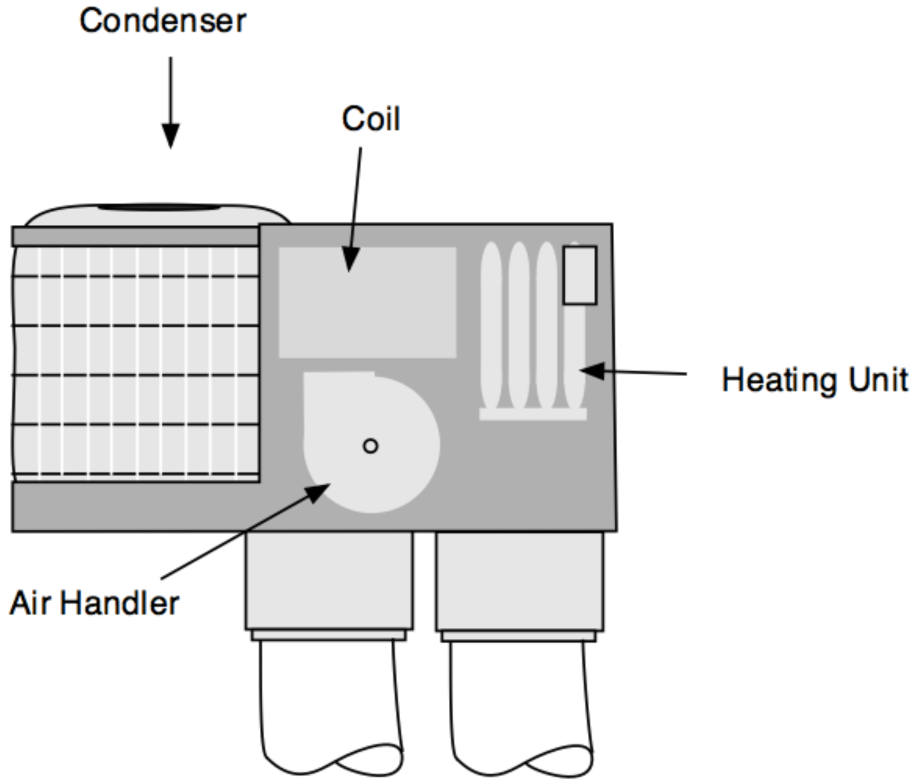
- Note that split systems are often described by the direction of the airflow and orientation of the air handler.
- Upflow,
- Downflow, and
- Horizontal



A Typical Split System

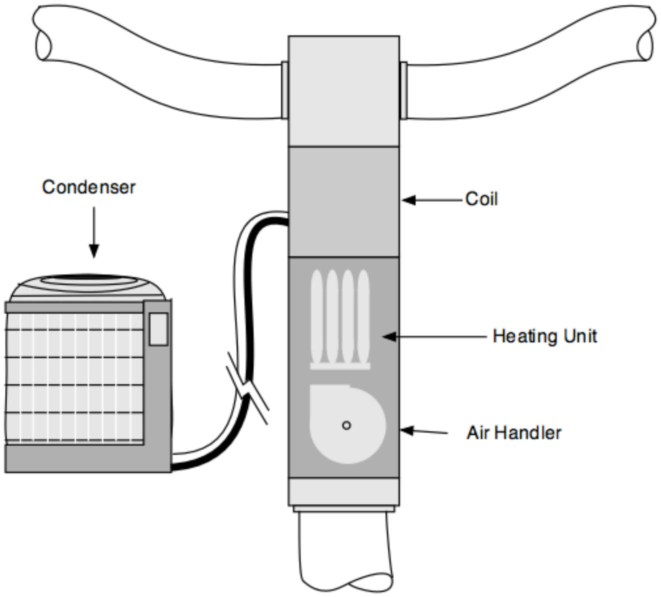
Types of HVAC Systems

- A package unit has all four components in one single box.
- The condenser must be outside, the entire package unit must be outside,

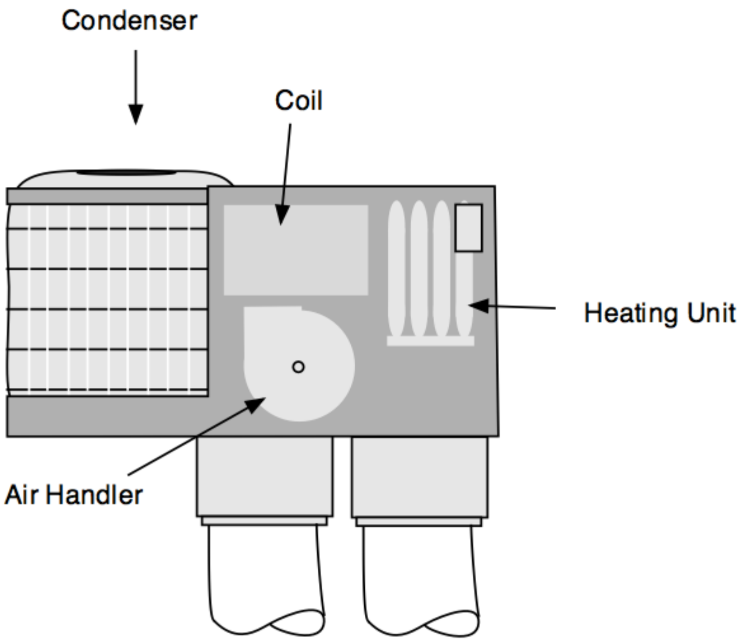


A Typical Package Unit

Types of HVAC Systems



A Typical Split System



A Typical Package Unit

- With a split system the condenser unit can sit outside and the airhandler, heating unit and evaporator coil can be located inside the house, or in the attic, crawlspace or garage.

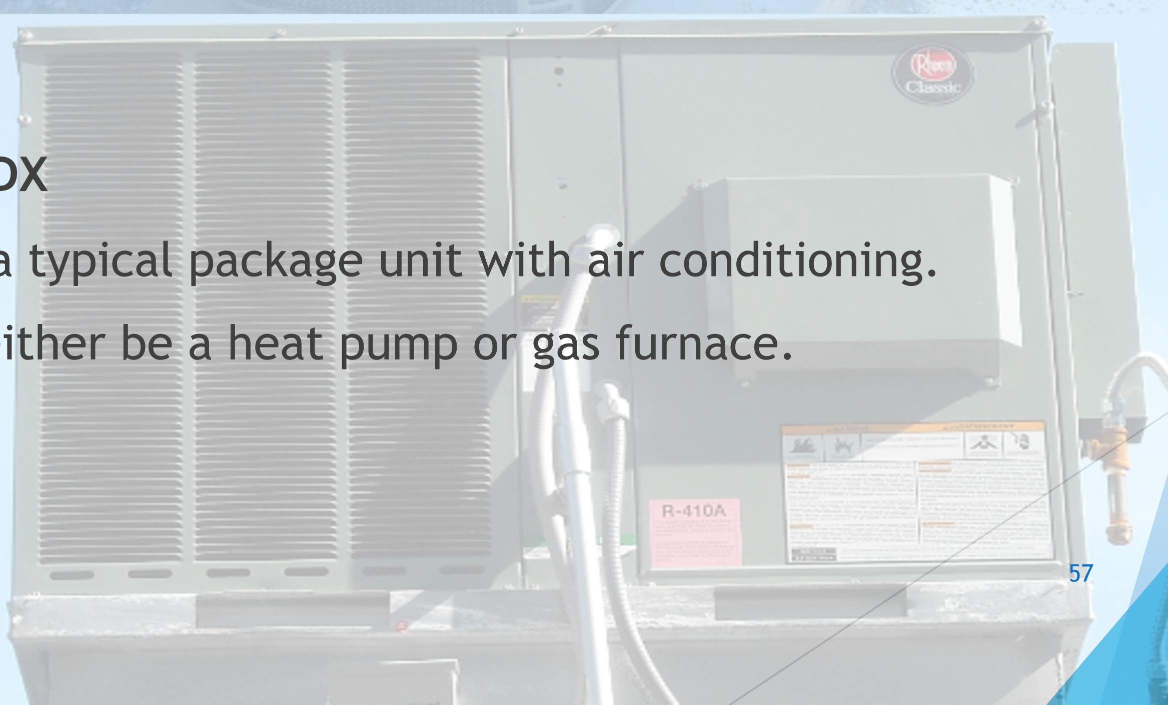
Common HVAC System Descriptions

Split DX

- Split system with direct expansion (DX) air conditioning – This is the common type of split system whether gas furnace or heat pump.

Packaged DX

- This is a typical package unit with air conditioning.
- It can either be a heat pump or gas furnace.



Common HVAC System Descriptions

Hydronic Heat Pump

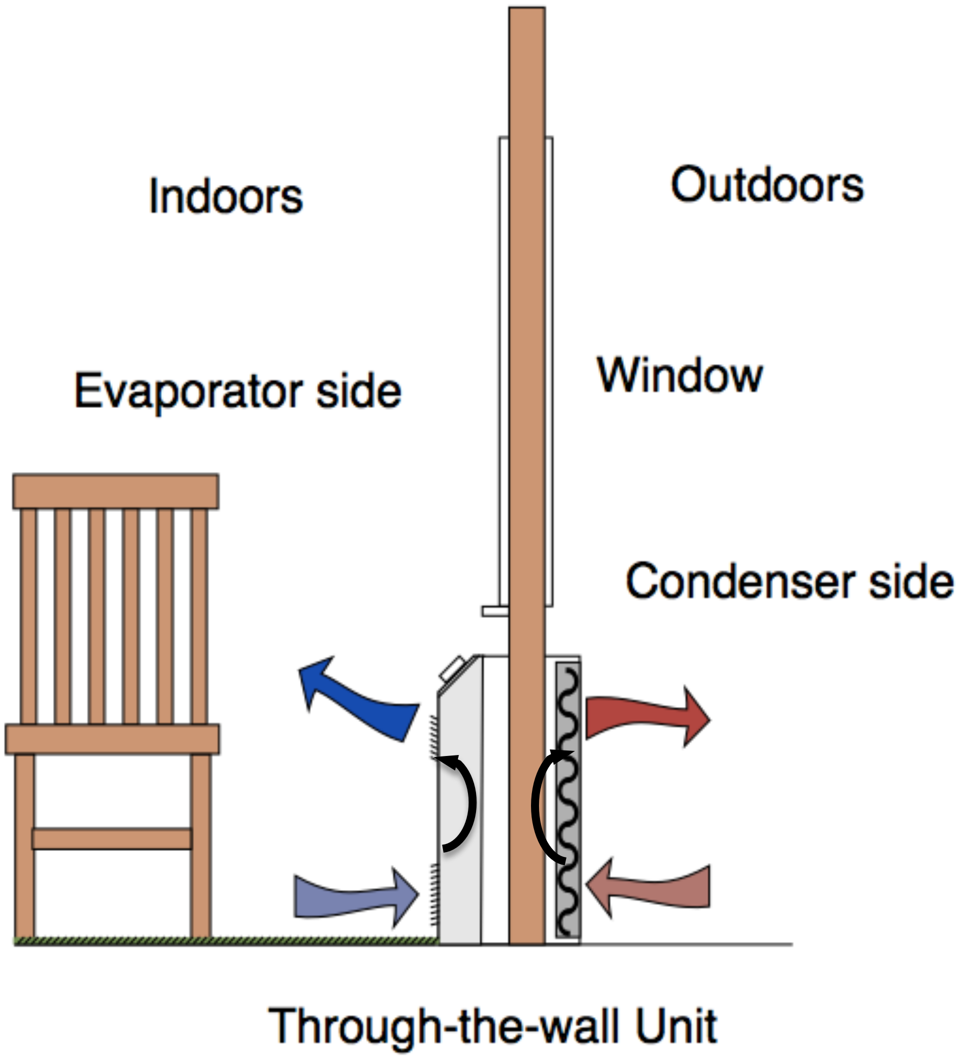
- This is also called a ground source or geothermal heatpump.
- Unlike the common air-source heatpump, it exchanges heat with outside by means of water rather than air.
- The main unit will be attached to a water loop of flexible piping that provides a thermal link with the earth, or is can connect directly to a large water source such as a lake or pond.

Common HVAC System Descriptions

Room PTAC

- PTAC stands for package terminal air conditioner.
- The units commonly found in hotel/motel rooms fall into this category.
- Window mounted air conditioners also fall into this category.

Common HVAC System Descriptions



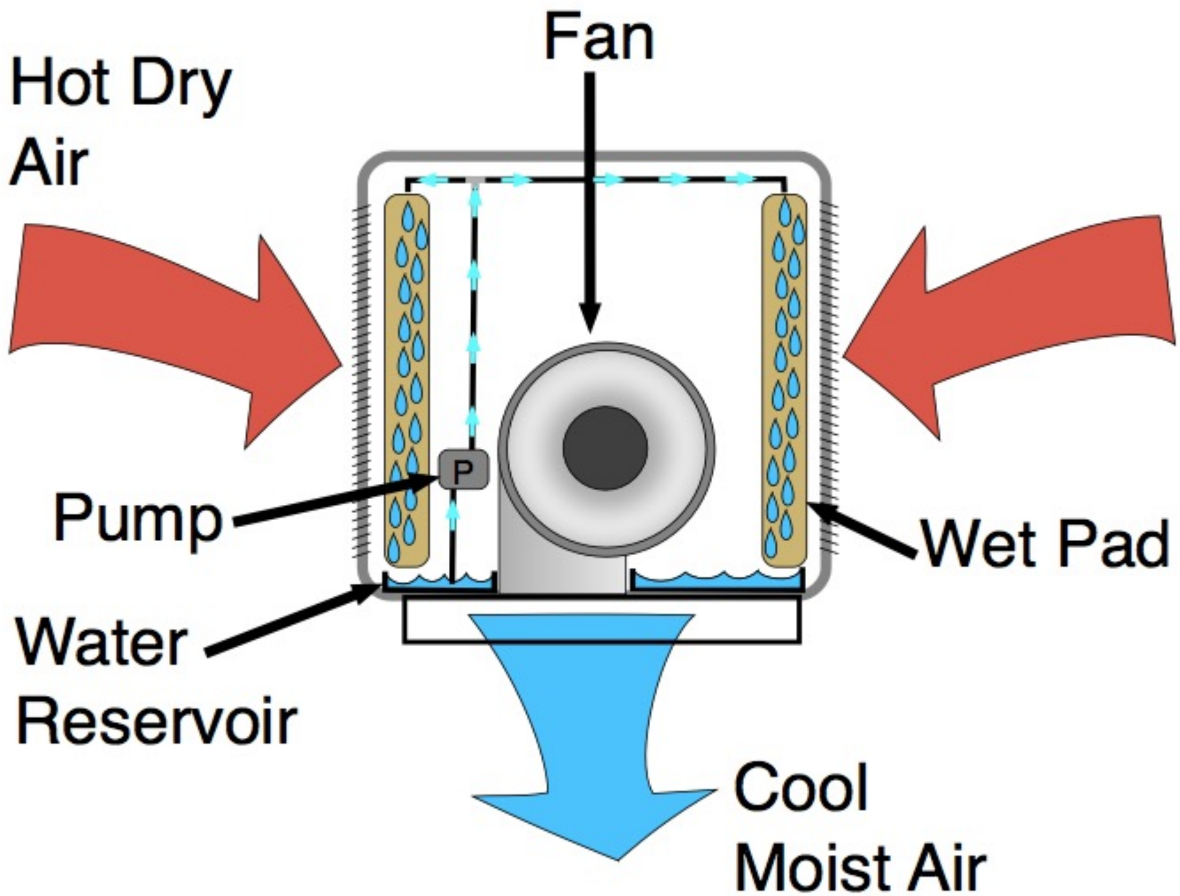
Common HVAC System Descriptions

Evaporative Cooler (aka "Swamp Cooler")

- These work by the fact that evaporating water absorbs BTU's from the surrounding air.
- Our bodies have their own evaporative cooling system.
- Most people call it "sweat".
- Some call it "perspiration" (this would be the same people who call them evaporative coolers rather than swamp coolers).
- Swamp coolers work by pulling outside air directly though a pad that has water dripping through it.

Common HVAC System Descriptions

Evaporative Cooler (aka "Swamp Cooler")



Common Heating System types (page 18)

Gas Furnaces

- All gas furnaces create BTU's by burning gas, whether piped in as natural gas or stored on site as propane.
- Because they burn a gas that gives off potentially dangerous combustion products, the combustion must happen inside an enclosed heat exchanger.
- The outer surface of the heat exchanger gets very hot.
- This is what heats the house air, either through convection or radiation.
- The combustion gasses must never escape into the house air.
- They must be vented to the outside, away from the house.
- This is one of the main disadvantages of gas heating over electric heating.
- See also the next section titled *Forced Air Furnace Combustion Types*.

Common Heating System types

Central Furnace

- These are the furnaces that are attached to a ducted distribution system.
- See previous discussion split vs. package systems and later discussion on common residential configurations.
- This is the most common type of gas heating found in newer homes.

Common Heating System types

Gravity Wall Furnace

- These are the tall narrow, wall mounted, gas heaters found in many older homes and apartments.
- There is no fan in this type of wall furnace.
- Cool air is pulled into the bottom of the heat exchanger and rises naturally as it is warmed.

Common Heating System types

Fan Assisted Wall Furnace

- These units are a slight improvement on gravity wall furnaces.
- Rather than relying on natural convection, they have a fan that improves circulation across the heat exchanger and throws it farther into the room.

Common Heating System types

Floor Furnace

- This is a very old style of furnace found in homes with raised floors.
- Similar in concept to a wall furnace, they are mounted below the floor and have a large floor grate where the warm air rises up through by natural convection.

Common Heating System types

Room Furnace

- These are much smaller versions of wall furnaces, often found in bathrooms.
- They often have an open flame that runs up a corrugated ceramic plate.
- Heat is transferred to the room primarily by radiation off of the hot ceramic plate.

Common Heating System types

Electric Resistance

- This type of heating was popular back when electricity was cheap.
- It is very efficient in terms of heat provided per unit of electricity used, however the cost of electricity can make it much less desirable.
- “Electric resistance” describes exactly how it produces heat.

Common Heating System types

Electric Resistance

- A large current is passed through a metal element that is impregnated with something that resists electric flow.
- This causes it to heat up.
- The coiled elements on the top of an older electric stove are good examples of this.
- Electric resistance elements can be found in central furnaces, baseboard heaters, radiant heaters, water heaters, wall heaters, etc.

Common Heating System types

Heat Pump

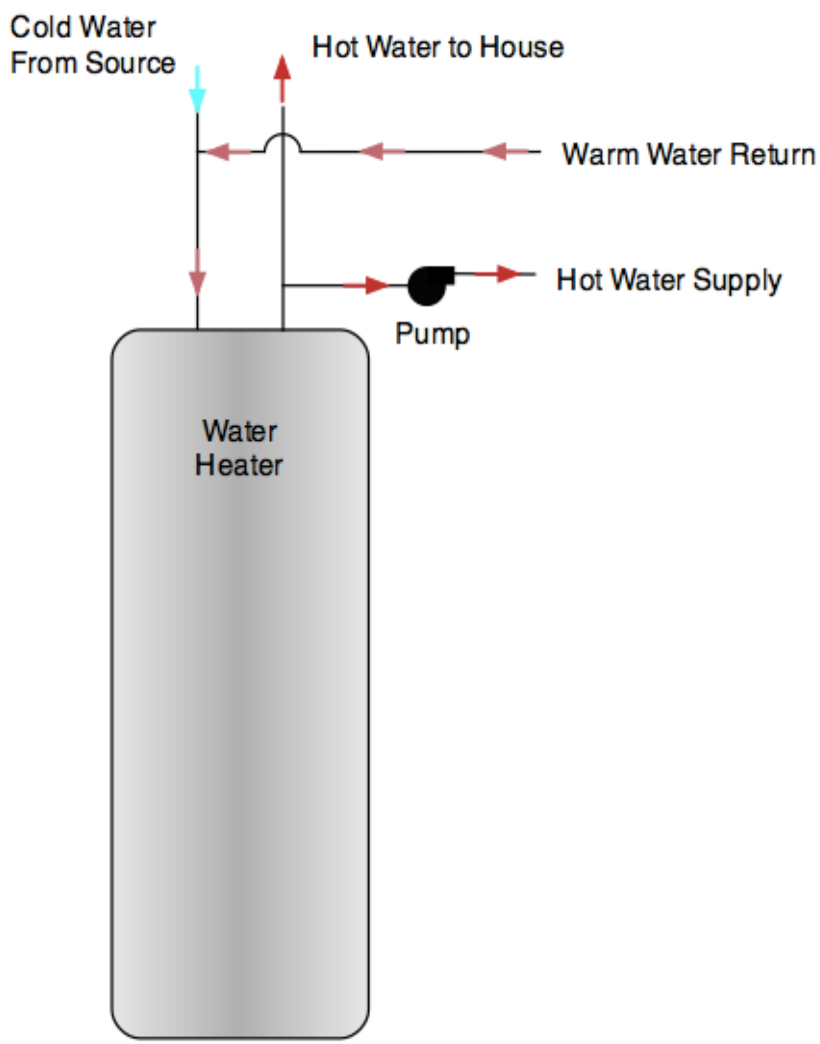
- Heat pumps and air conditioners are essentially the same thing but move the heat in opposite directions.
- Using mechanically compressed and expanded refrigerant, heat pumps extract heat from relatively cold air or water, condense it and deliver it into the house.
- Heat pumps can become an air conditioner by means of a reversing valve and moving heat from inside the house to the outside of the house.

Common Heating System types

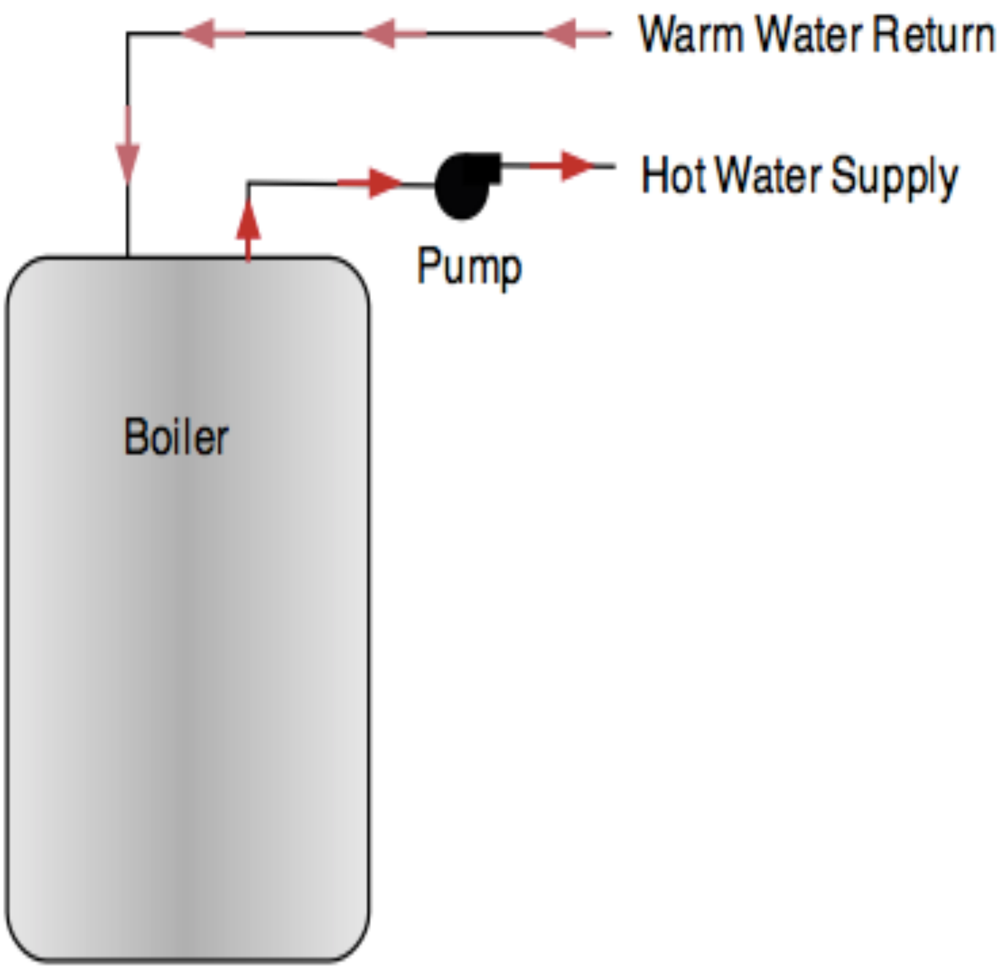
Hot Water

- Also known as hydronic systems, these systems use hot water as a heat source.
- Usually a loop of hot water pumped between a water heater and heat exchanger.
- Hydronic systems can be found in forced air central systems, non-ducted systems, baseboards, radiant panels and radiant floors.

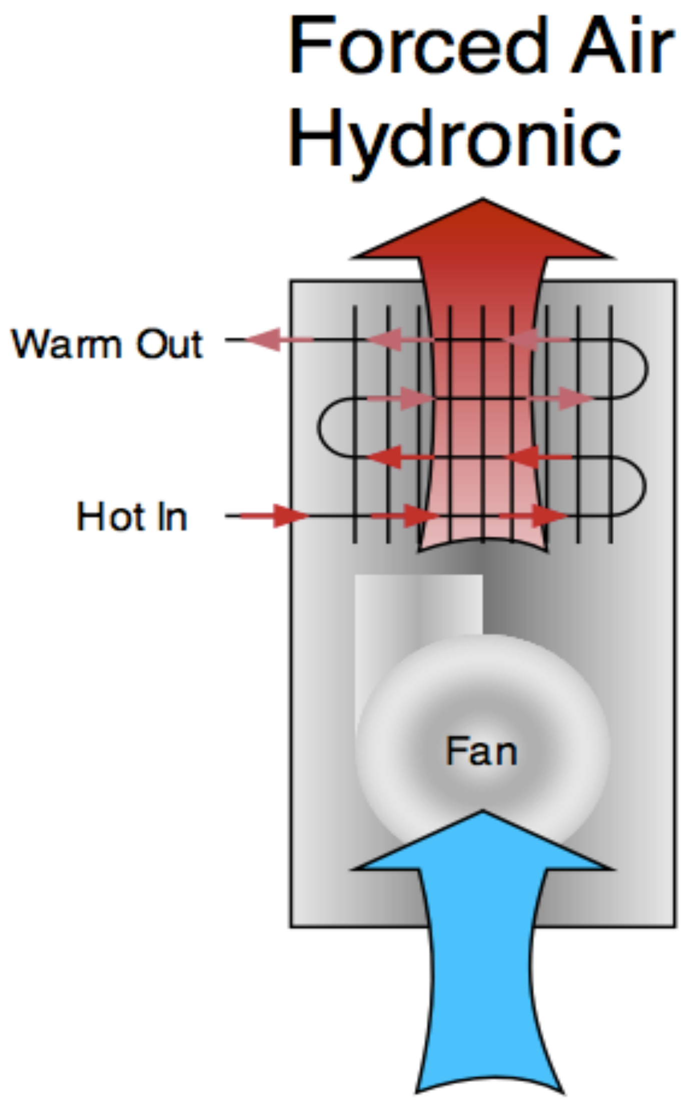
Common Heating System types



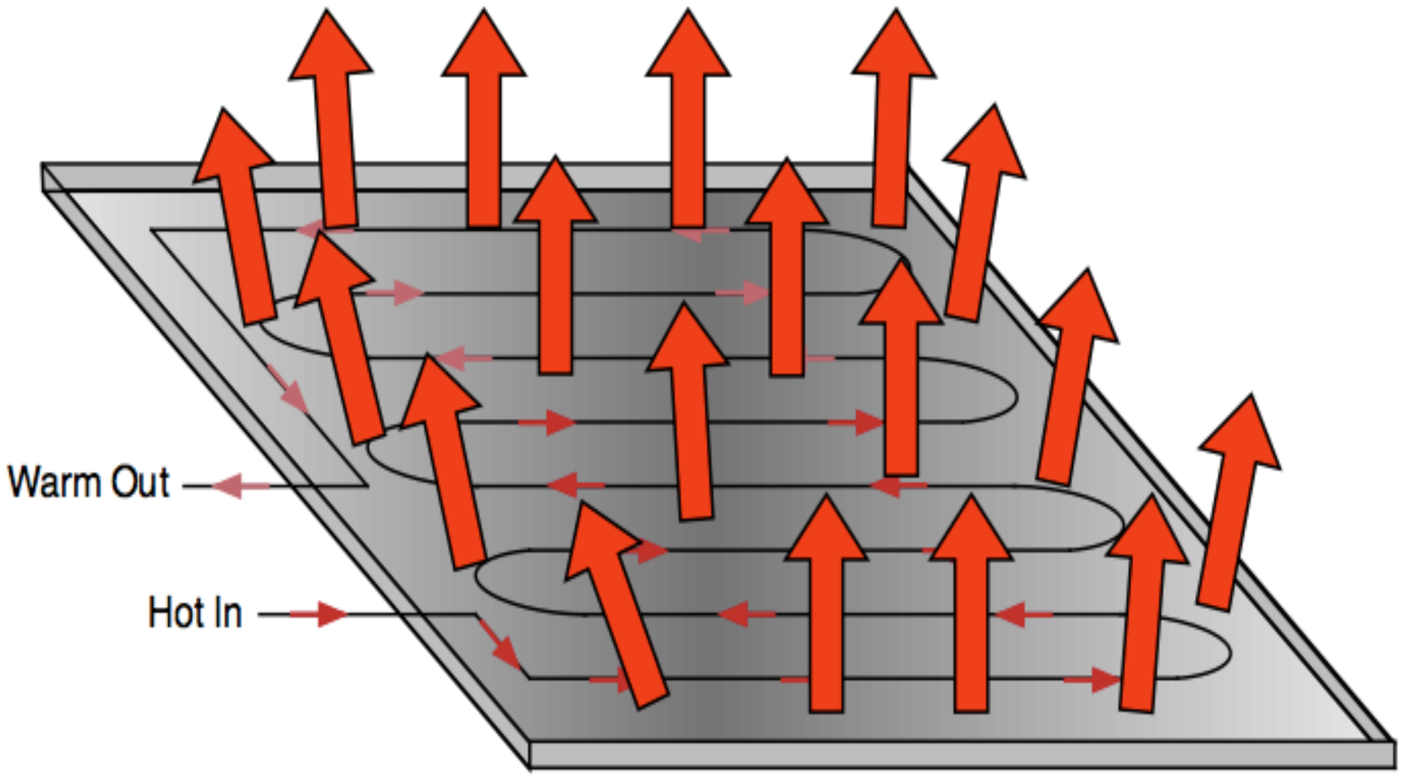
Common Heating System types



Common Heating System types



Common Heating System types



Radiant Floor
or Panel

Common Heating System types

Common HVAC System Configurations

- There are many varieties of residential HVAC configurations found out west.
- The popularity of each depends on several factors, the most important of which is the architecture of the home.
- You obviously cannot run ducts in a crawlspace if there is no crawlspace, as in a slab-on-grade house.
- Similarly, you can’t put ducts in an attic if you don’t have an attic, as in a flat-roofed home.

Common Ducted Central System Configurations

- The next factor is cost and ease of installation, especially in a retrofit situation.
- Let’s say that you have an older, single story home that has an adequate crawlspace and an adequate attic.
- In deciding whether to put in an upflow unit and run the supply ducts in the attic or put in a downflow unit and run the supply ducts in the crawlspace, you could get bids for both.

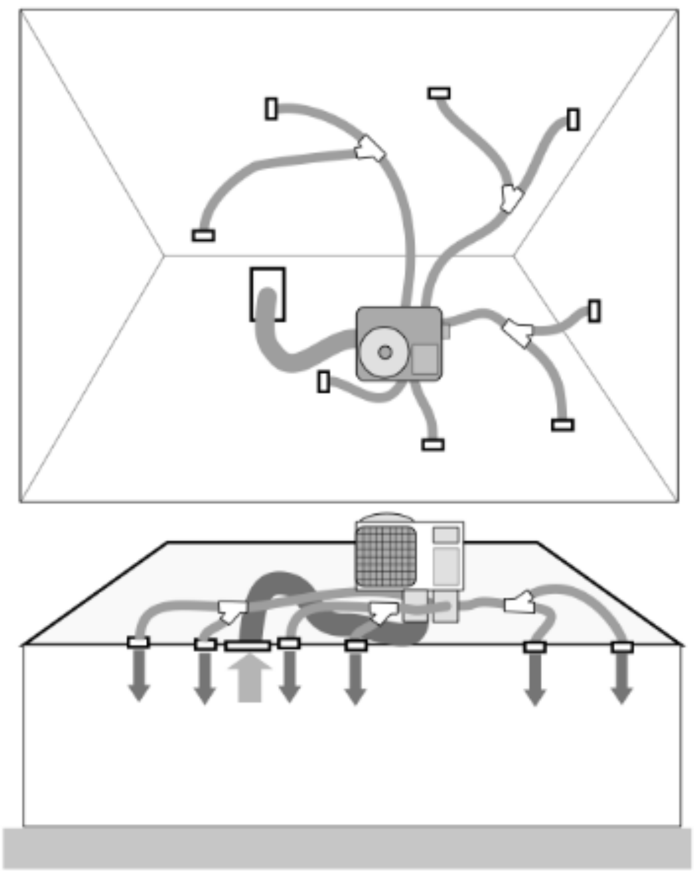
Common Ducted Central System Configurations

- Before we describe the various configurations, we should probably talk about some of the various parts of a system.
- The generic type of system that is most common out west is a "forced air, ducted, central system".
- "Forced air" means that there is a fan.
- "Ducted" simply means that the air travels through some sort of contained passageway
- "Central" means that the system is centrally located, has one air handler, is usually controlled by one or more thermostats

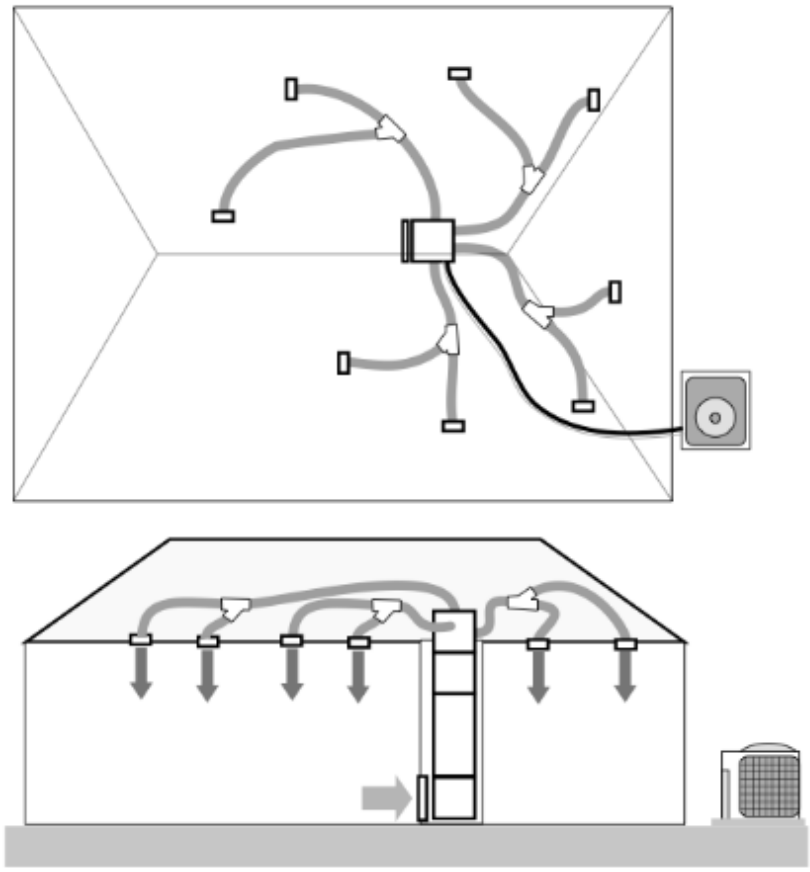
Common Ducted Central System Configurations

- These systems are most commonly gas furnaces with or without air conditioning
- They can also be heatpump systems.
- Vinyl flex duct with sheet metal t-wyes is shown in the following diagrams
- Metal and other rigid duct material may be found.

Common Ducted Central System Configurations

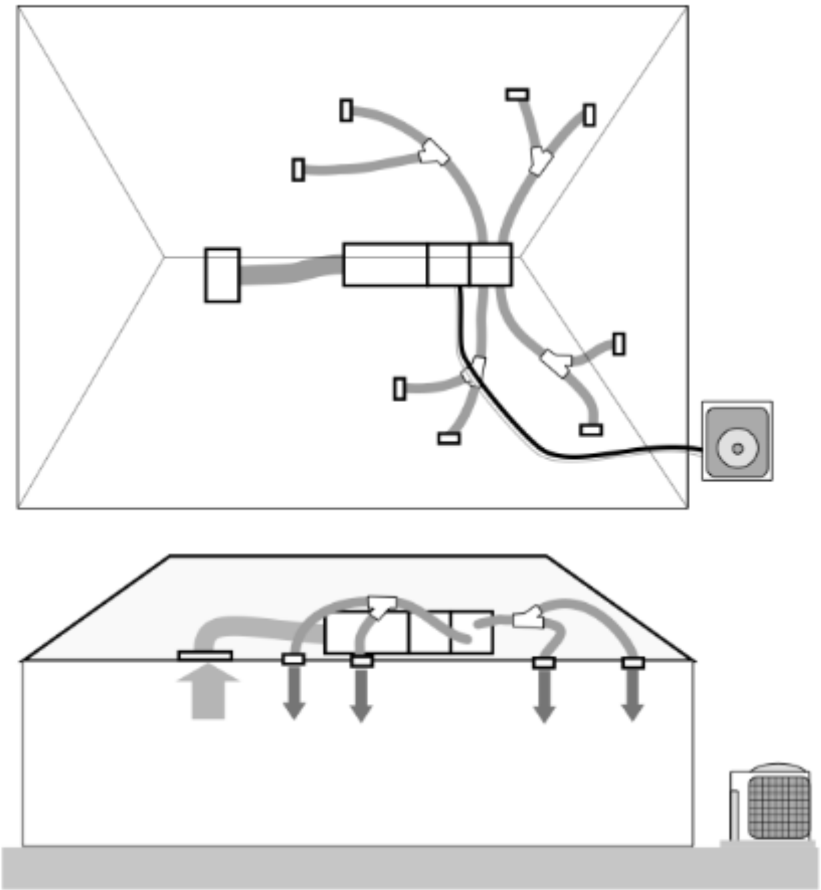


Package unit on roof.
Ducts in attic

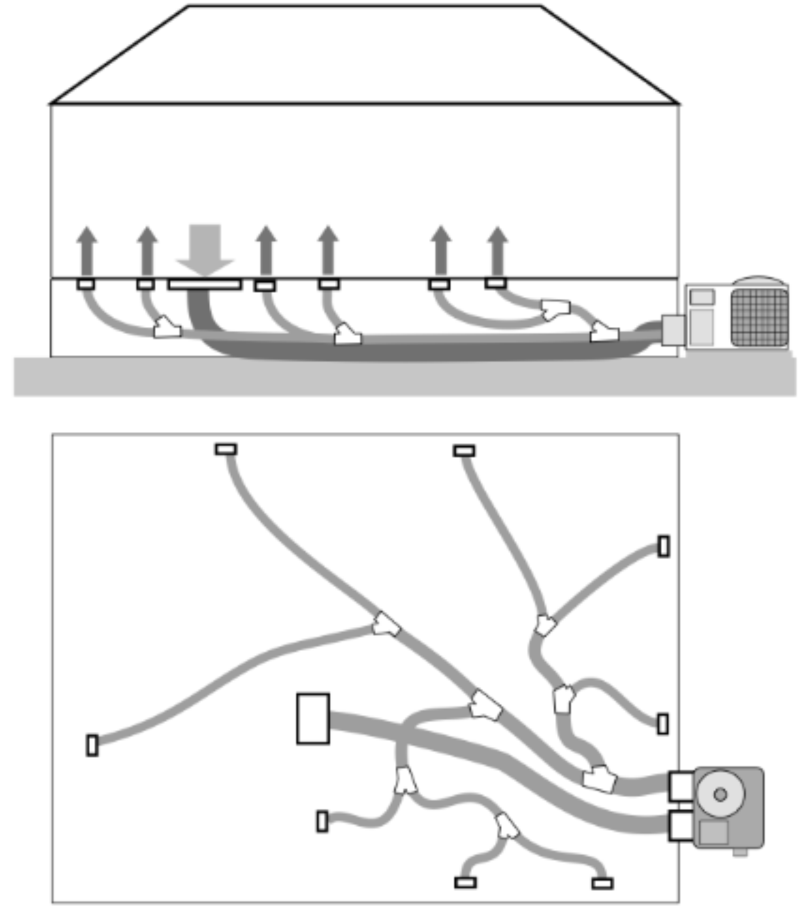


Upflow split system in hall closet.
Ducts in attic

Common Ducted Central System Configurations

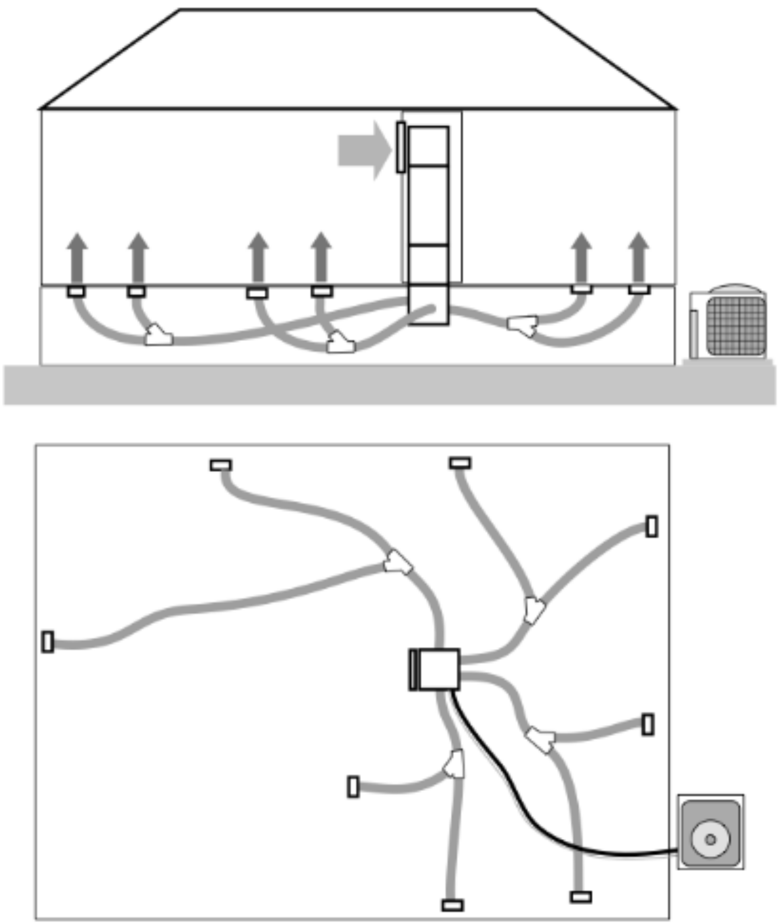


Horizontal split system in attic.
Ducts in attic

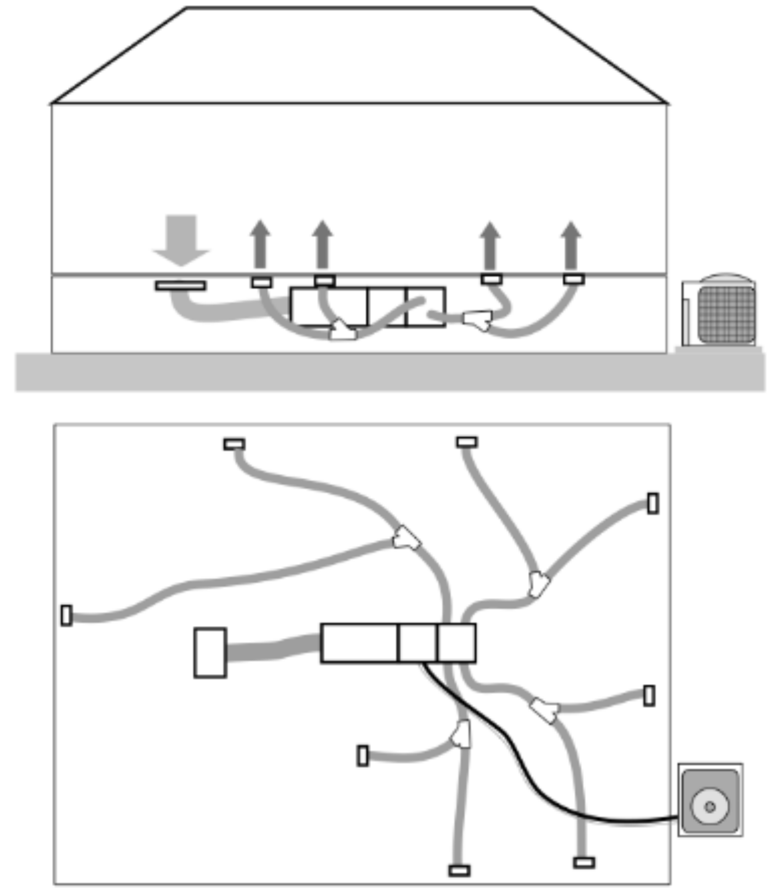


Package unit on ground.
Ducts in crawlspace

Common Ducted Central System Configurations



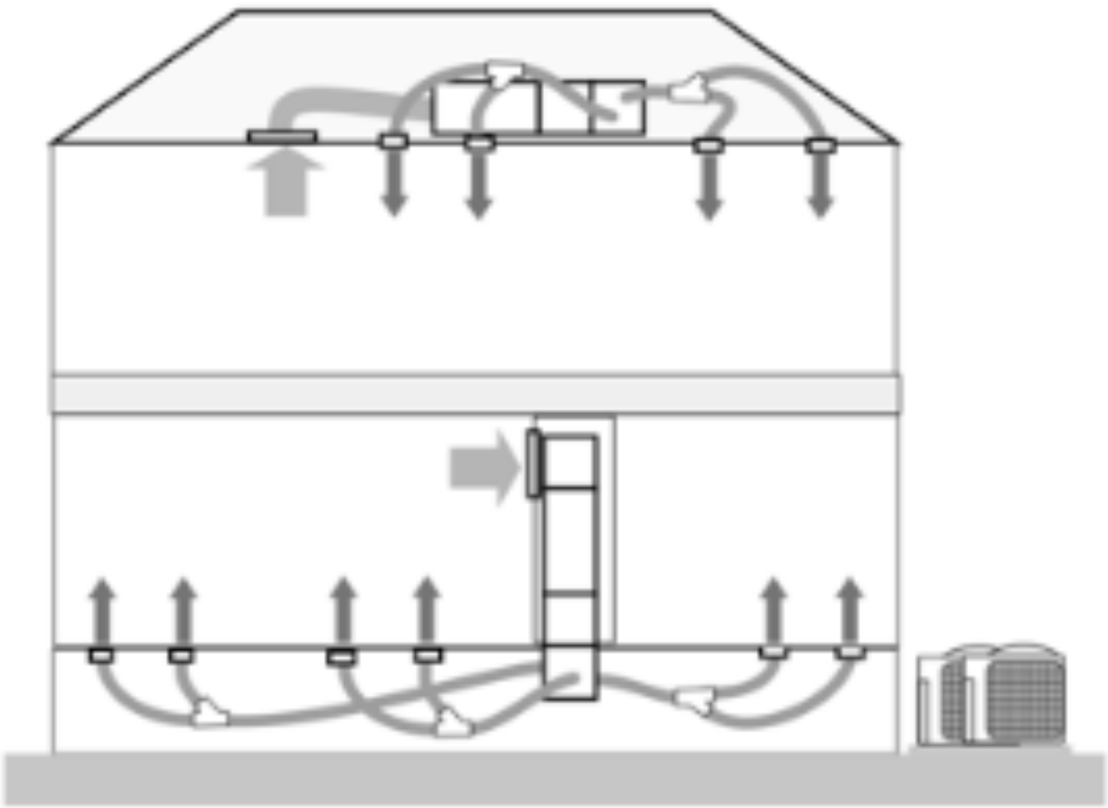
Downflow split system in hall closet.
Ducts in crawlspce



Horizontal split system in
crawlspace.
Ducts in crawlspace.

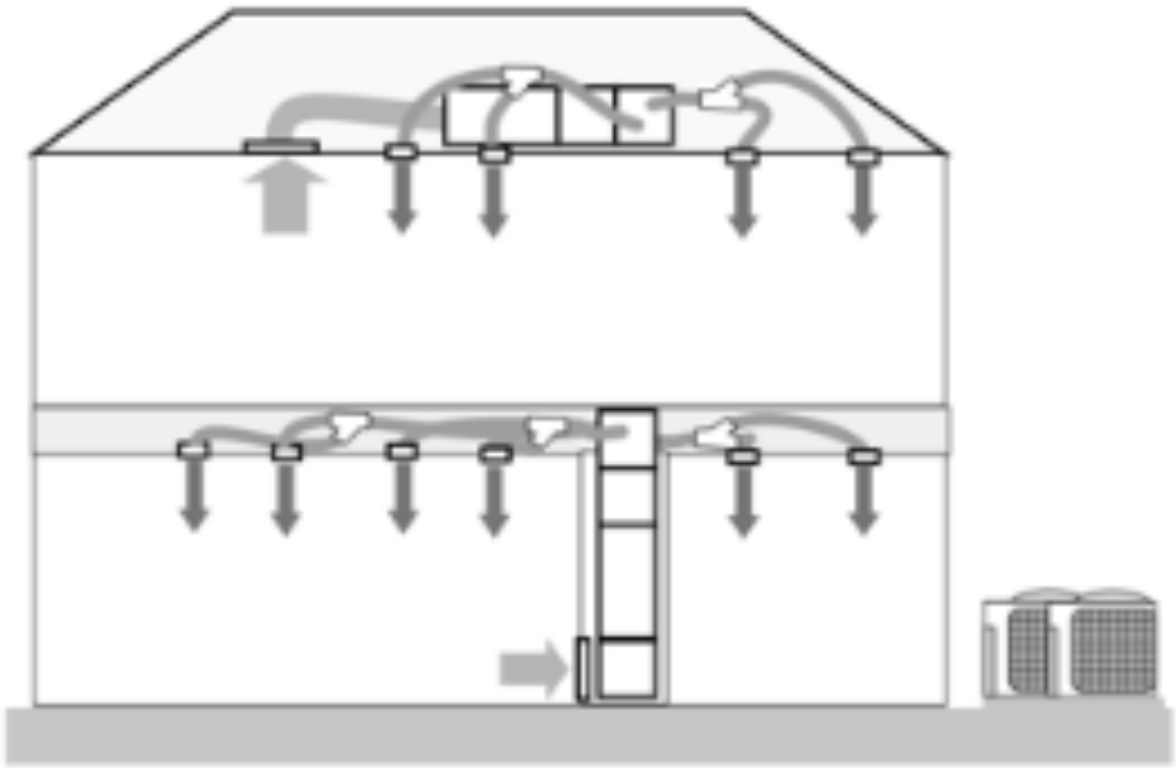
Common Ducted Central System Configurations

Configurations for Two Story Homes



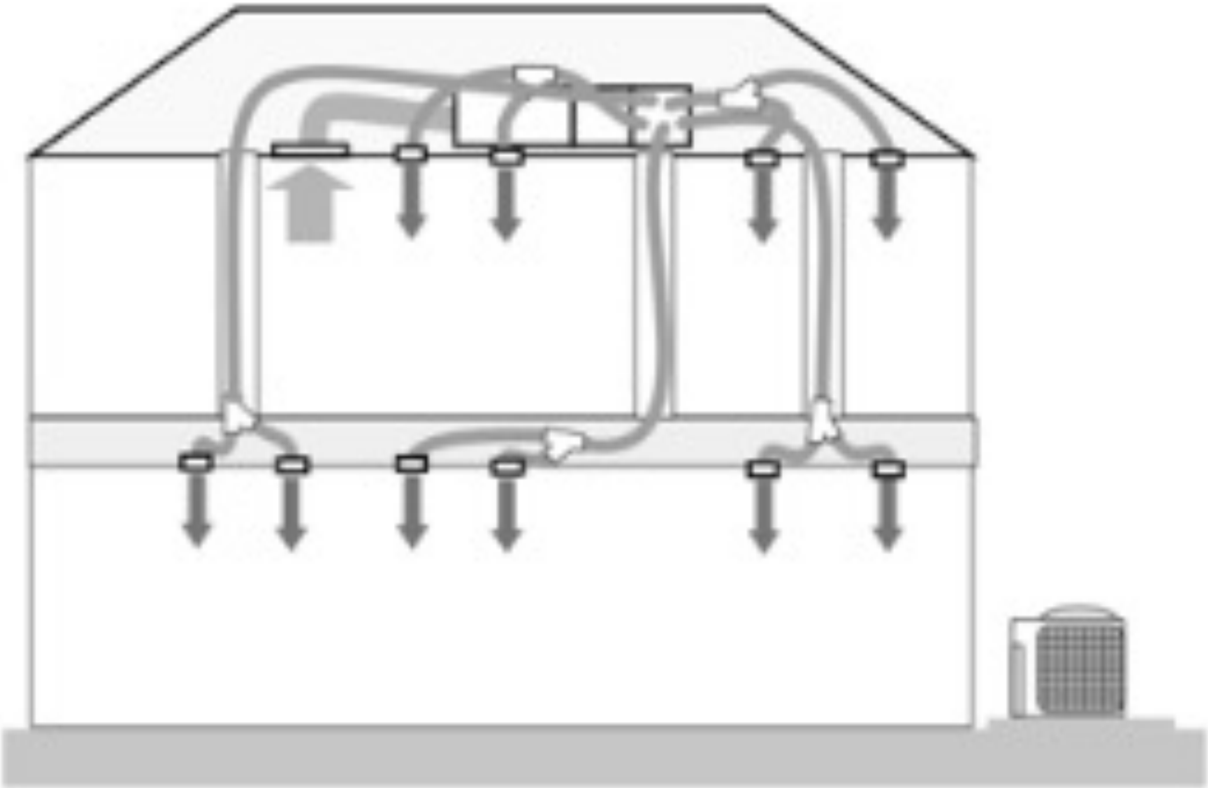
Common Ducted Central System Configurations

<u>Configurations for Two Story Homes</u>



Common Ducted Central System Configurations

<u>Configurations for Two Story Homes</u>



Mini-Splits

- Mini-splits have been around for a long time in Japan, but only in the last few years have become popular in the US.
- They come in a ductless and ducted version.

Mini-Splits

- These are a true split system in that the condenser sits outside and the airhandler and coil are inside.
- With the ductless version, the airhandler and coil are a wall mounted “cassette”, about the size and shape of an electric keyboard.
- The condenser is a rectangular “suit case” style box with a horizontally mounted fan.

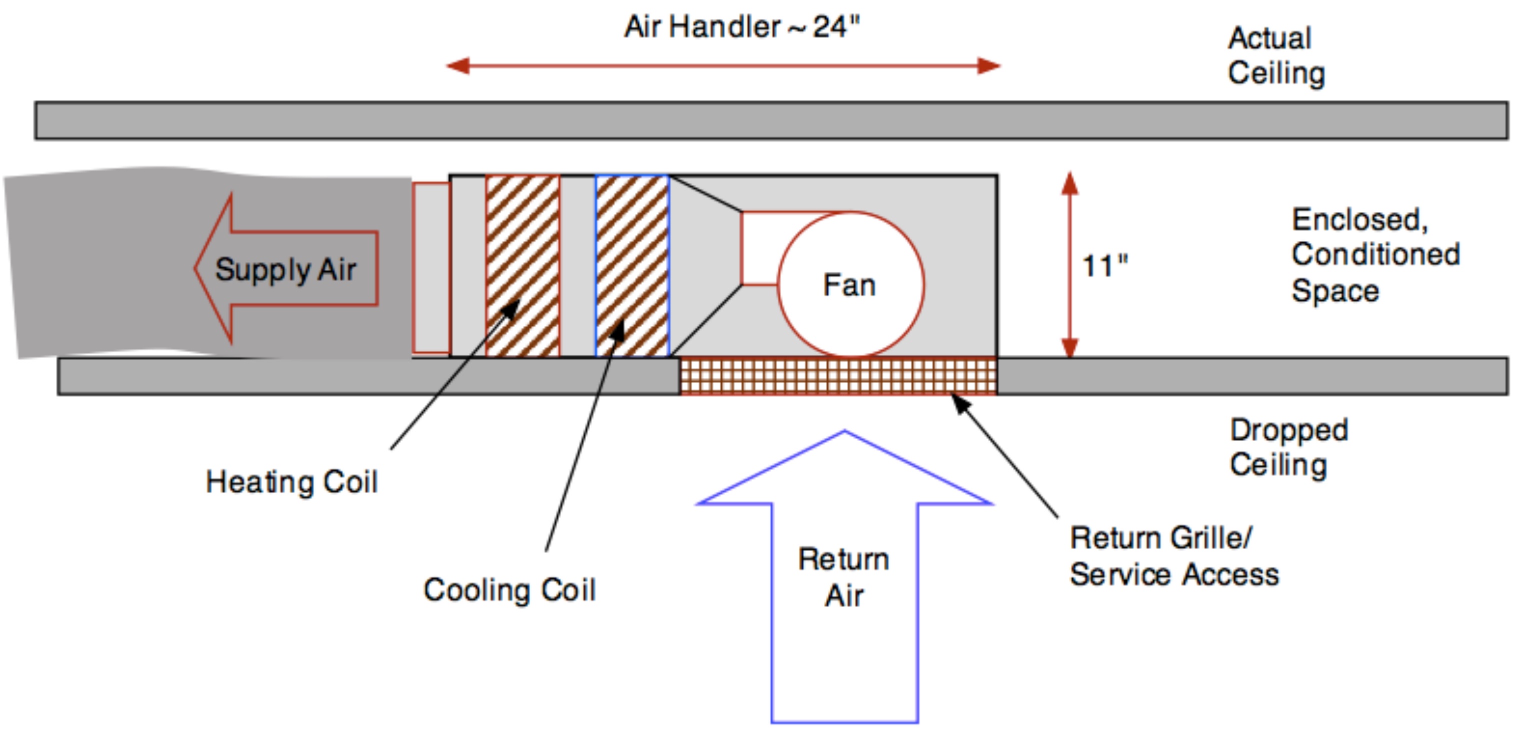
Other Somewhat Common Systems (page 35)

Soffit Mounted Fan Coils

- Also called “pancake units” because of their flat shape, these are small air handlers designed to fit into a dropped ceiling with as little as 12” of clearance.
- Very popular in apartments, these units are accessed through a panel on the bottom of the unit, which can also serve as the return grille.

Other Somewhat Common Systems

Soffit Mounted Fan Coils



High Velocity Systems

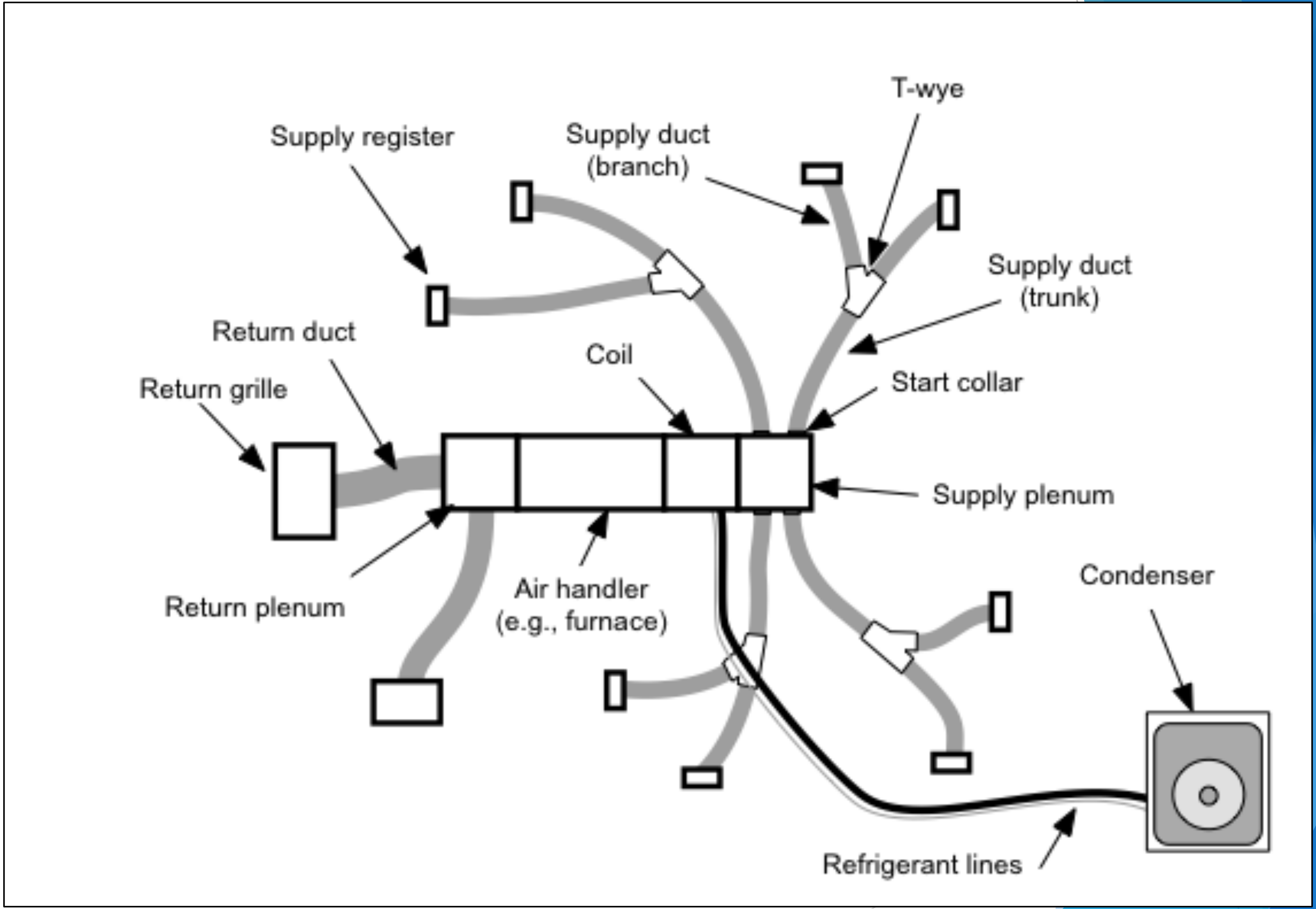
- This is a type of system that was developed primarily for retrofitting historical buildings and other buildings that were built before ducted HVAC systems but cannot have many structural or architectural changes made to them.
- Very small diameter ducts (2” and 3” inner diameter) are run through walls and floor joists.

Less Common "Ducted" Configurations

High Velocity Systems

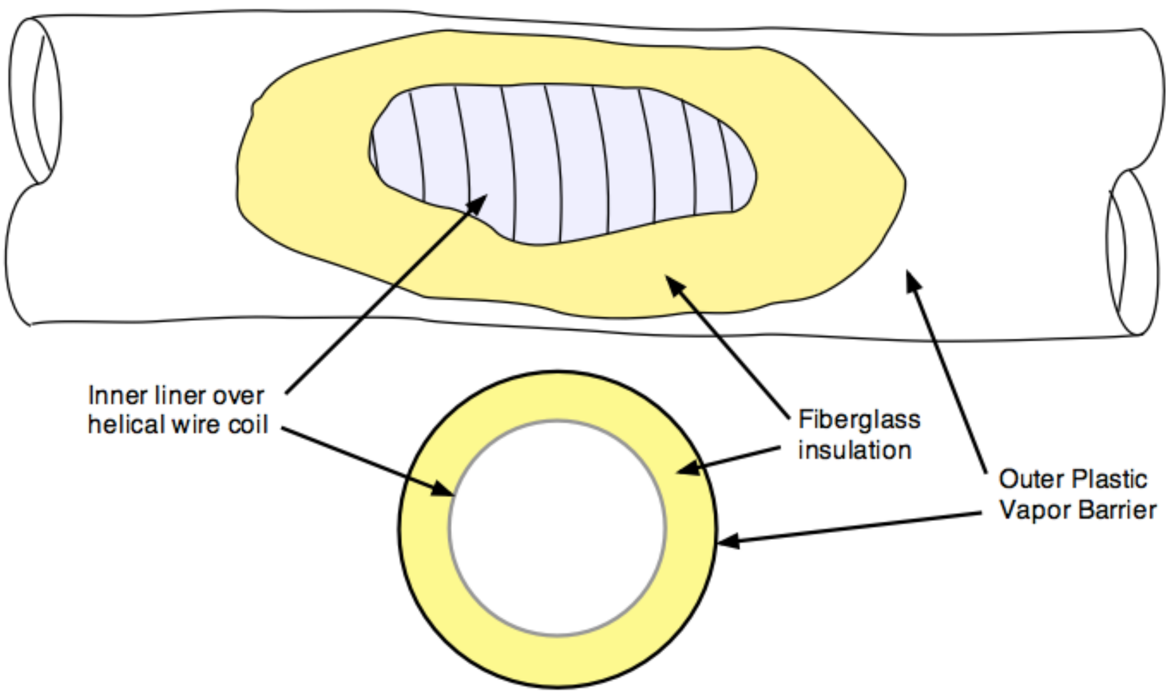
- To carry enough air to heat or cool a room, the air must travel extremely fast, hence the name.
- This takes a very strong fan to overcome the resistance of moving so much air through very small ducts.
- This very high fan energy and relatively low airflow per ton makes them not much more efficient than a regular system, if at all.
- They are still popular with new custom homes that have very complex architecture.

Common HVAC System Components (page 39)



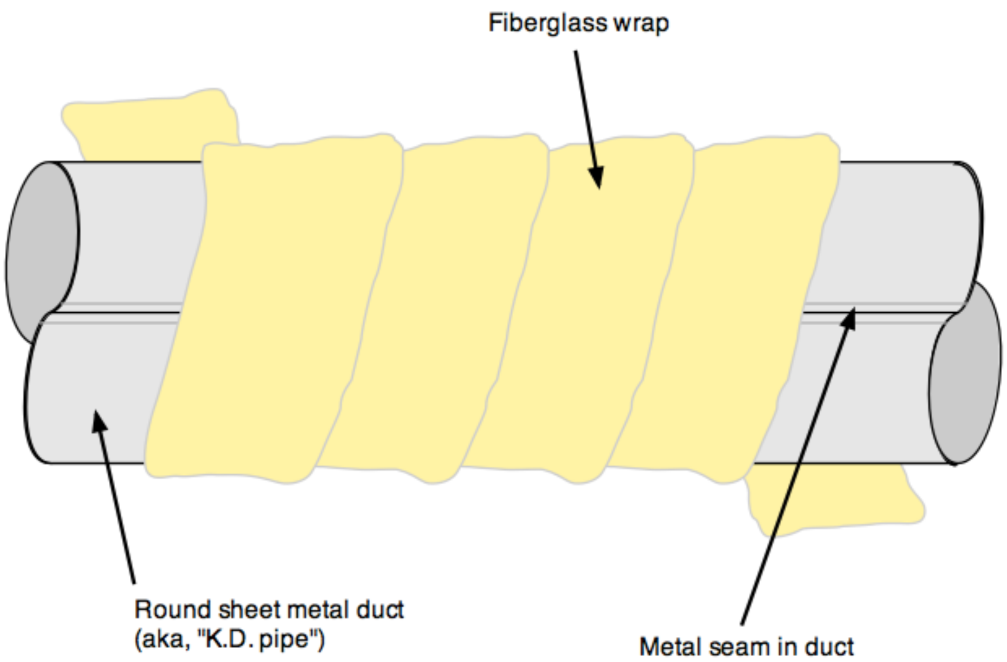
Common HVAC System Components

- Duct (types) – The most common type of duct material used out west for the past 20-30 years is called “vinyl flex duct”, or just “flex duct”.



Common HVAC System Components

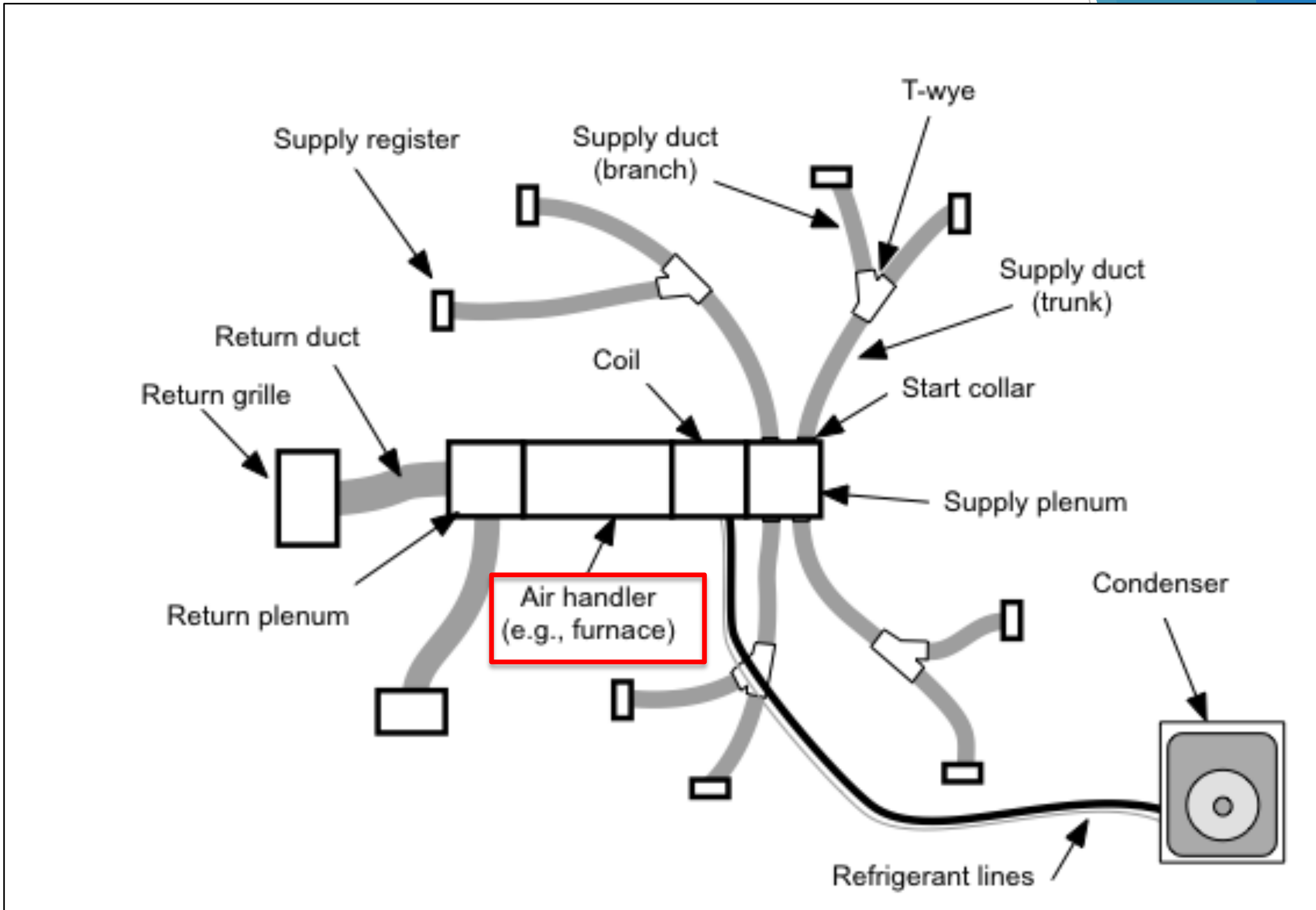
- The next most common type of residential ducting is round sheet metal.
- Also known as “K.D. pipe”, it was quite common before flex duct took over. K.D. stands for “knock down”.



Common HVAC System Components

- **Air Handler** – This is the rectangular box that contains the fan that is responsible for pushing the air through the ducts.
- Most commonly this is a furnace, which has the fan and the gas heating module (flame, heat exchanger, etc.), but in heat pump systems it is called a “fan-coil”.
- A fan-coil looks very similar to a furnace, but rather than gas heat, it has a built in refrigerant coil that can both heat and cool the air.

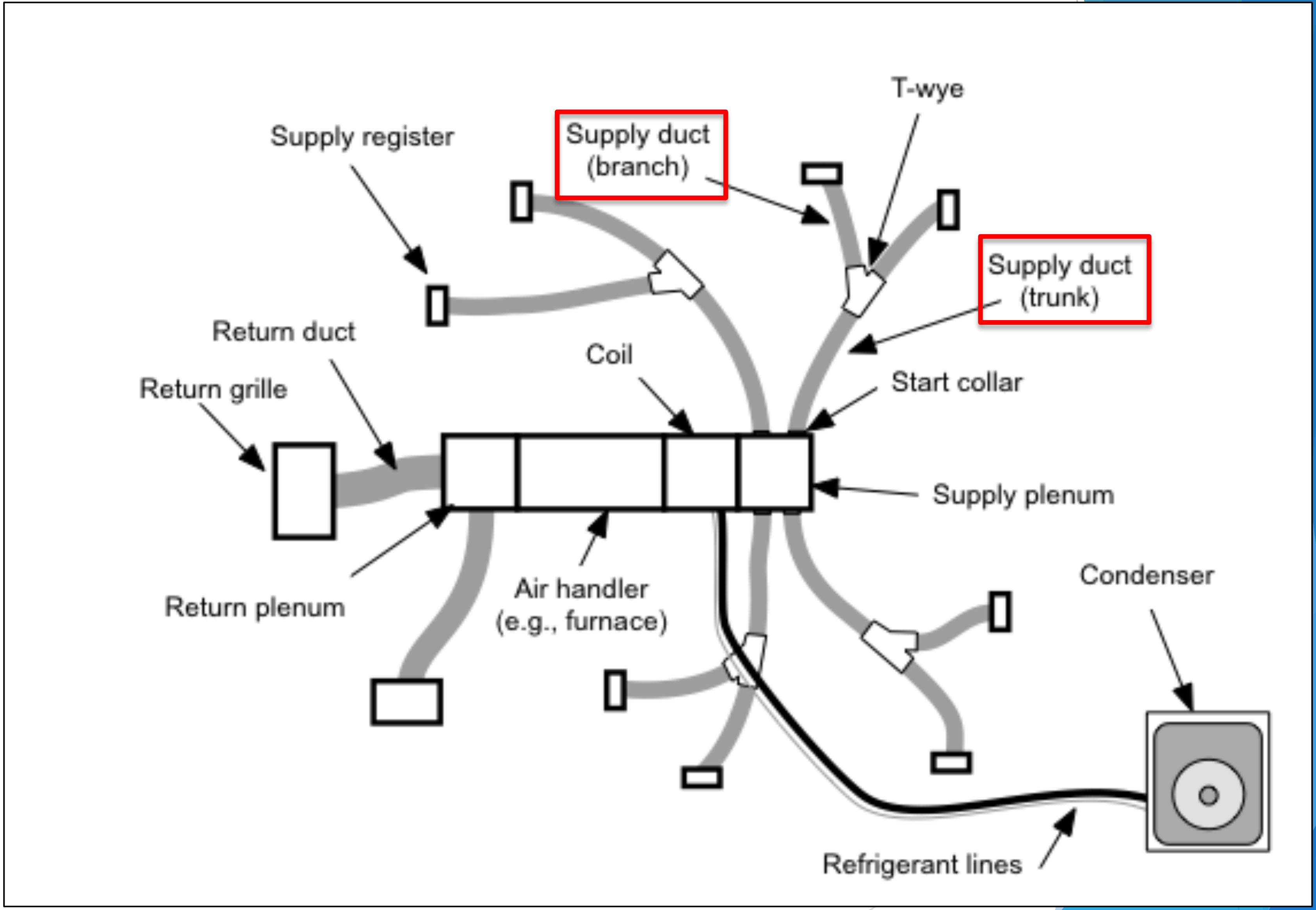
Common HVAC System Components



Common HVAC System Components

- **<u>Supply Air Ducts</u>** – These are the ducts that come off of the supply end of the airhandler and deliver the air through the supply registers to the rooms.
- They are under positive pressure when the system fan is on.
- These ducts contain either very hot air (heating mode) or very cold air (cooling mode).

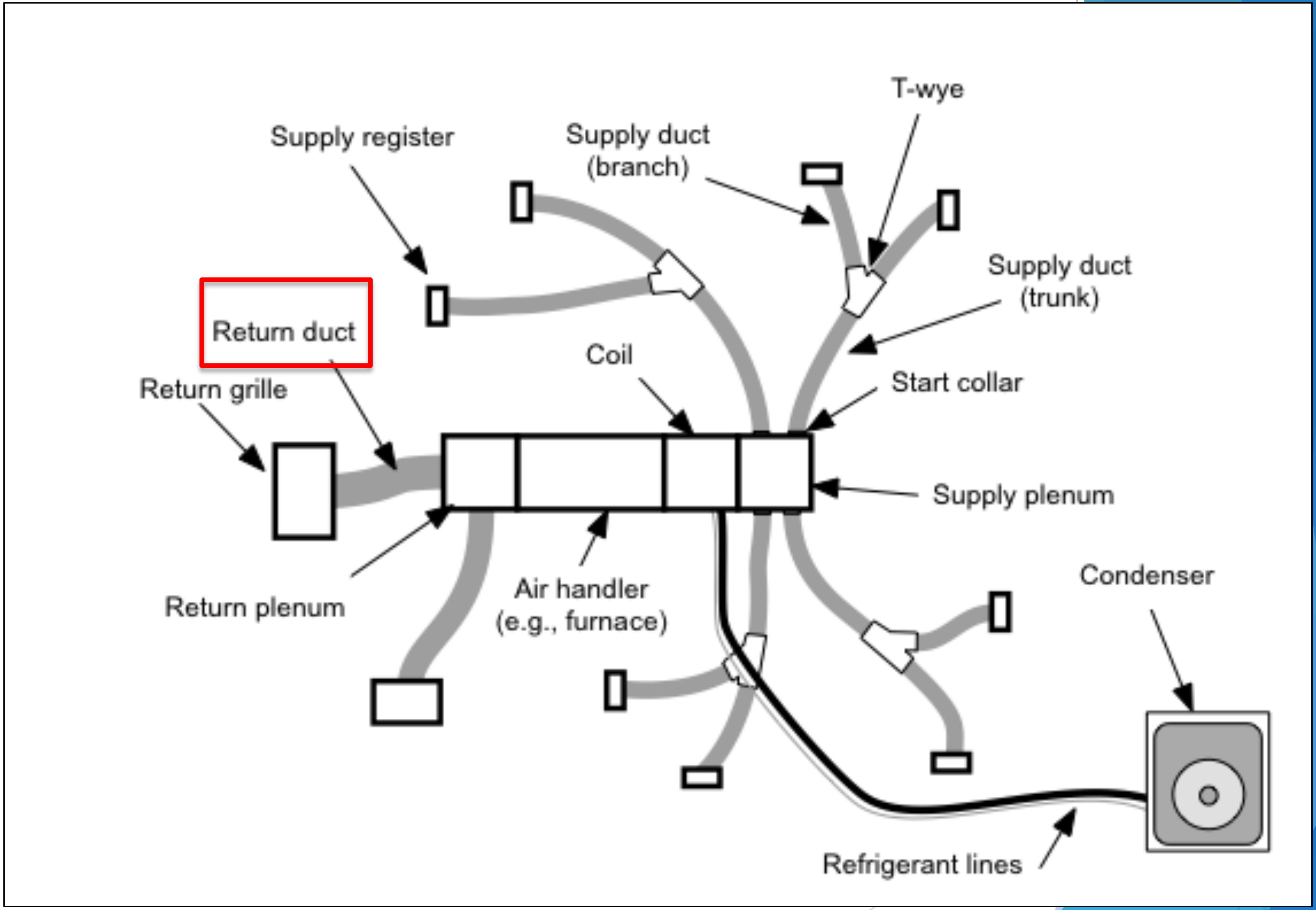
Common HVAC System Components



Common HVAC System Components

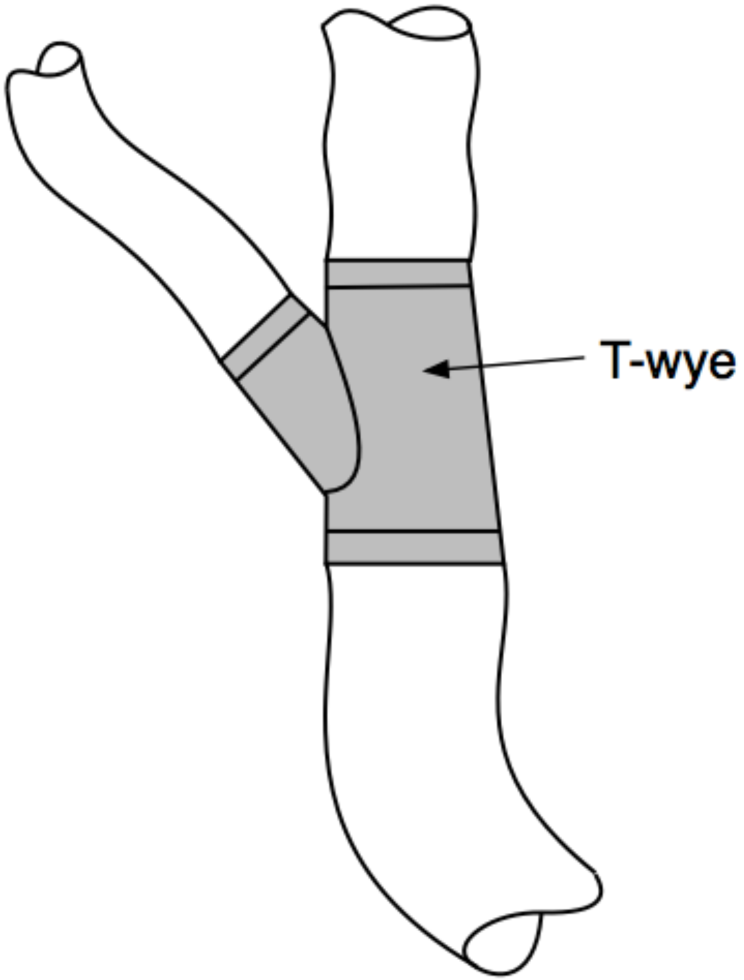
- **<u>Return Air Ducts</u>** – These are the ducts, or duct, that are attached to the return (intake) side of the air handler and pull the air out of house so that it can be heated or cooled.
- These ducts are under negative pressure (air leaks will go into the ducts).
- The air temperature in the return ducts is essentially the same as inside the house.

Common HVAC System Components



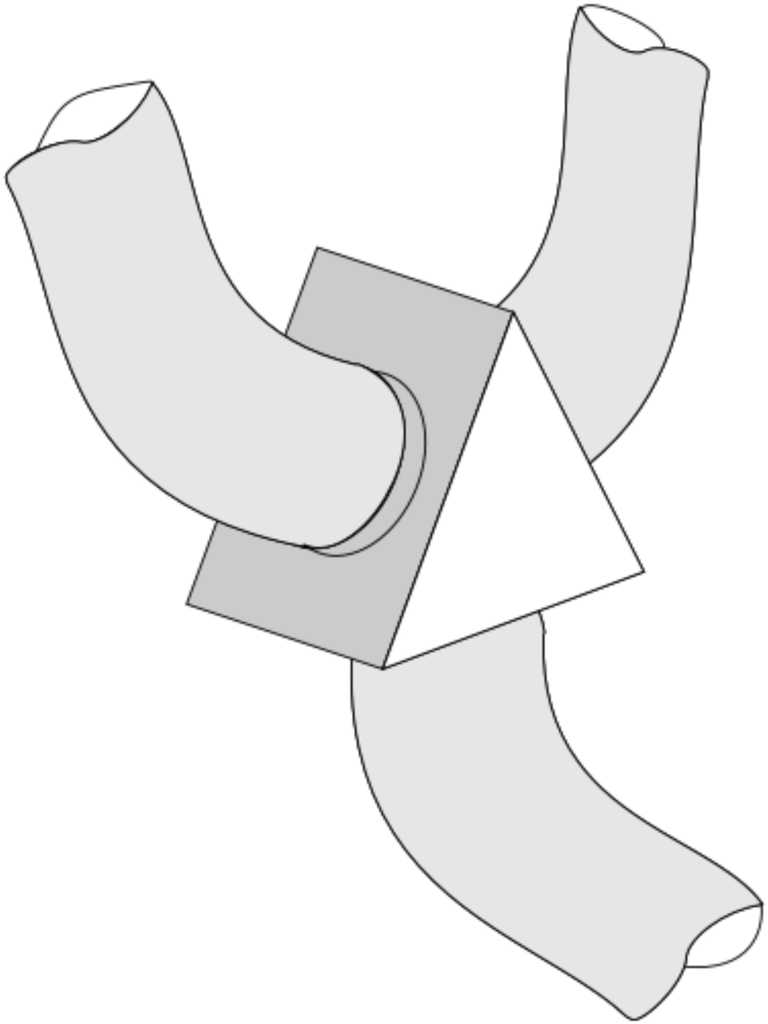
Common HVAC System Components

- **T-Wye** – This is a duct fitting, usually sheet metal, that allows one size duct to be split into multiple ducts.



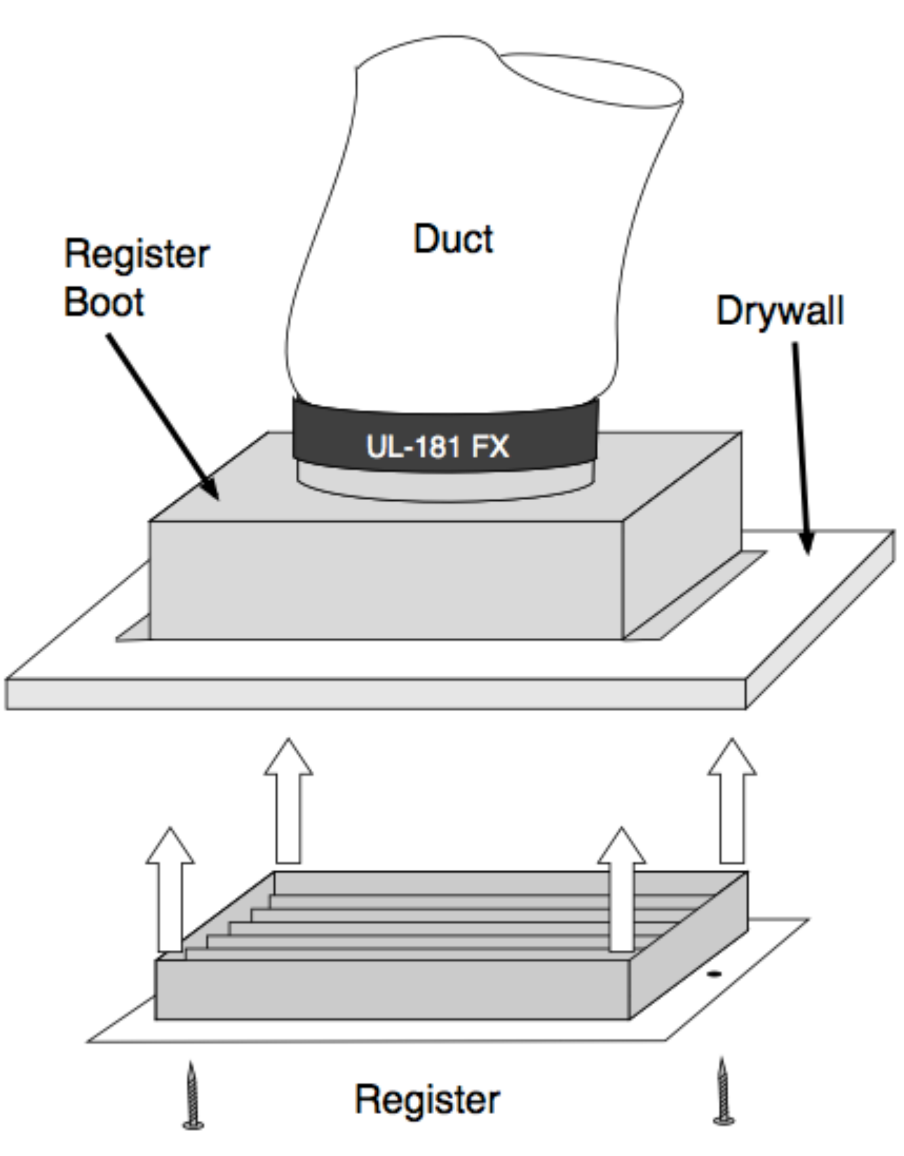
Common HVAC System Components

- There is another type, sometimes referred to as a splitter box that is made out of duct board and is triangular in shape.



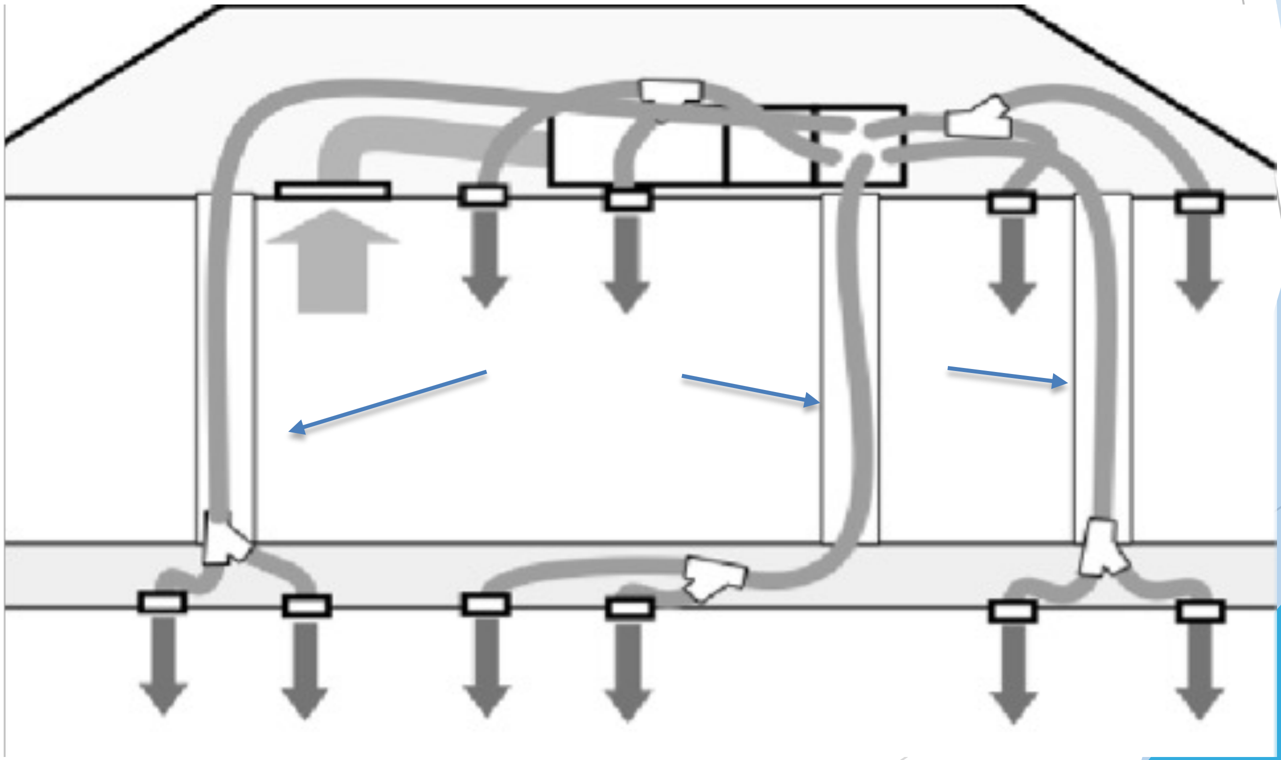
Common HVAC System Components

- **Register Boot** – This is a sheet metal fitting that transitions from the round or rectangular duct to the rectangular termination into which the supply register is attached.



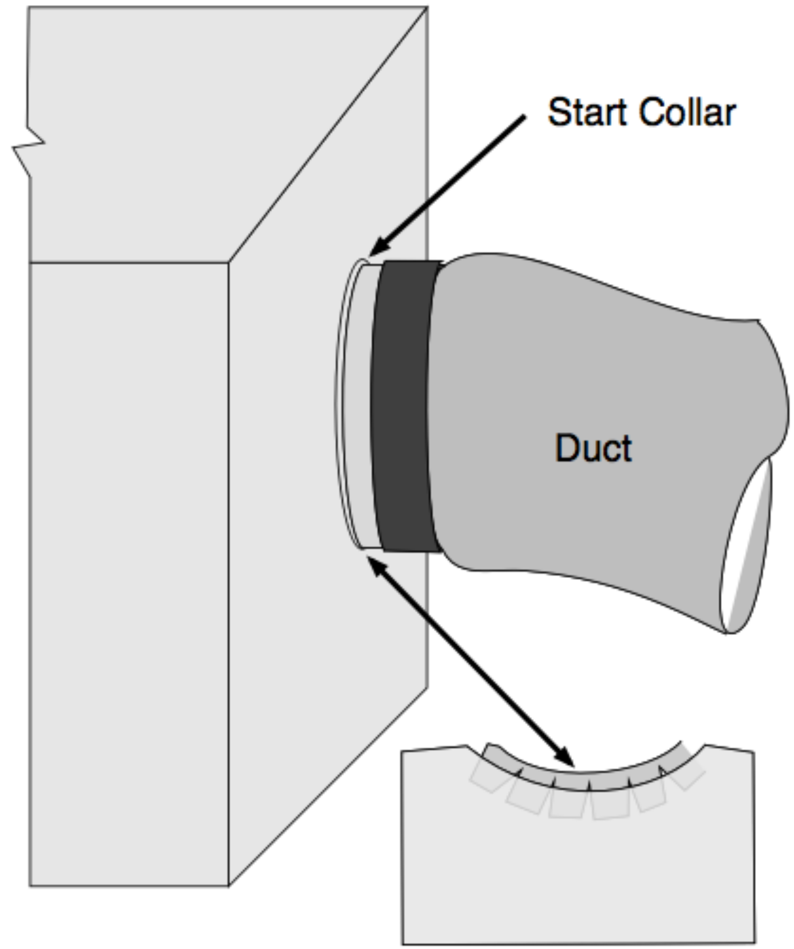
Common HVAC System Components

- **Chase** – This is a boxed out corner or “dead space” between walls that allows a duct to pass through a floor, such as from the attic of a two story, through the second floor to the first floor home.



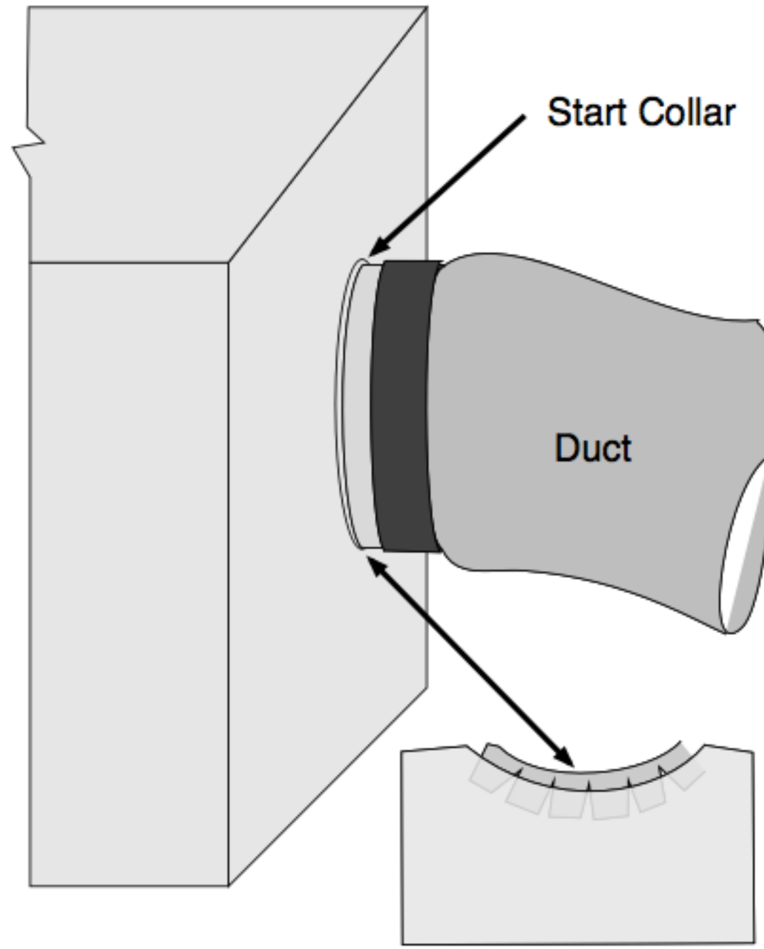
Common HVAC System Components

- **Start Collar** – This is a sheet metal fitting that allows a round or square duct to be attached to a much larger sheet metal box, such as a supply or return plenum.
- These are very often poorly sealed and excellent locations to apply mastic.



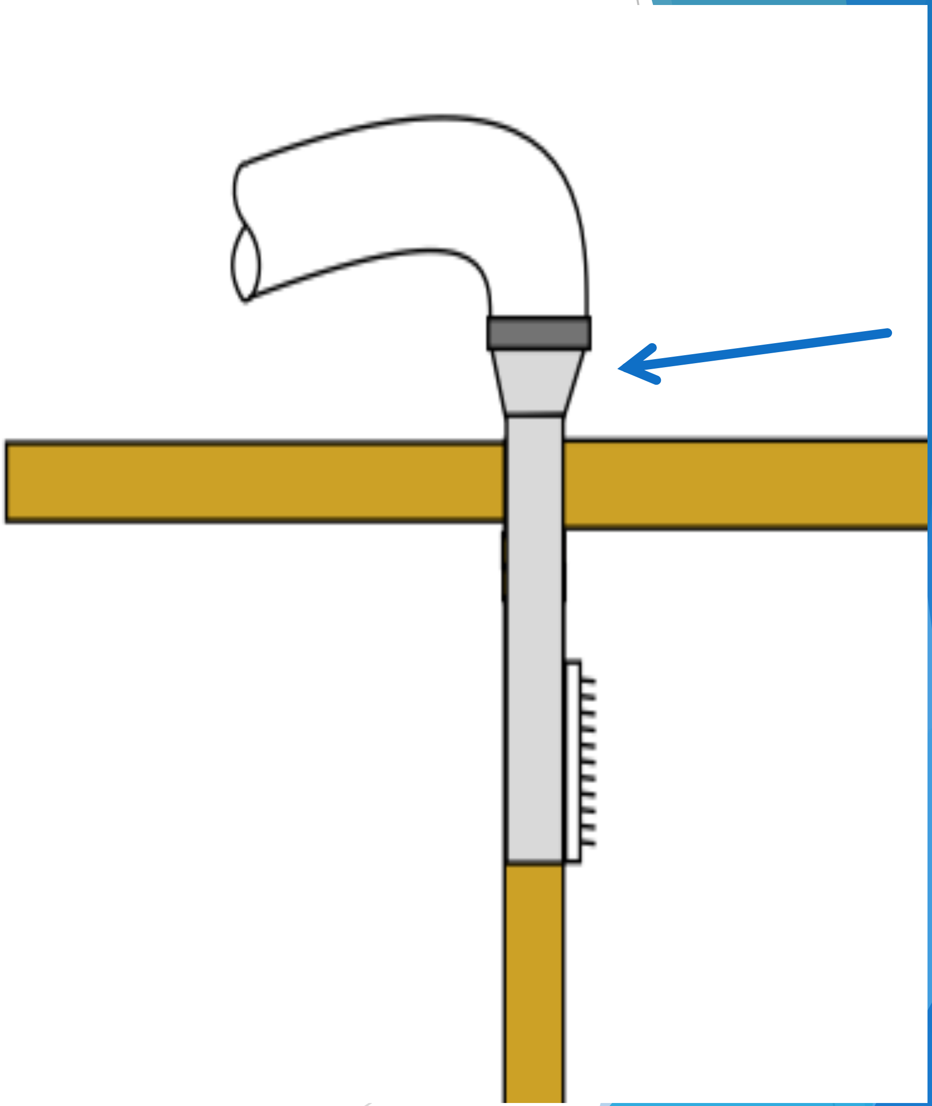
Common HVAC System Components

- When installed a hole must be cut in the box.
- If that hole is bigger than the collar, there can be a lot of leakage, especially with the type of start collar that has tabs that have to be folded back inside the box.



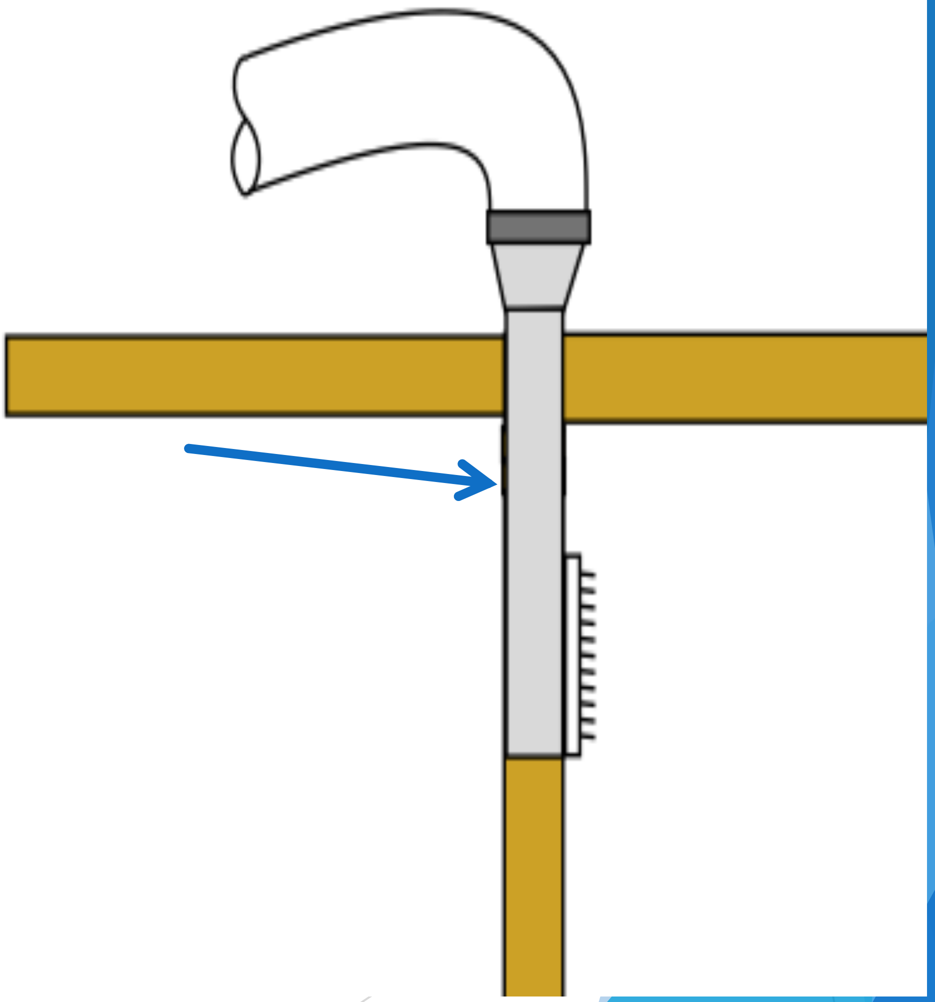
Common HVAC System Components

- **<u>Square-to-Round Transition</u>** – A sheet metal fitting that simply transitions from square (or rectangular) to round.



Common HVAC System Components

- **<u>Wall Can</u>** (aka riser can) – This is a rectangular sheet metal can that is run down a wall stud bay, either to serve a register in the wall or as an alternative to a round duct going down a chase.



Common HVAC System Components

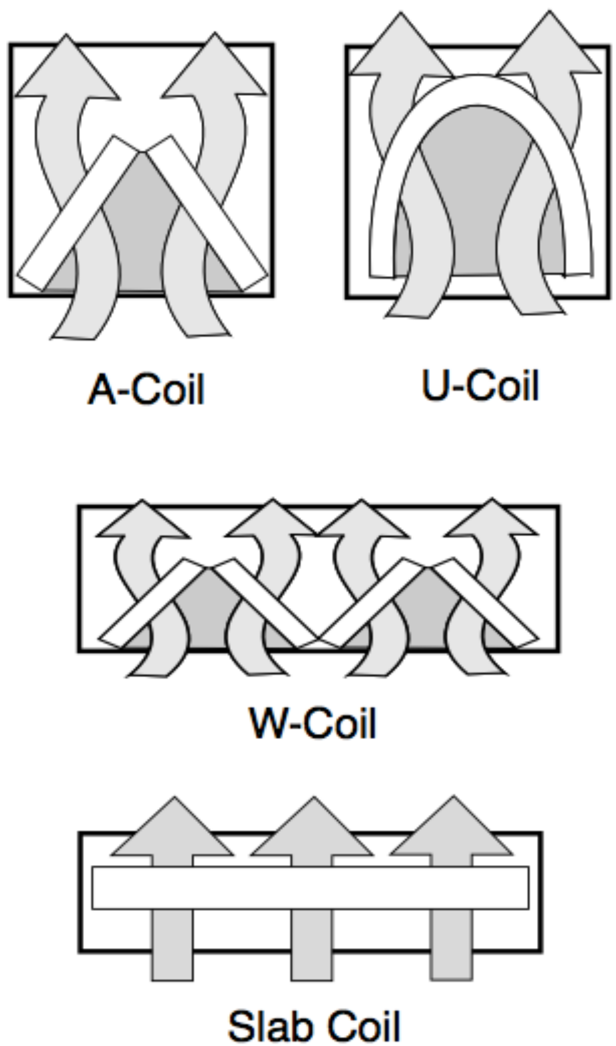
- **<u>Condenser</u>** – There are two main parts of a direct expansion (DX – the typical kind) air conditioning system: the part where the refrigerant expands and the part where it is compressed.
- The condenser is essentially the part where it is compressed.

Common HVAC System Components

- **<u>Coil</u>** - The Coil is the part where the refrigerant expands.
- This photo shows a coil with the front cover removed.
- It has a fixed orifice (as opposed to a TXV – next topic)

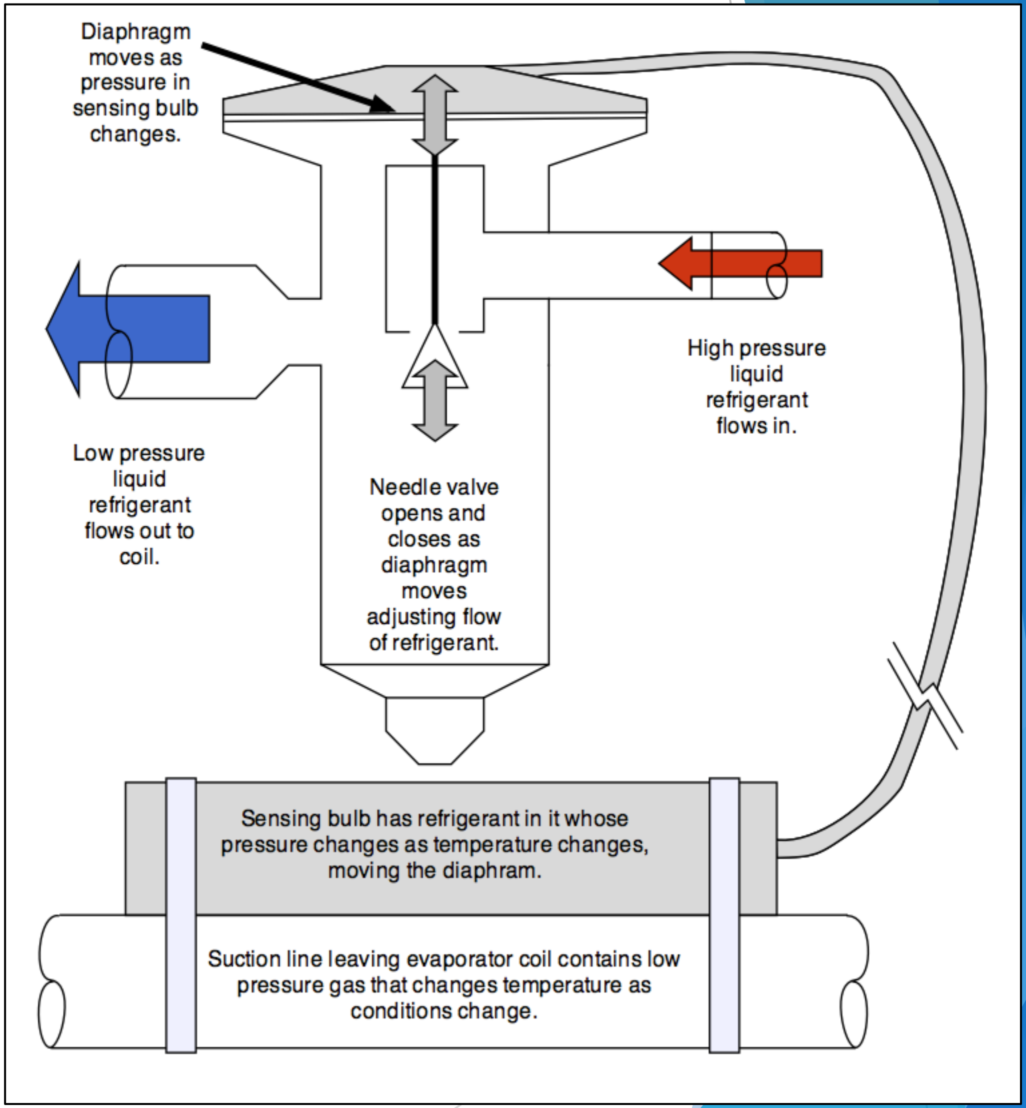
Common HVAC System Components

- Coils come in several configurations named after the rough shape of the coil elements.
- They may be selected based on geometry and room available to install the system.
- Notice that slab and W-coils are wider and flatter.
- A-coils are by far the most common.



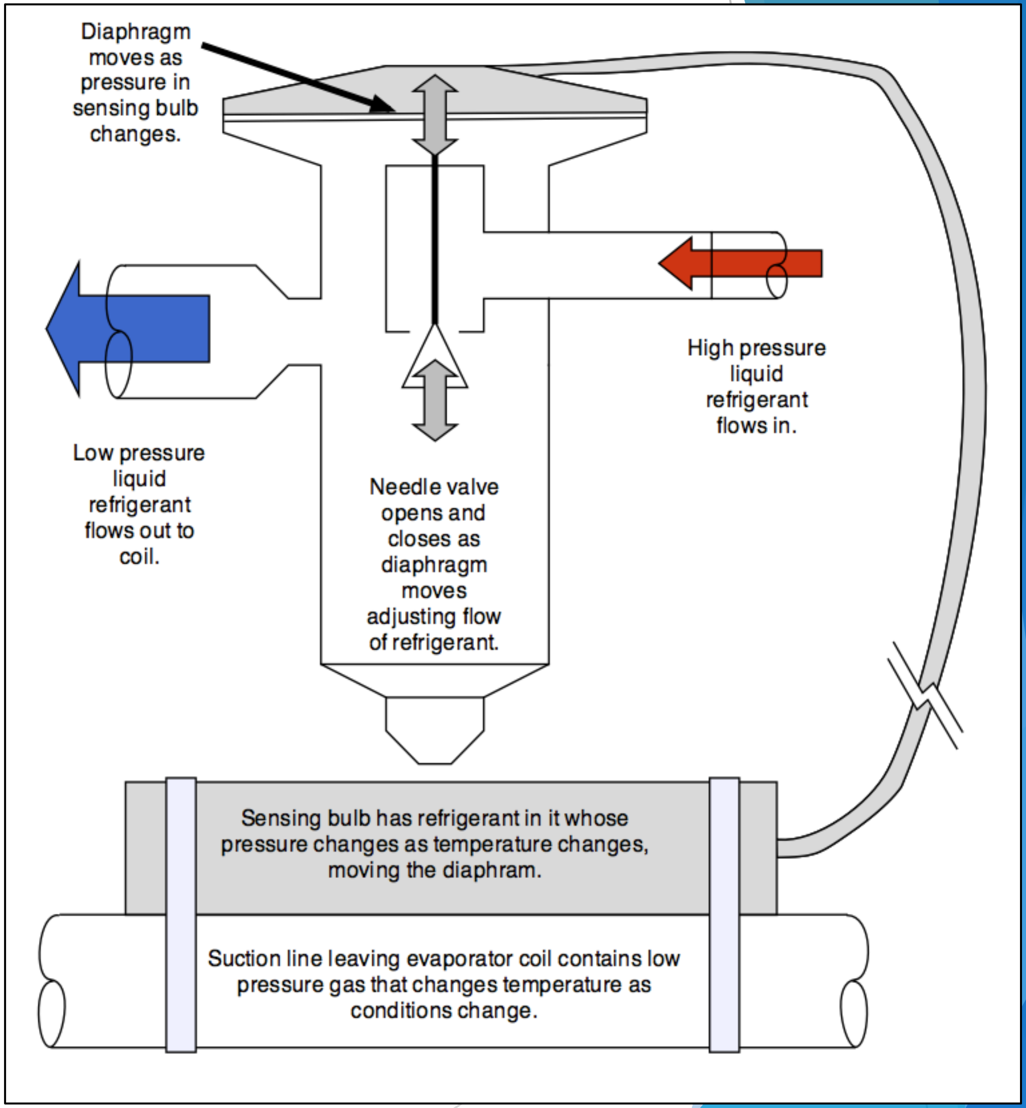
Common HVAC System Components

- **<u>Thermostatic Expansion Valve (TXV)</u>** – A TXV, and its fancy electronic cousin, the EXV, are valves that regulate the flow of refrigerant through the evaporator coil.



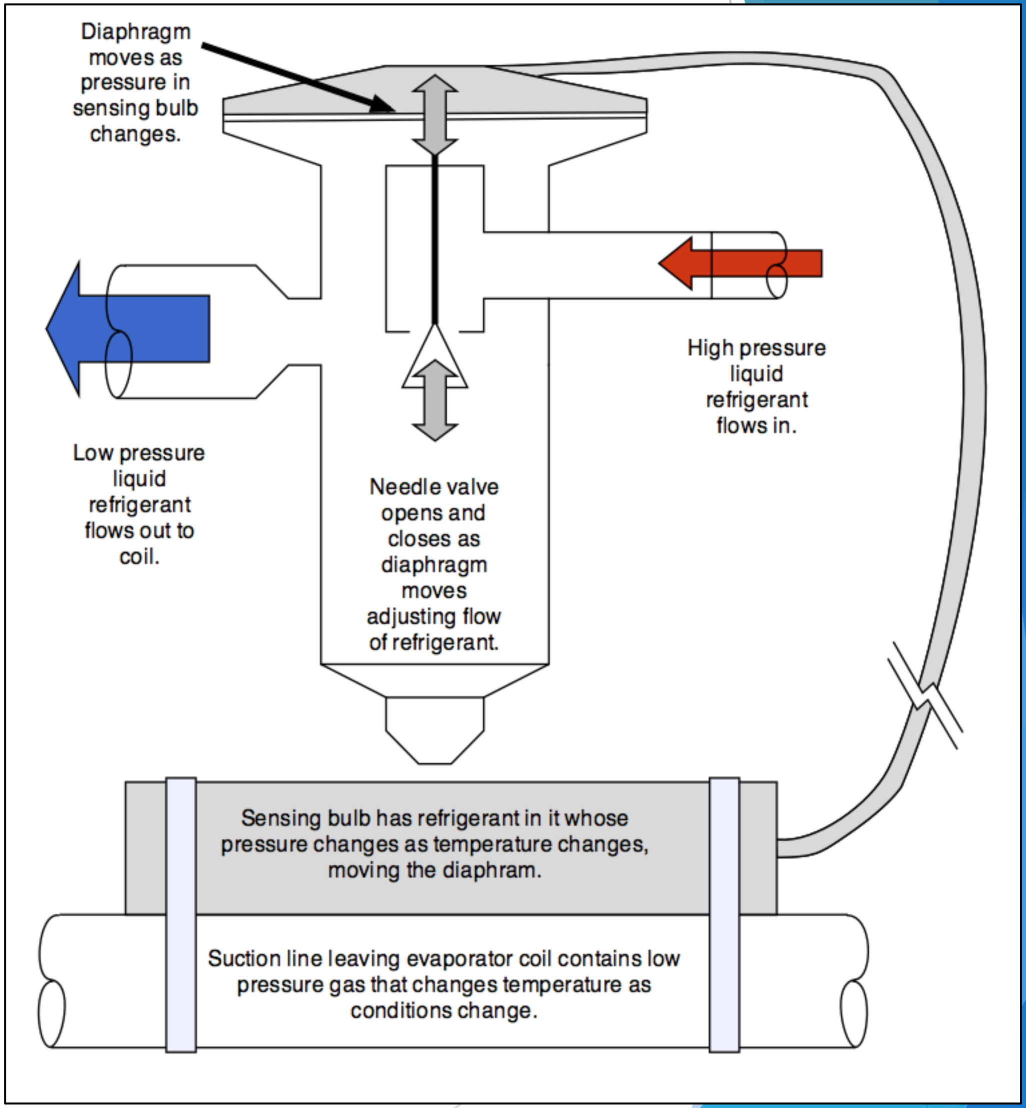
Common HVAC System Components

- Some older coils relied on something called a fixed orifice, which only allows refrigerant to flow at one rate, regardless of the operating conditions.
- The purpose of a TXV is to maintain something called a constant “superheat”, a number that indicates proper refrigerant flow.

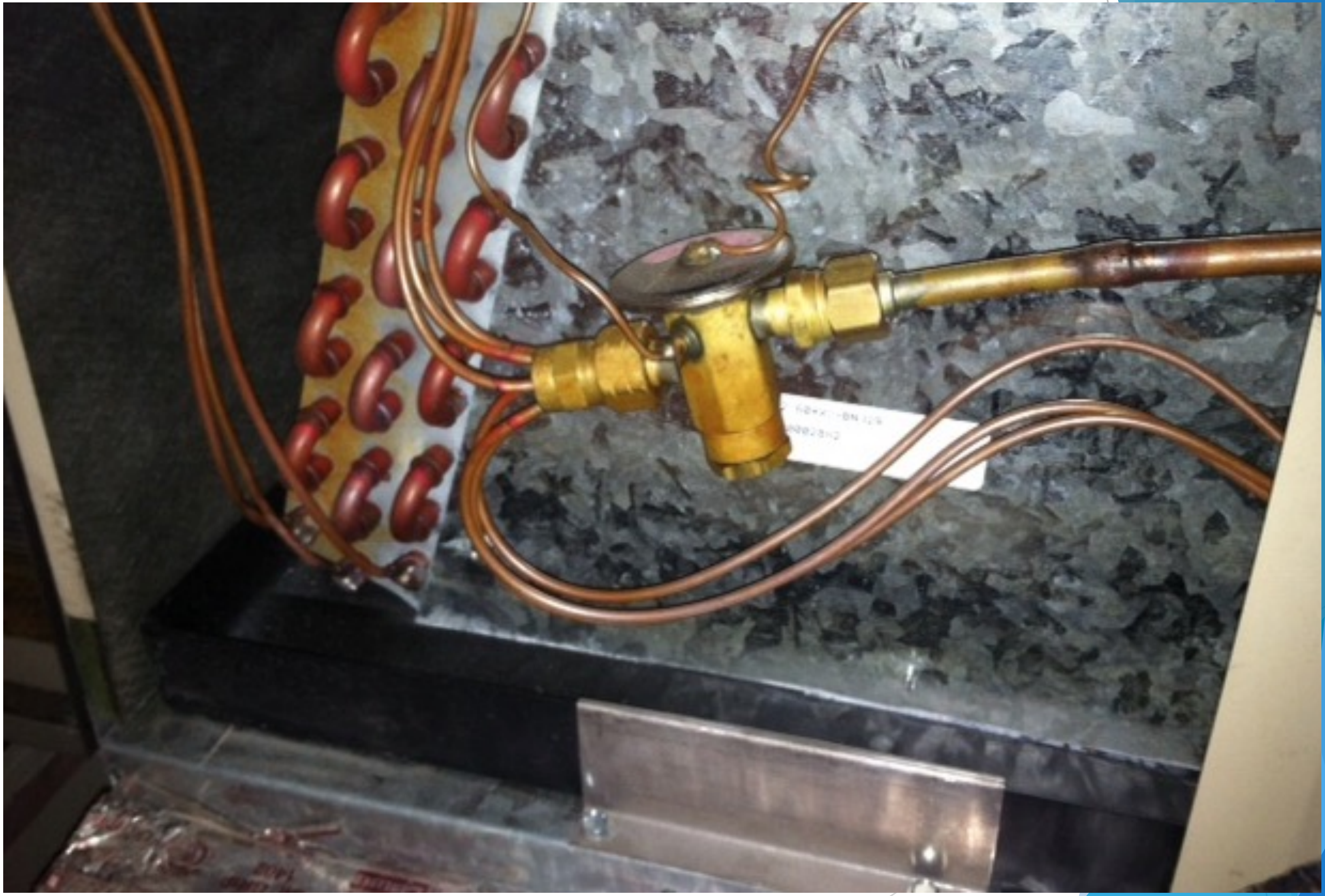


Common HVAC System Components

- A TXV basically opens and closes in response to changes in operating conditions to help the refrigerant flow stay in the "sweet spot" of optimum performance.
- It is a mechanical device and highly prone to poor installation practices.
- It also occasionally fails due to particulates in the refrigerant.



Common HVAC System Components



Common HVAC System Components

Common HVAC System Components

- **Refrigerant Lines** (aka, line set) – There are four things coming off of the back of a condenser and going into the house.

1. A large gauge electrical wire (power)
2. Some small gauge electrical wires (low voltage controls)
3. A large copper tube (3/4" to 1"),
4. A small copper tube (3/8" to ½").

- The two copper tubes are the refrigerant lines.

Common HVAC System Components

- The larger one goes by a variety of names, including suction line, vapor line, low pressure line, low side, etc.
- It contains refrigerant as a low pressure vapor that is going back to the condenser to be compressed and condensed.
- This line should be insulated.
- Partly to prevent it from gaining heat and partly to prevent moisture from condensing on it and eventually causing damage.

Common HVAC System Components

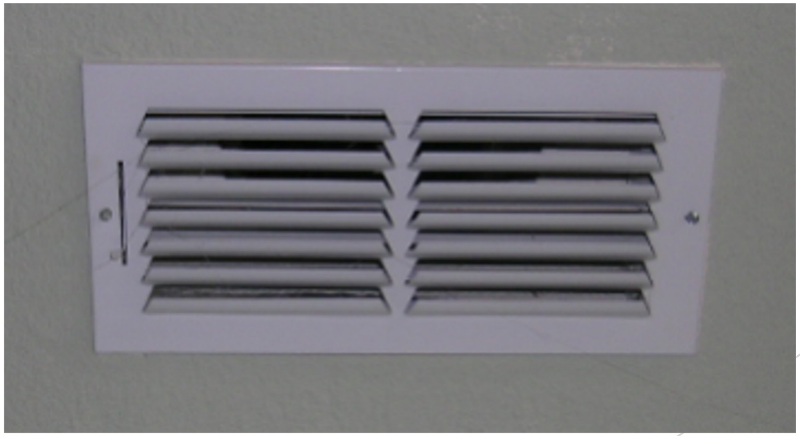
- The smaller one goes by names such as liquid line, high pressure line, high side, etc.
- It contains high pressure liquid refrigerant that is traveling to the evaporator coil where it will expand and boil into a vapor.

Common HVAC System Components

- **Plenum** – This term, as it is used in the HVAC industry, basically refers to a large sheet metal or duct board box to which one or more smaller ducts are connected.
- Supply plenums are the box that the supply ducts are connected to and the return plenum is the box that the return duct or ducts are connected to.

Register Types and Locations (page 50)

- Supply registers are where the heated and cooled air comes out, so it is obviously very important that they be properly placed.
- There are many misconceptions about this. For example:
  - What's better for heating a room, floor registers or ceiling registers, and why?
  - Most people will say that floor registers are better because hot air rises.



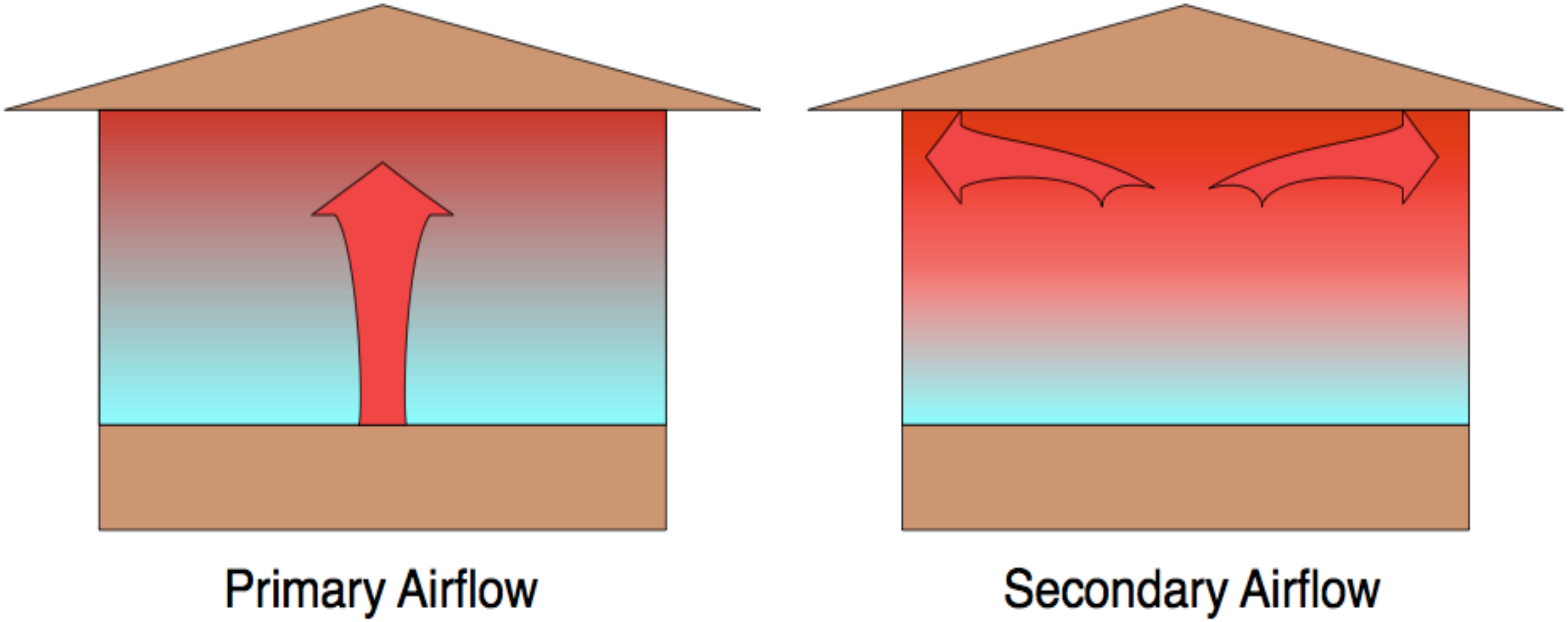
Register Types and Locations

- Sorry, that is incorrect.
- Yes, hot air does rise, but you have to remember the sole purpose of a supply register: to efficiently and effectively **MIX** the conditioned air with the room air.
- One very good rule of thumb (even though rules of thumb can be dangerous) is to blow the air in the opposite direction that it will naturally want to go.

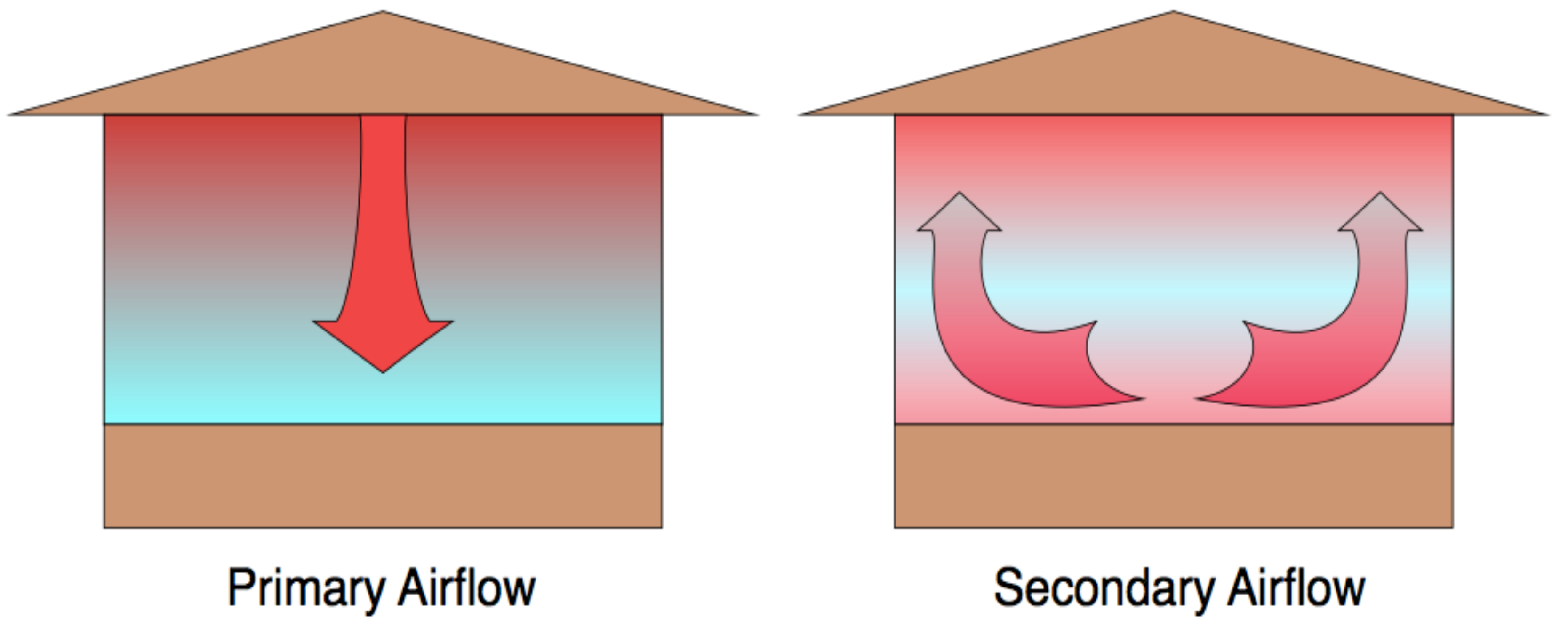
Register Types and Locations

- If hot air comes out of a floor register it will go up . . . and stay up.
- This does not promote good mixing.
- In fact, it promotes stratification.
- If you blow hot air downward, it will reach close to the floor and then begin to rise naturally, but by that time it has mixed with the room air making it less likely to stratify.

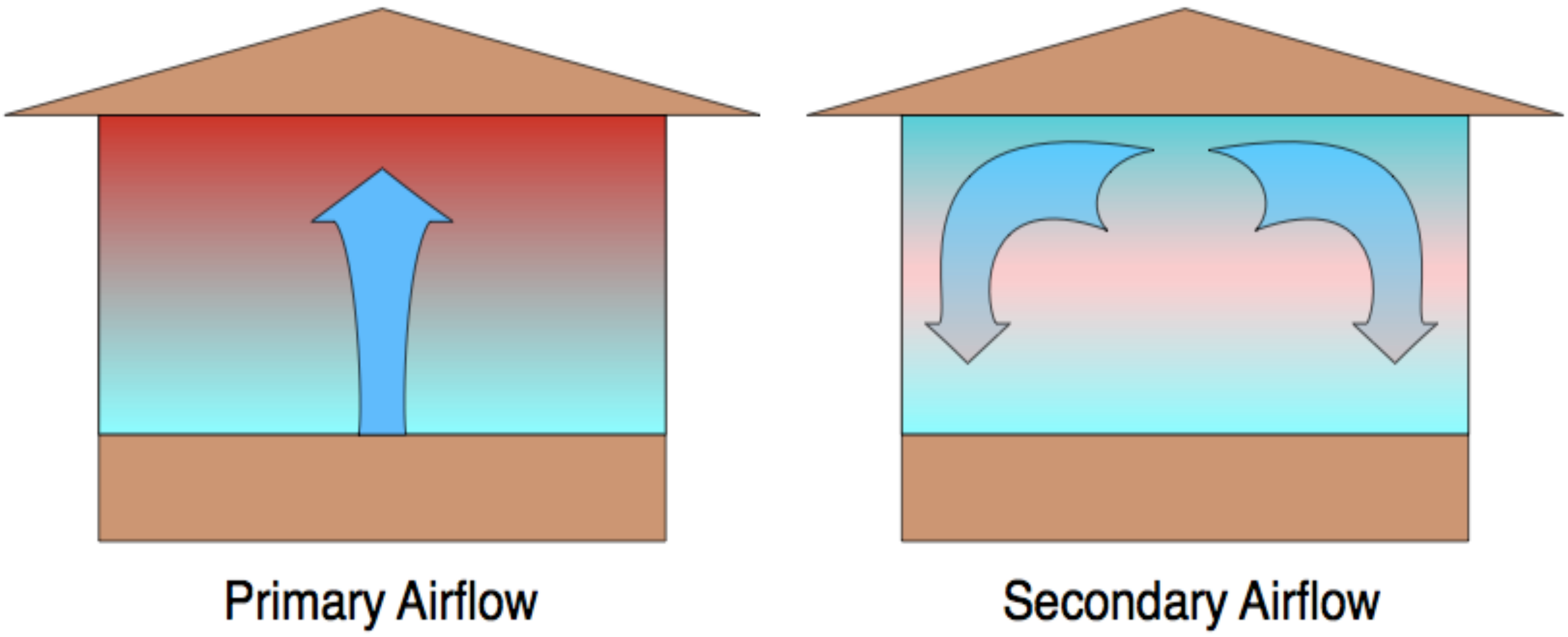
Register Types and Locations



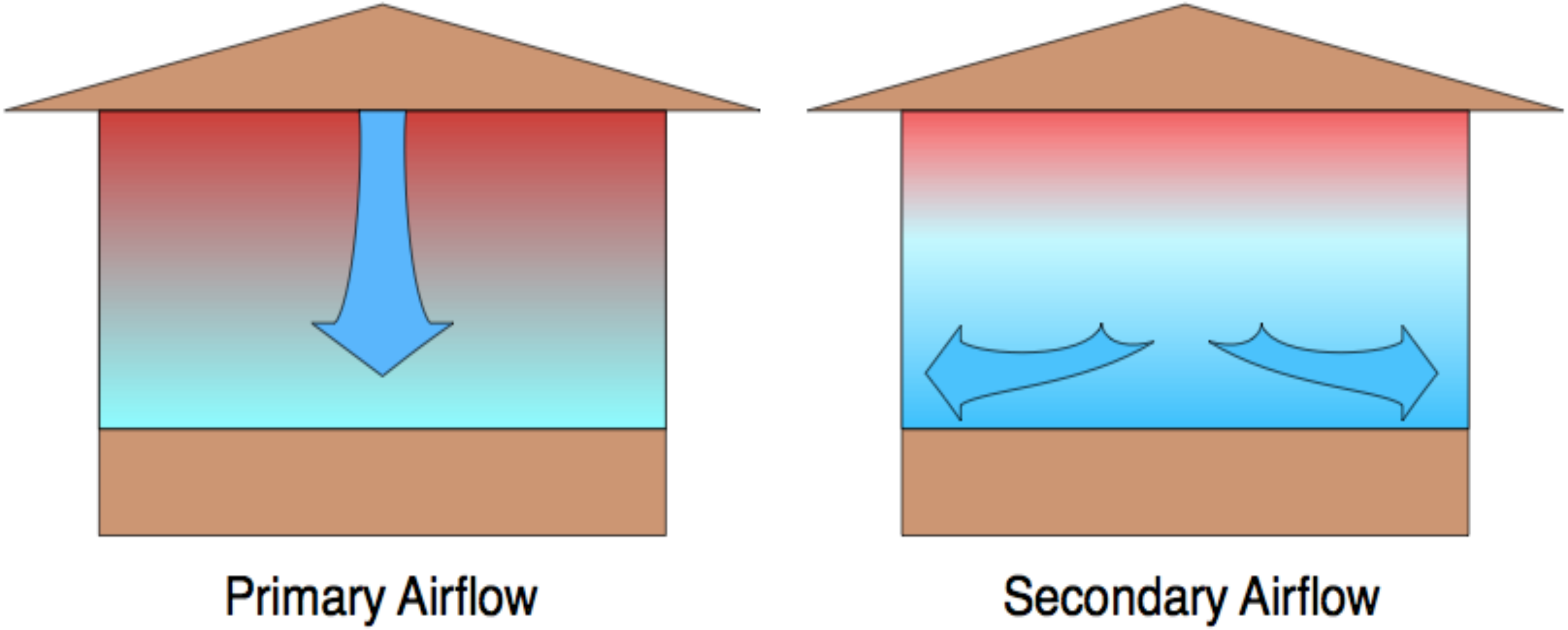
Register Types and Locations



Register Types and Locations



Register Types and Locations



Register Types and Locations

- This same rule of thumb can work for where you place a register within a room: Blow the air in the opposite direction that it will naturally want to go.
- In a typical room the natural direction is out, toward the door, back to the return.
- Assuming that the return is out in the hall, better mixing is achieved by putting the register near the door and blowing it away from the door.

Register Types and Locations

- Just as important as where you put a register is the type of register that you choose.
- There are many types of registers, but the most common are simple rectangular registers.
- There are two basic types of these:
  - Stamped-face and
  - bar-type.
- These terms basically describe how they are made.

Register Types and Locations

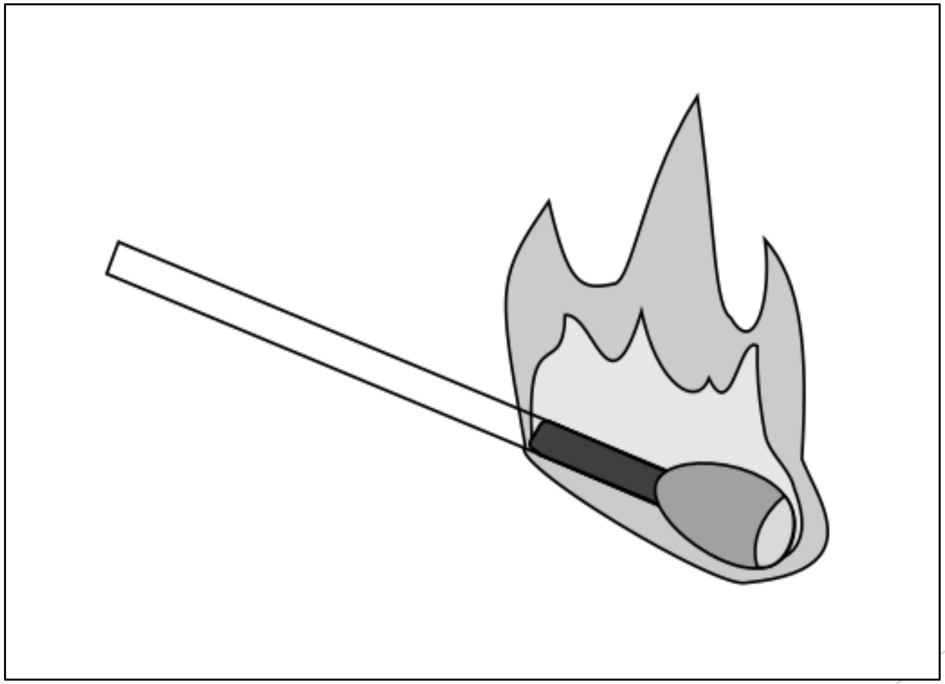
- Stamped-face start out as a flat piece of sheet metal and are put into a press (stamped) so that the fins are cut and bent outward.
- Bar type registers are more expensive to make.
- The frame and fins are separate pieces.
- Each fin is separately adjustable.
- Both kinds come in straight and curved blade.
- The also come with fins designed to send the air in different directions.

Register Types and Locations

- This is a 3-way stamped-face register with straight fins.
- This is an adjustable bar-type register with straight fins.
- This is a 3-way stamped-face register with curved fins (aka blades).

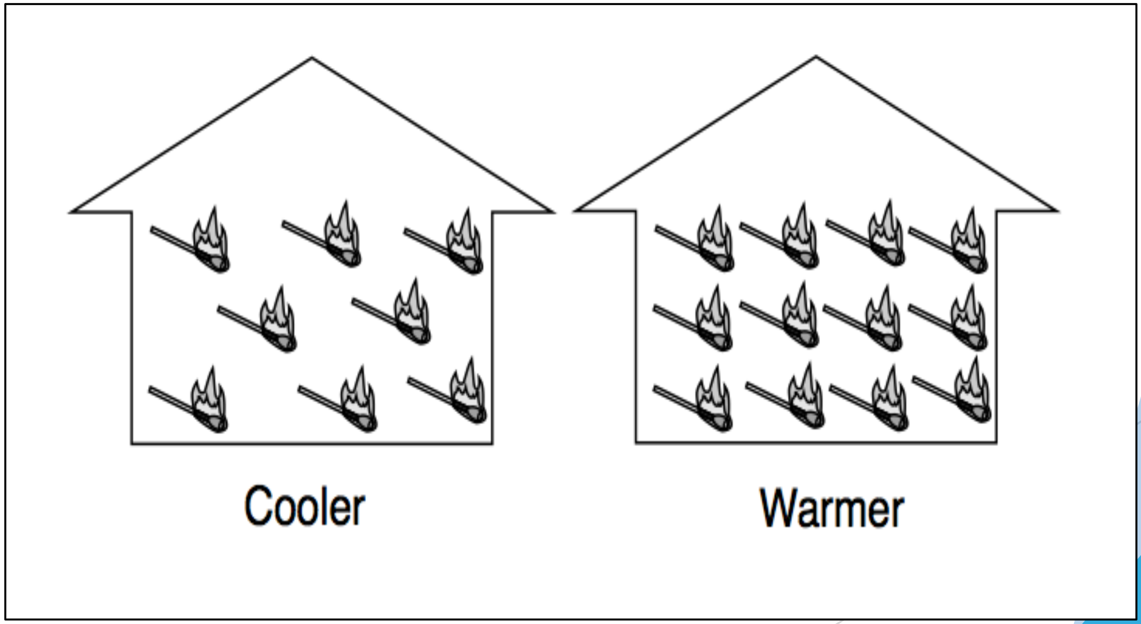
Super Basic Thermodynamics (page 114)

- Heat = BTU = British Thermal Unit
- 1 BTU = 1 kitchen match



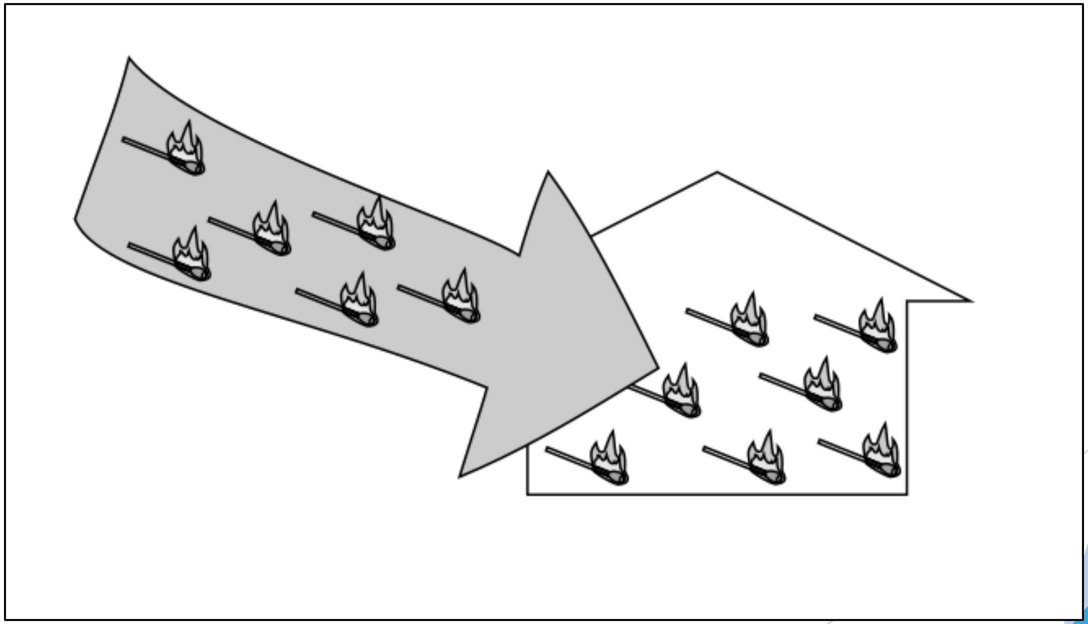
Super Basic Thermodynamics

- Temperature = density of BTU's = how many BTU's you have in an object or volume of fluid
- Everything has *some* BTU's in it, even very cold objects.



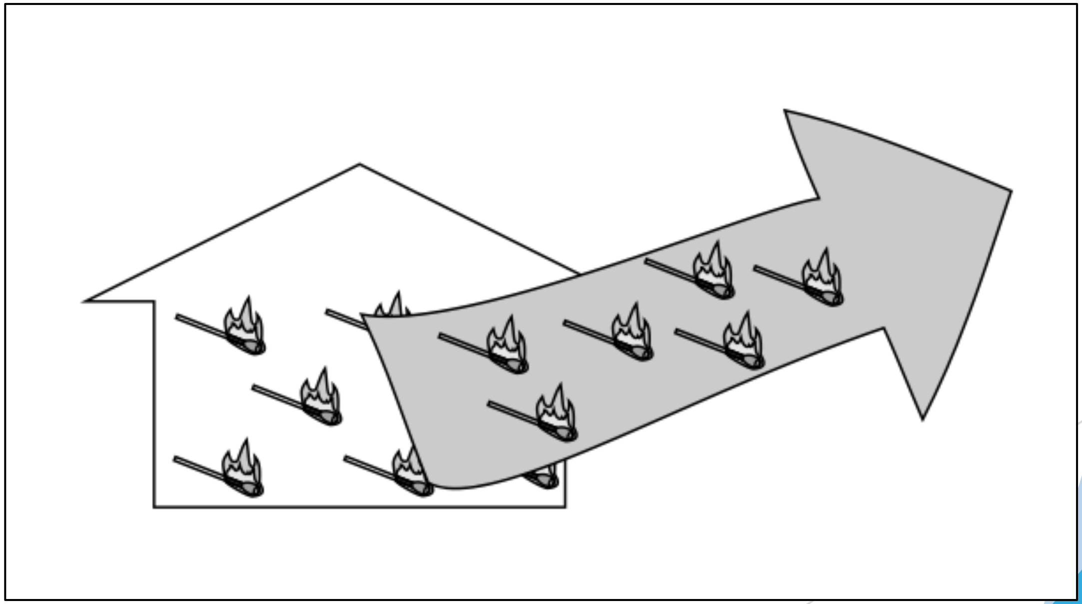
Super Basic Thermodynamics

- Heating = BTU/hr = kitchen matches added per hour
- When you add BTU's to something the temperature goes up.



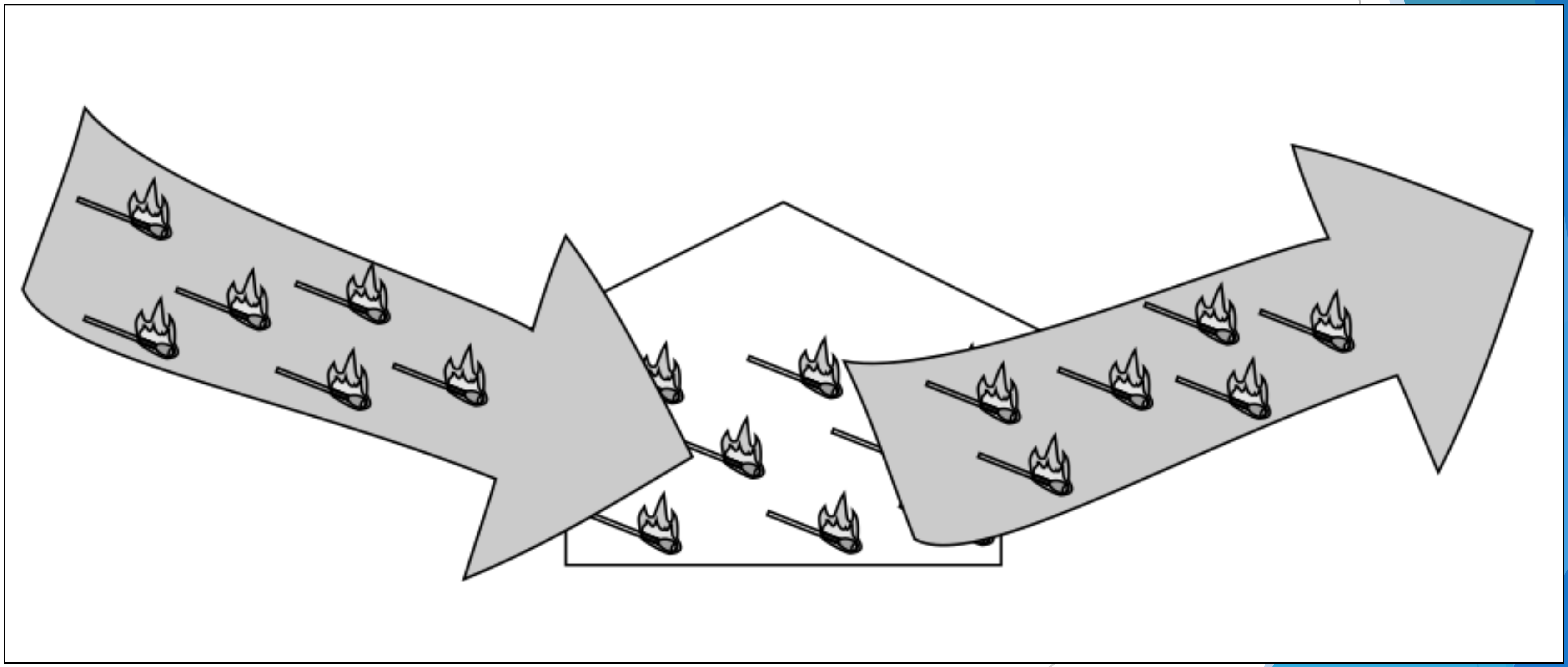
Super Basic Thermodynamics

- Cooling = - BTU/hr = kitchen matches removed per hour
- When you remove BTU's from something the temperature goes down.



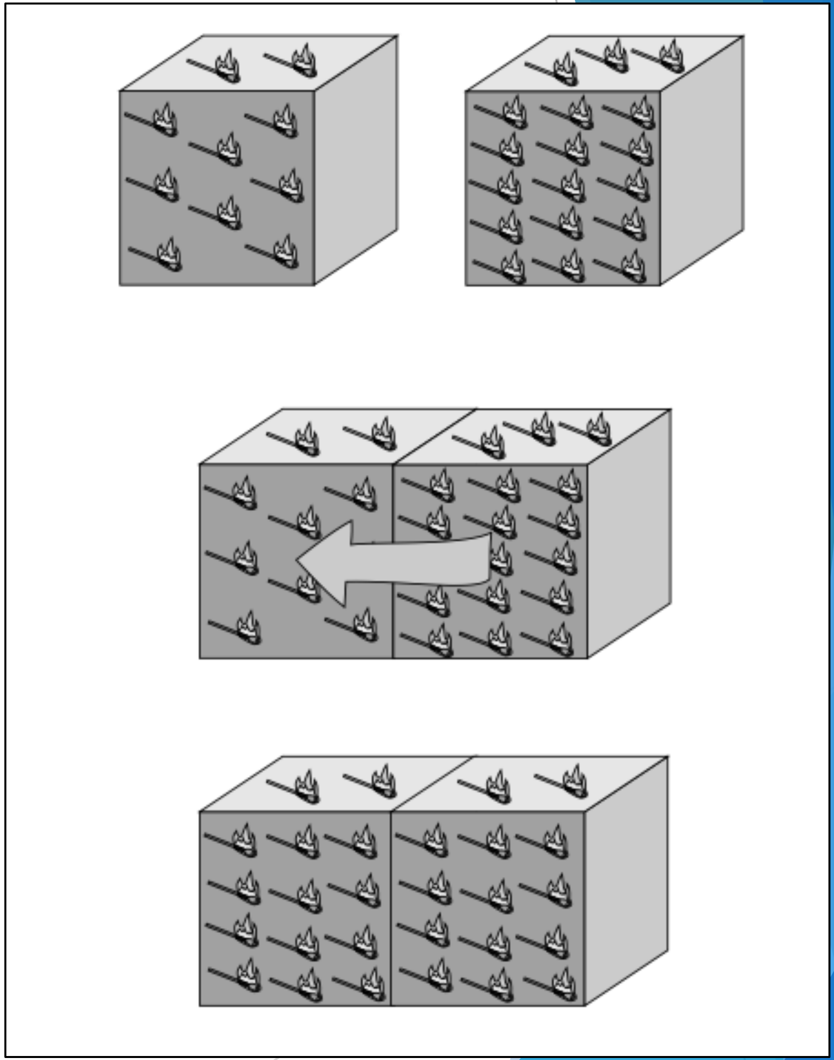
Super Basic Thermodynamics

- If you remove BTU's at the same rate at which they are being added, the temperature will remain constant.



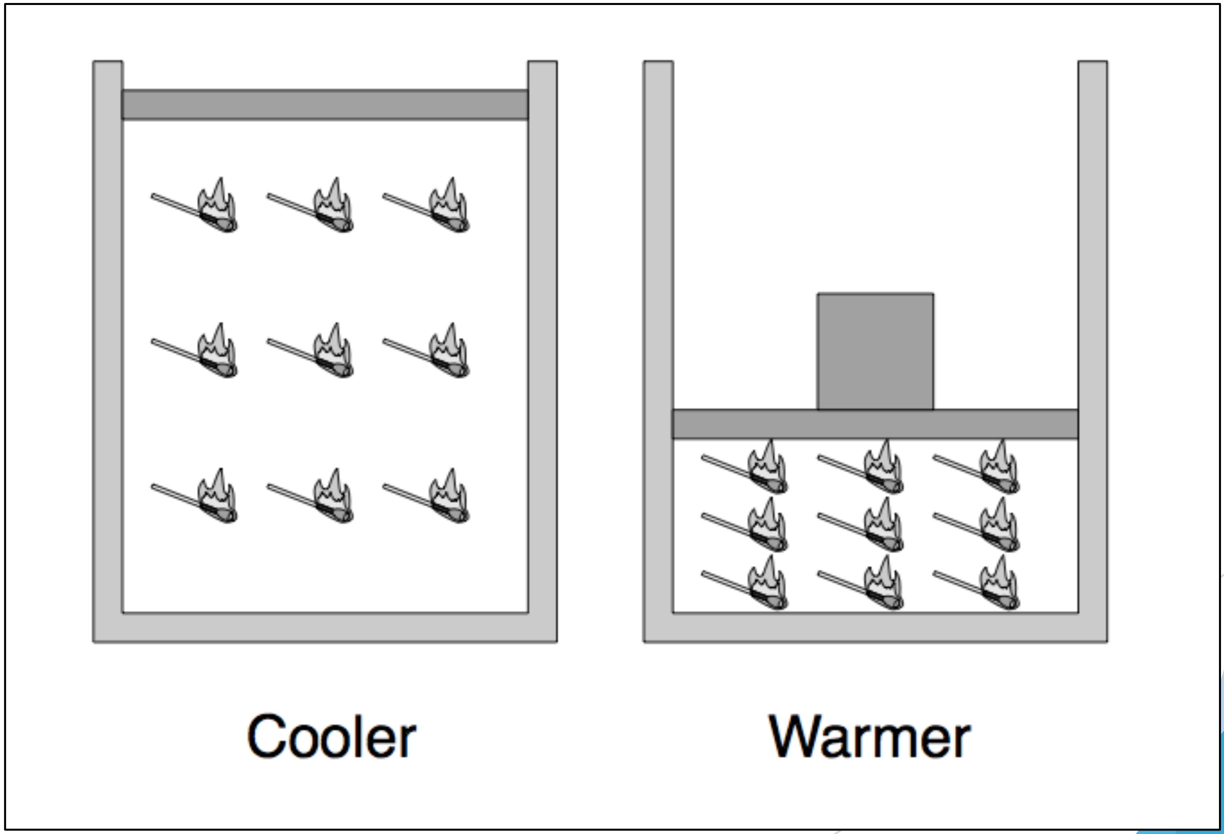
Super Basic Thermodynamics

- BTU's naturally move from higher temperatures to lower temperatures, until the temperatures equalize.



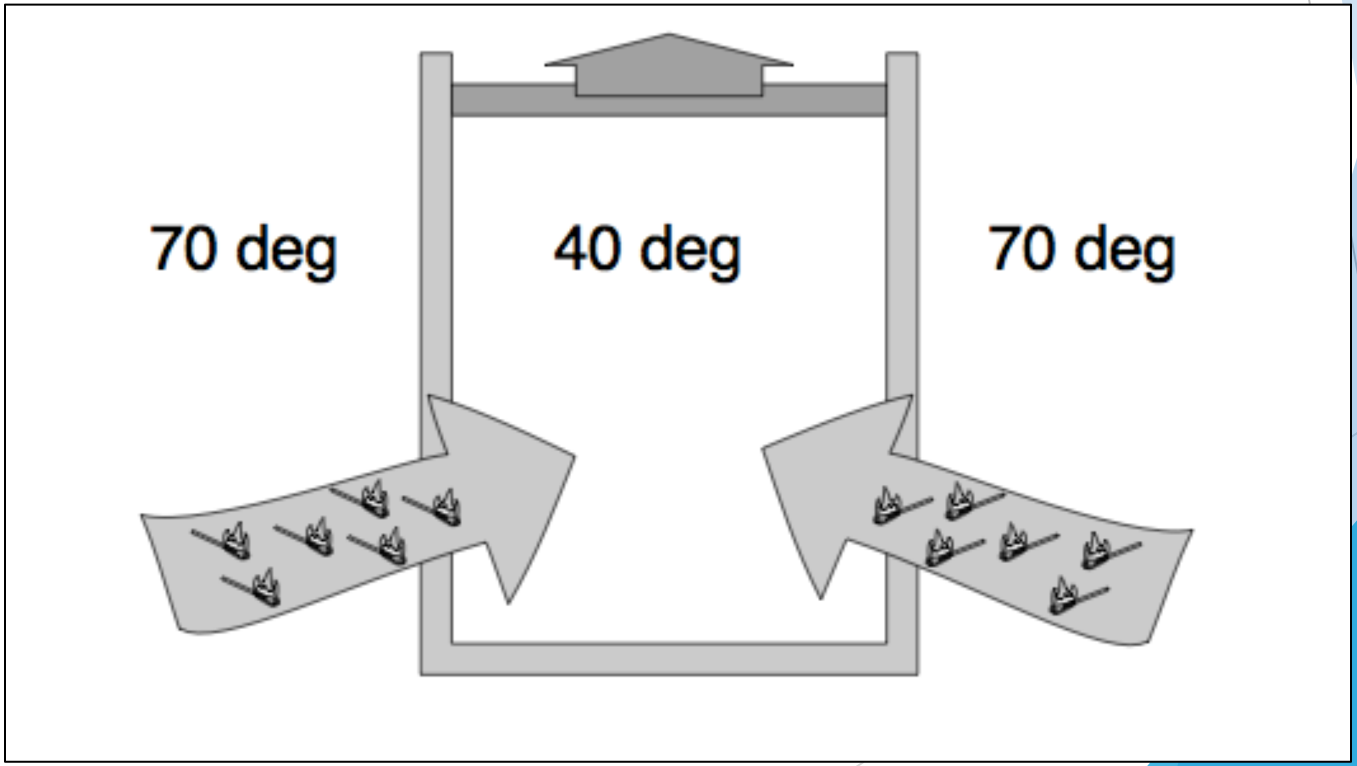
Super Basic Thermodynamics

- If you decrease the volume of something that contains a certain number of BTU's, such as air, the temperature goes up, and visa-versa.



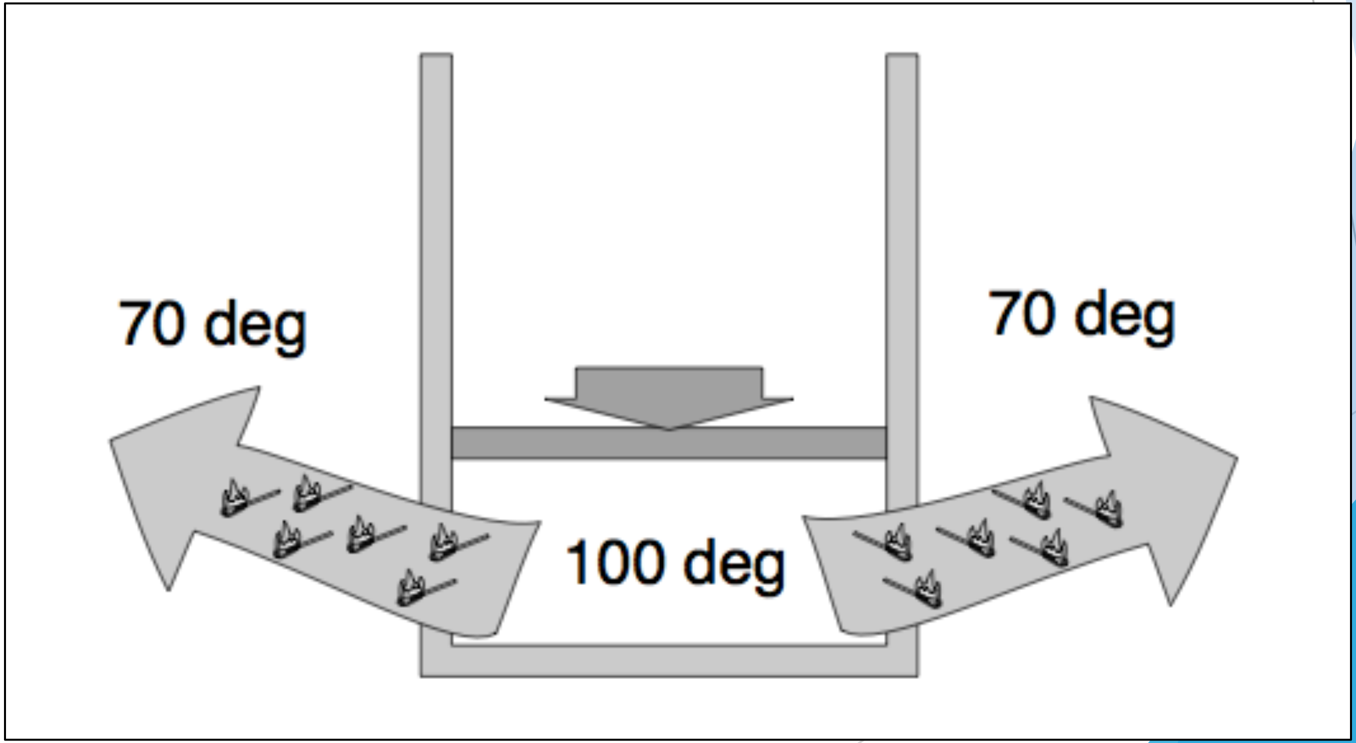
Super Basic Thermodynamics

- A volume of compressible fluid can have its temperature reduced by expanding to a larger volume.
- If the temperature is lower than the air around it, heat will naturally go into the volume from the air.



Super Basic Thermodynamics

- Similarly, a volume of compressible fluid can have its temperature raised by compressing it into a smaller volume.
- If the temperature is greater than the air around it, heat will naturally leave the volume to the air.



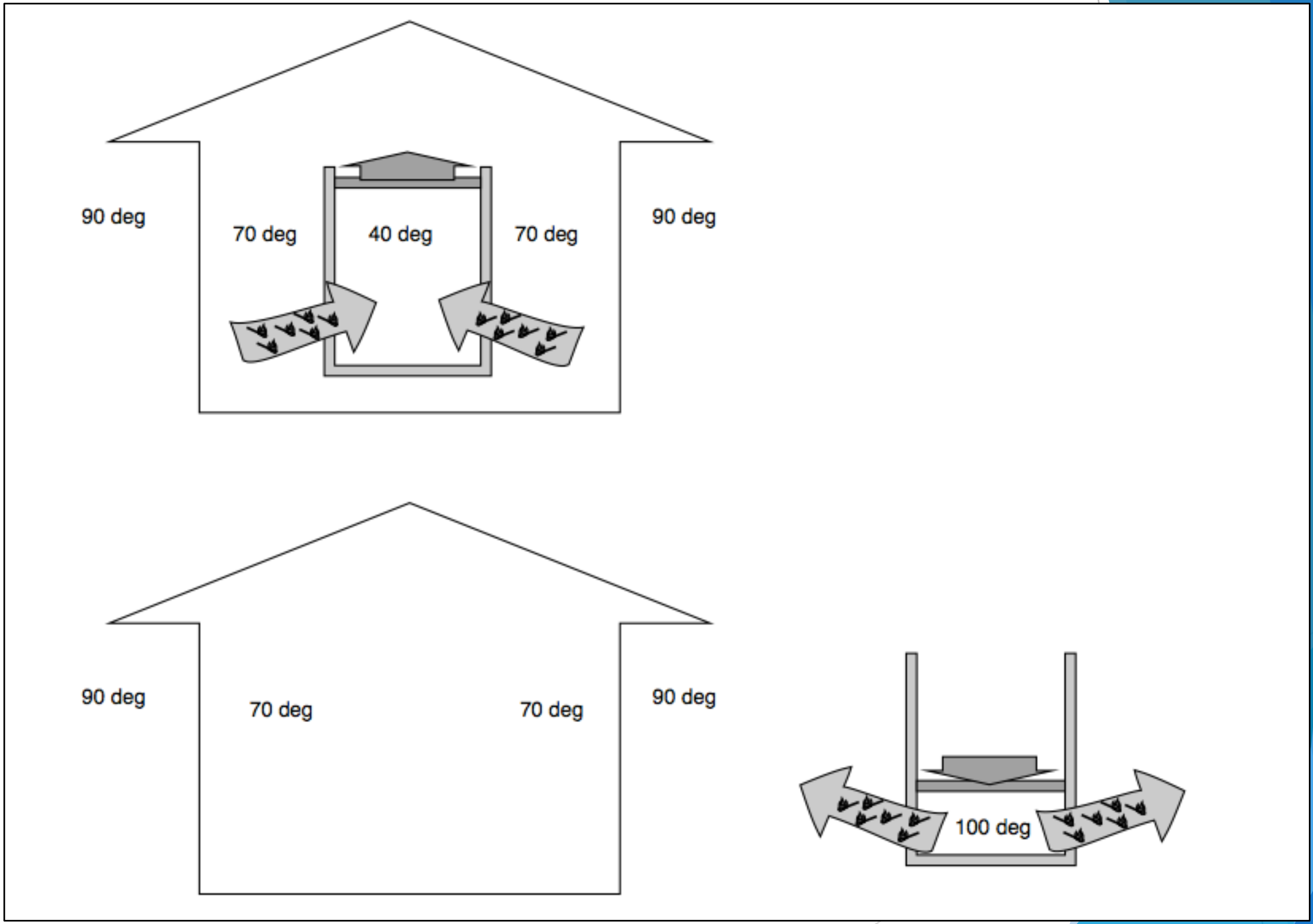
Super Basic Thermodynamics

- The ability to change the temperature of something mechanically, by changing its volume, is a very important concept in understanding air conditioning and refrigeration.
- If we take a vessel of this special compressible fluid inside a house and mechanically expand it so that the temperature is lower than the temperature inside the house it will absorb BTU’s from the house.

Super Basic Thermodynamics

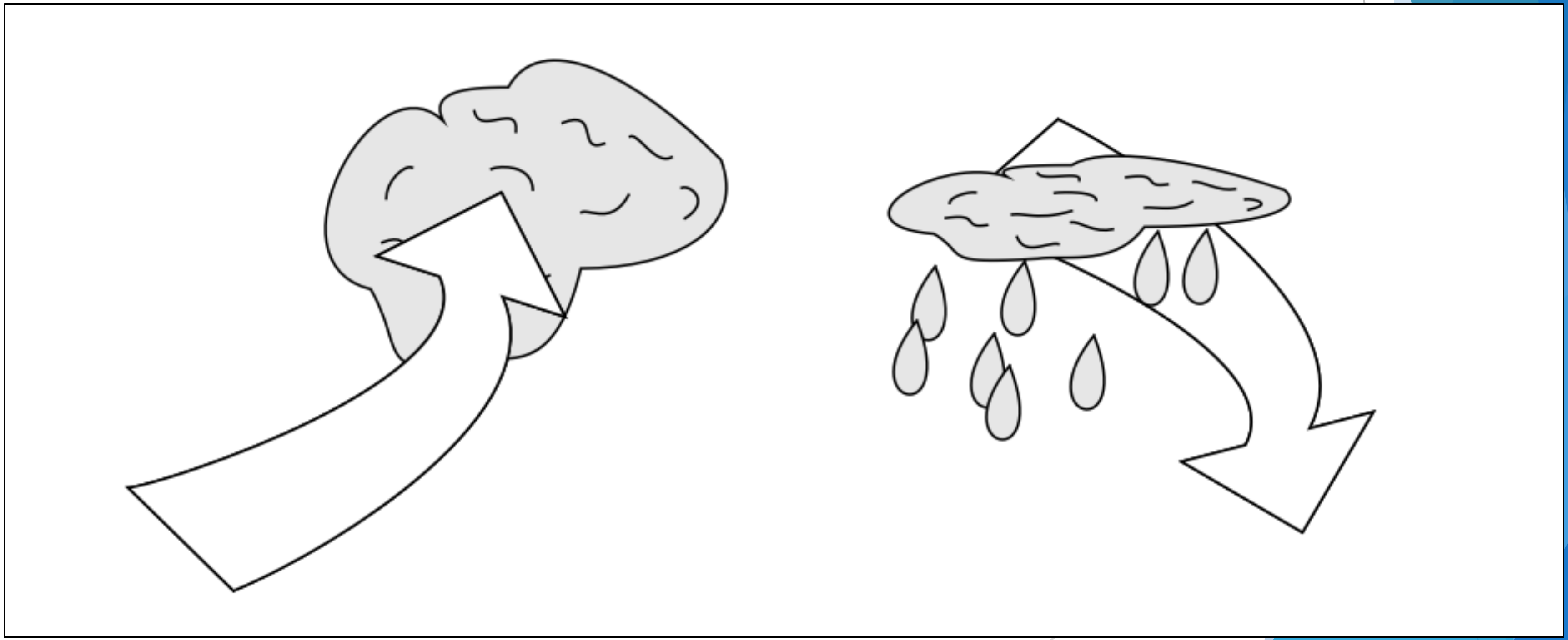
- If we then took it outside and compressed it so that its temperature was greater than the air outside BTU’s would go to the outside air and even though the outside temperature of the air is greater than the inside.
- We have just mechanically moved BTU’s in the opposite direction than the laws of physics say they should naturally go (from hotter to colder).

Super Basic Thermodynamics



Direct Expansion (DX) Cooling (page 68)

- Refrigerant behaves in much the same way that a sponge does.
- When you squeeze it, water comes out, when it expands water is absorbed.
- The water represents BTU's.

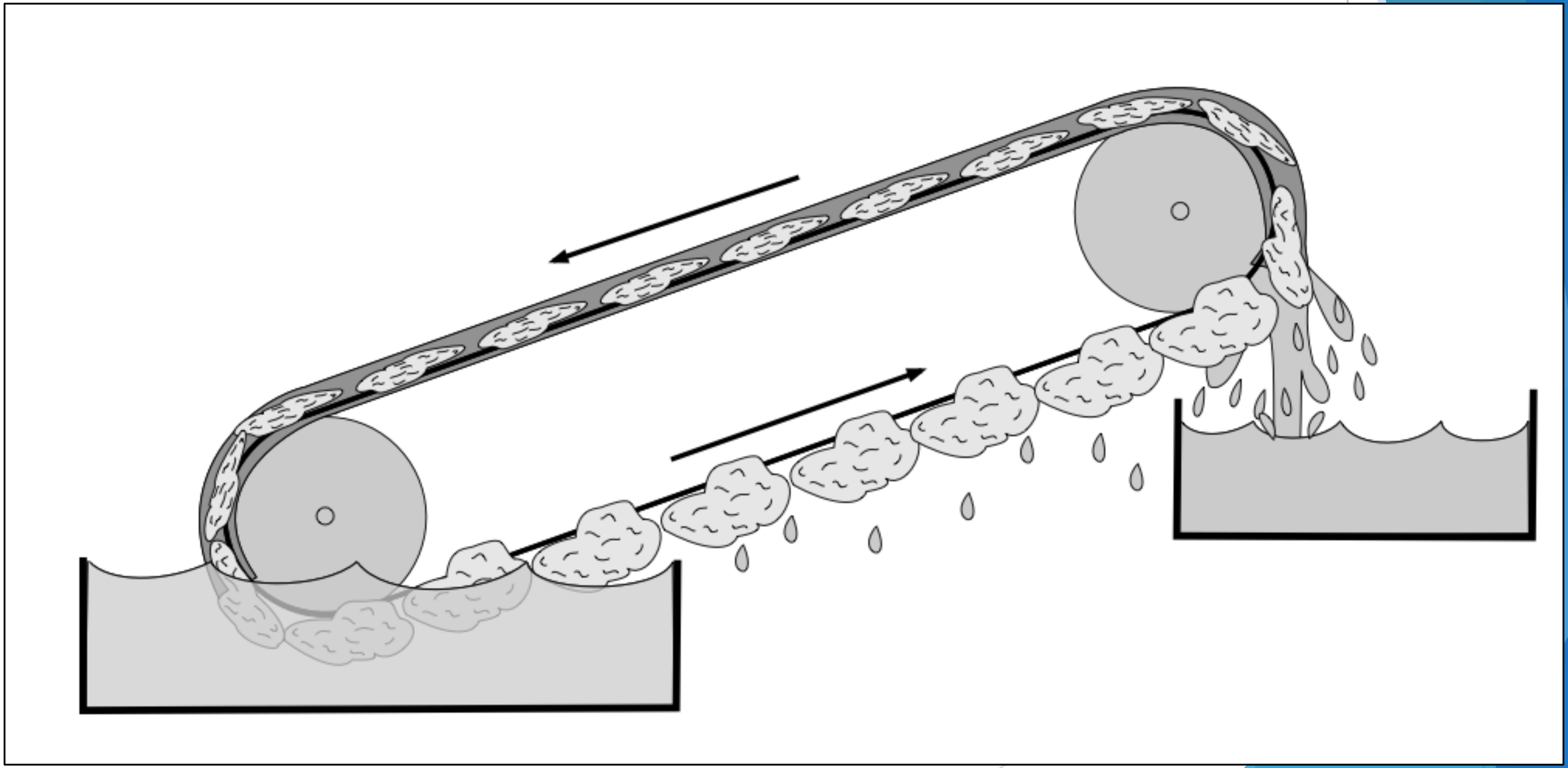


Direct Expansion (DX) Cooling

- Using this analogy, it is possible to explain how a mechanical direct expansion (DX) cooling system works.
- Imagine a bunch of sponges tied at even distances along a large loop of string.
- The string is mounted on two big wheels like a conveyor belt.
- At one end, the sponges dip into water and soak it up.
- At the other end the sponges are squeezed and the water comes out.

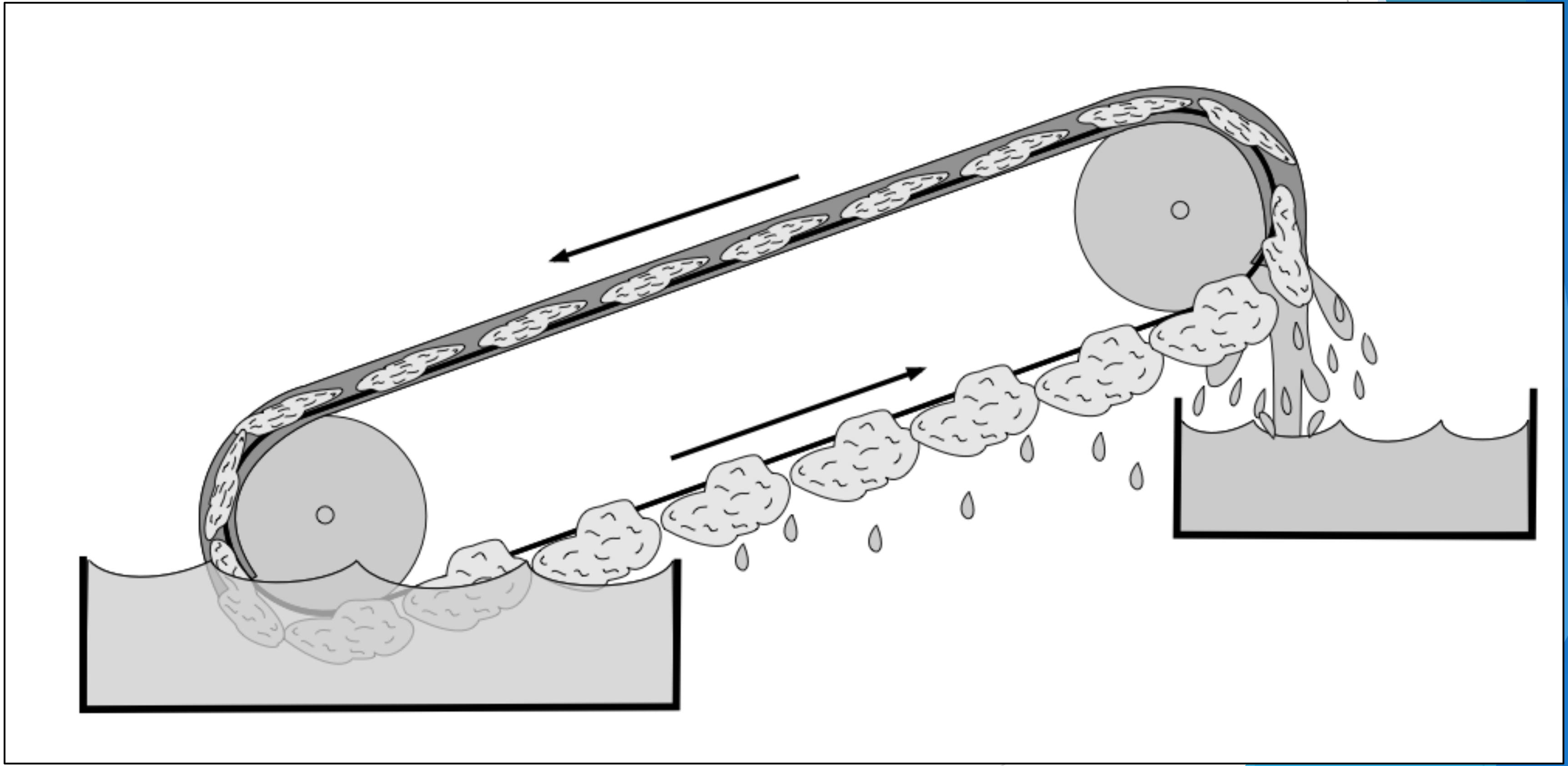
Direct Expansion (DX) Cooling

- The side where the sponges expand is analogous to the evaporator and the side where the water is squeezed out of the sponges is analogous to the condenser.



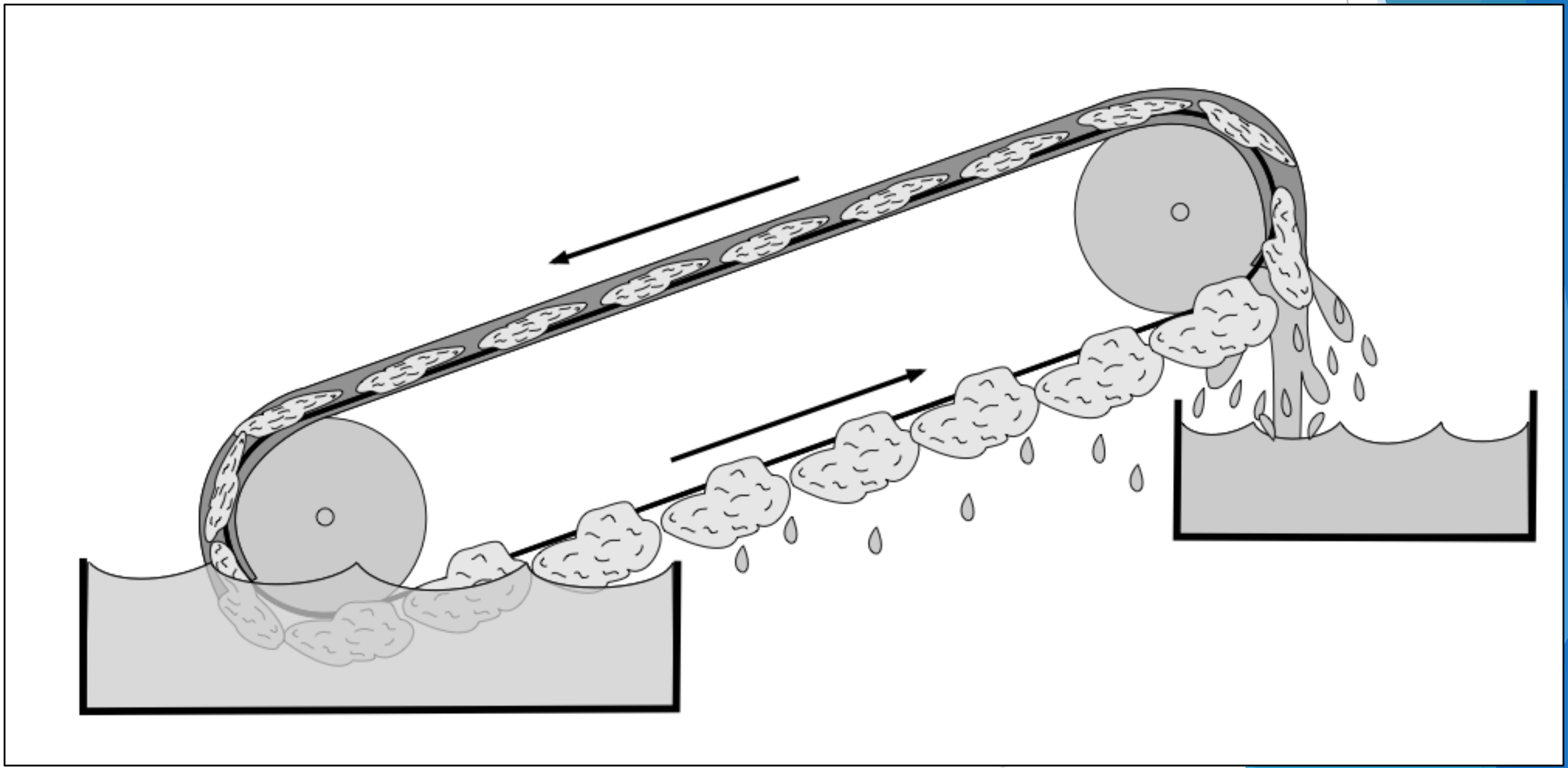
Direct Expansion (DX) Cooling

- The sponge represents the refrigerant.
- When it is squeezed, it represents liquid refrigerant. When it is expanded it represents gaseous refrigerant.

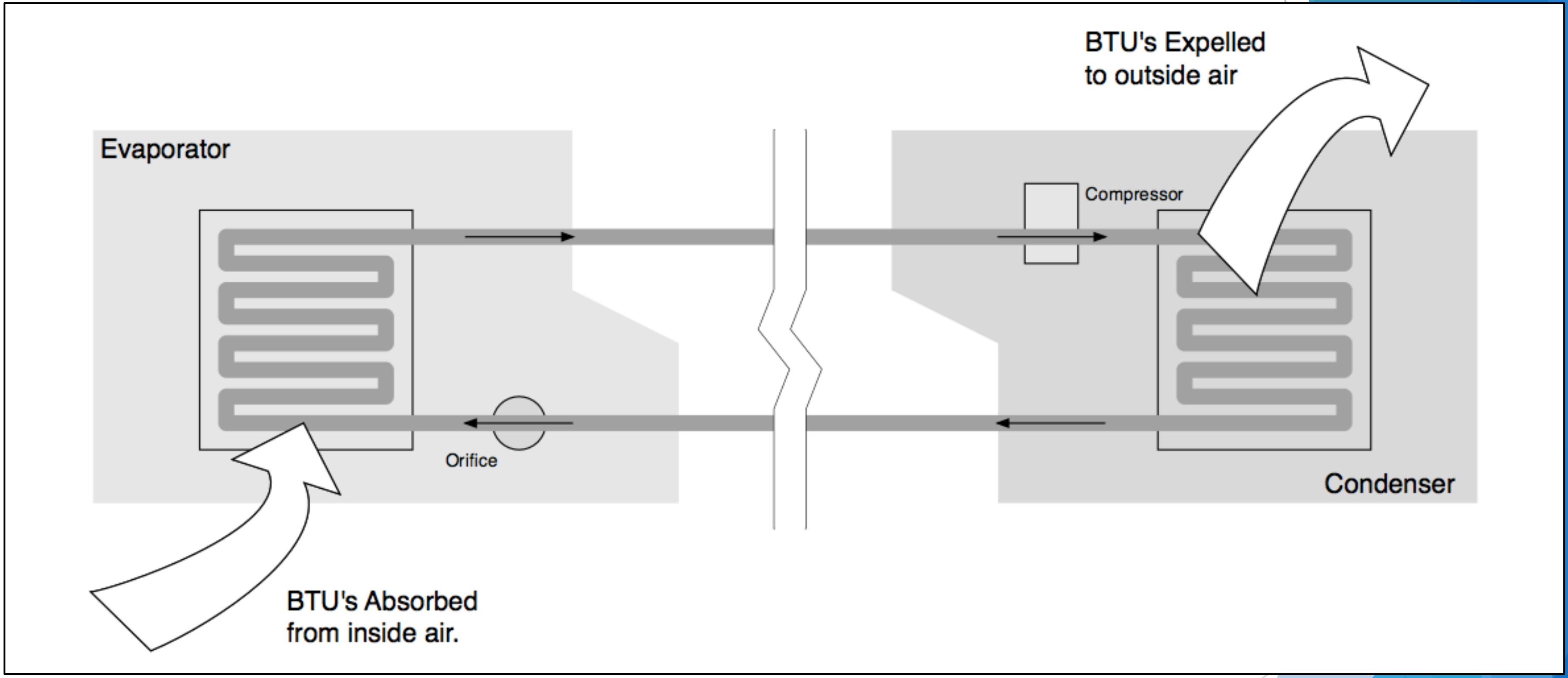


Direct Expansion (DX) Cooling

- The compressed sponges returning back to the water represent the liquid line.
- The expanded sponges leaving the water and heading up to be squeezed represent the suction line or vapor line.



Direct Expansion (DX) Cooling



Introduction to Residential HVAC Systems

The End

Thank You

Closing

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