Safe Operation of HVAC Systems – It's Not Always the HVAC Systems Fault

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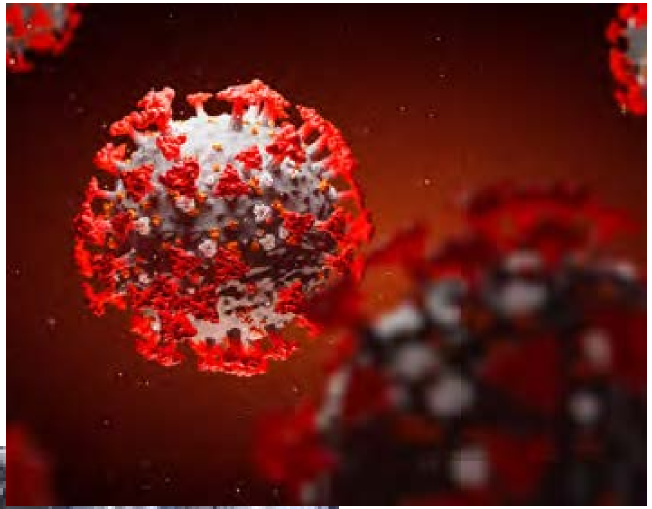

Agenda

- What CDC/ASHRAE are saying about Covid?
- HVAC 101
- Vapor Pressure Diffusion – Not always the AC's Fault

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Introduction

Presenter: Scott M. Katzer, P.E., CFEI
Senior Engineer / Florida Division Manager

Education: B.S. Mechanical Engineering from
Northeastern University, Boston, MA

Area of Expertise: Mechanical/HVAC, Electrical, Plumbing, Fire Protection, Property Condition Assessments, Construction Litigation

Highlights: Professional Engineer in 12 states
Certified Fire and Explosion Investigator
Certified Residential/Commercial Roof Inspector
Risk Assessment – Severe Weather (i.e. Hurricanes)
Expert Witness

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What is the CDC saying regarding HVAC systems?

Consider improving the engineering controls using the building ventilation system. This may include some or all of the following activities:

- *Increase ventilation rates.*
- *Increase the percentage of outdoor air that circulates into the system.*

https://www.cdc.gov/coronavirus/2019-ncov/community/guidance-business-response.html?CDC_AA_refVal=https%3A%2F%2Fwww.cdc.gov%2Fcoronavirus%2F2019-ncov%2Fspecific-groups%2Fguidance-business-response.html

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What is ASHRAE saying regarding HVAC systems?

On the recommendation of the ASHRAE Epidemic Task Force, ASHRAE leadership has approved the following two statements regarding transmission of SARS-CoV-2 and the operation of HVAC systems during the COVID-19 pandemic:

- ***Statement on airborne transmission of SARS-CoV-2:*** *Transmission of SARS-CoV-2 through the air is sufficiently likely that airborne exposure to the virus should be controlled. Changes to building operations, including the operation of heating, ventilating, and air-conditioning systems, can reduce airborne exposures.*
- ***Statement on operation of heating, ventilating, and air-conditioning systems to reduce SARS-CoV-2 transmission:*** *Ventilation and filtration provided by heating, ventilating, and air-conditioning systems can reduce the airborne concentration of SARS-CoV-2 and thus the risk of transmission through the air. Unconditioned spaces can cause thermal stress to people that may be directly life threatening and that may also lower resistance to infection. In general, disabling of heating, ventilating, and air-conditioning systems is not a recommended measure to reduce the transmission of the virus.*

https://www.ashrae.org/technical-resources/resources

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What is ASHRAE saying regarding HVAC systems?

ASHRAE Position Document on Infectious Aerosols

- Original title *ASHRAE Position Document on Airborne Infectious Diseases* approved by the ASHRAE Board of Directors on January 19, 2014
- Reaffirmed by the Technology Council on February 5, 2020.
- The BOD approved the revised PD titled *ASHRAE Position Document on Infectious Aerosols* on April 14, 2020.

Although ASHRAE provides general recommendations and air quality requirements in Standards 62.1, 62.2 and 170; "ASHRAE does not provide specific requirements for infectious disease control in homes, schools, prisons, shelters, transportation, or other public facilities."

https://www.ashrae.org/technical-resources/resources

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What is ASHRAE saying regarding HVAC systems?

ASHRAE Position Document on Infectious Aerosols (Non-Healthcare)

- *Increase outdoor air ventilation (disable demand-controlled ventilation and open out-door air dampers to 100% as indoor and outdoor conditions permit).*
- *Improve central air and other HVAC filtration to MERV-13 (ASHRAE 2017b) or the highest level achievable.*
- *Keep systems running longer hours (24/7 if possible).*
- *Add portable room air cleaners with HEPA or high-MERV filters with due consideration to the clean air delivery rate (AHAM 2015).*
- *Add duct- or air-handling-unit-mounted, upper room, and/or portable UVGI devices in connection to in-room fans in high-density spaces such as waiting rooms, prisons, and shelters.*
- *Maintain temperature and humidity as applicable to the infectious aerosol of concern.*
- *Bypass energy recovery ventilation systems that leak potentially contaminated exhaust air back into the outdoor air supply.*

https://www.ashrae.org/technical-resources/resources

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What is ASHRAE saying regarding HVAC systems?

Generally speaking,

- ***Increase ventilation***
- ***Better Filtration***

But can your existing systems can handle this?

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Re-opening Facilities
General HVAC/Building Operation

- Before occupants return, have a licensed professional assess for mold and excess moisture.
  - If moisture infiltration and/or microbial growth is detected, address the source of moisture first. Clean-up and remediation should be conducted before the building is reoccupied in accordance with current professional and governmental standards.
- After an assessment has confirmed that moisture and/or microbial growth are not detected, OR after remediation has been completed, a building HVAC system that has not been active during a prolonged shutdown should be operated for at least 48 to 72 hours (known as a "flush out" period) before occupants return.
  - During this period, open outdoor air dampers to the maximum setting that still allows proper indoor air temperatures and relative humidity levels to be maintained as noted per ASHRAE standards
  - It is not recommended to incorporate extreme setbacks for thermostat setpoints during this time when the building is unoccupied.
  - Continue the "flush out" process until no odors are apparent.
  - The condition of HVAC filters used during the "flush out" period should be carefully assessed prior to building occupancy and replaced with new or clean filters as necessary.

Re-opening Facilities
General HVAC/Building Operation

- Ensure that custodial staff's scope includes proper cleaning procedures built from EPA and CDC guidance on approved products and methods:
  - Disinfect high-touch areas of HVAC and other building service systems (e.g. thermostats)
- In buildings with operable windows, only if the outside air temperature and humidity are moderate, open all windows for two hours minimum before the reoccupation. Close windows before operation of the HVAC system.
- Review HVAC programming to provide flushing two hours before and post occupancies. This includes operating the exhaust fans as well as opening the outside air dampers. Run the system on minimum outside air when unoccupied.
- Install signage to encourage tenants to use a revolving door, if any, rather than opening swing doors in lobby area.
- After a building is reopened and occupied, routine (e.g., weekly) checks of the HVAC system are recommended to ensure operating efficiency.

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Re-opening Facilities
Airside Systems

- Verify the HVAC system is operational and that the building overall is under "positive pressure."
- Check to make sure the dampers (outside and return) are working properly to control the outdoor (fresh) air to the building.
- Remove existing filters and replace them with new. Operator should consider increasing the level of filtration in the Air Handling Units (AHUs) for one or two replacement cycles upon opening the building (minimum MERV-13 preferred). Make sure the air handling systems and fans can overcome the additional pressure drop of the new filters and still maintain air flow at acceptable levels.
- In addition to selecting the proper filter and respective filter efficiency, careful consideration and protocols should be employed to removing and disposing of used filters.
- If higher filtration is not available at the specific air handling units due to limited capacity, portable units in the high-traffic areas may be used for a few months.

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Re-opening Facilities

Cooling / Heating Systems

Cooling systems

- Check the refrigerant pressures to make sure the system is adequately charged.
- Check the water quality in the systems and add chemicals as needed.
- Check coil leaving air temperatures to make sure the systems are providing dehumidification.
- Check the water levels and make-up water source for cooling towers to ensure they are available.
- Check pump operation and that water is flowing.

Heating System

- Check the fuel source to make sure it is on and available. Old fuel oil may need to be replaced.
- Confirm that the flues and make-up air paths are open prior to engaging boilers.
- Check that the coil actuators are controlling to temperature, or that heating elements are turned on at the disconnect.
- If boiler systems were shut down, follow state boiler codes and the manufacturer's written instructions for starting up, and bring hot water and steam heating systems and plants back online.

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Re-opening Facilities

HVAC Controls and Water Delivery Systems

Building Automation System / Controls

- Check that the devices and sensors are within an acceptable calibration for controlling space comfort and ventilation.
- Check that battery (or generator) backup power is working and any alarms are set up and their communication path is correct (it is notifying the right person).

Water Delivery Systems

- If one is not currently implemented, consider implementing a water risk management plan.
- Turn on the water and run the drinking fountains, lavatories, urinals, water closets, and pantries to ensure water quality before usage.
- Make sure all P and U-traps on plumbing drains are wet.
- Distributed domestic hot water systems - if possible, keep these systems circulating. Keep water above 140°F to avoid microbial incursion. Do not let it drop below 120°F. If circulation was stopped, try to circulate once every two weeks for two hours at temperature. If the hot water recirculating system goes down for extended duration, do a high temperature flush and pull the strainers before going back online.

Increasing Outdoor Air Ventilation - Concerns

Increasing outdoor air ventilation will:

- Increase the mixed air temperature being delivered to the cooling coil
- Increase the supply air temperature leaving the AHU and delivered into the space along with any excess moisture the AHU system was not able to remove
- Increase building pressurization so exhaust quantities may need to be adjusted
- Excess moisture can make occupants feel uncomfortable and lead to condensation/moisture issues leading to microbial growth if not corrected.

Before implementing, verify the existing system can accommodate

Increasing Outdoor Air Ventilation - Concerns

If system has been verified it can handle additional outdoor air ventilation:

- Verify that insulation around ductwork, air devices, piping and air handling equipment is properly installed
- Insulation surrounding building envelope areas including attic spaces should be checked for proper consistent installation throughout and repaired/reinstalled as necessary

Increasing Outdoor Air Ventilation - Concerns

If system utilizes a plenum:

- Consider a fully ducted system, even temporary
- Do not directly add outdoor air ventilation to a plenum space, like above a ceiling, without being conditioned
- If possible, duct outdoor air directly to return plenum opening of AHUs

Increasing Filtration - Concerns

Minimum Efficiency Reporting Value (MERV) is a rating (on a scale from 1 to 20) developed by ASHRAE on the efficiency of the filter to trap airborne particles. For reference, clean room HEPA and ULPA filters are rated at between MERV 17 and 20.

Hospital facilities – typically MERV 15 and above
Most residential – MERV 3 to 7
Most Commercial – MERV 7 to 10

<u>MERV-13: Approximately 90% efficiency for airborne droplets</u>

Standard 52.5 Minimum Efficiency Reporting Value	Dust Spot Efficiency	Arrestance	Typical Controlled Contaminant	Typical Applications and Limitations	Typical Air Filter/Cleaner Type
20	n/a	n/a	< 0.30 pm particle size	Cleanrooms	≥99.999% eff. On .10-.20 pm Particles
19	n/a	n/a	Virus (unattached)	Radioactive Materials	Particles
18	n/a	n/a	Carbon Dust	Pharmaceutical Man.	Particulates
17	n/a	n/a	All Combustion smoke	Carcinogenetic Materials	>99.97% eff. On .30 pm Particles
16	n/a	n/a	.30-1.0 pm Particle Size	General Surgery	**Bag Filter**- Nonsupported
15	>95%	n/a	All Bacteria	Hospital Inpatient Care	microfine fiberglass or synthetic media, 12-36 in. deep, 6 12 pockets
14	90-95%	>98%	Most Tobacco Smoke	Smoking Lounges	**Box Filter**- Rigid Style Cartridge Filters 6 to 12" deep m ay use
13	89-90%	>98%	Proplet Nuceli (Sneeze)	Superior Commercial Buildings	lofted or paper media.
12	70-75%	>95%	1.0-3.0 pm Particle Size Legionella	Superior Residential	**Bag Filter**- Nonsupported microfine fiberglass or synthetic media, 12-36 in. deep, 6 12 pockets
11	60-65%	>95%	Humidifier Dust Lead Dust	Better Commercial Buildings	**Box Filter**- Rigid Style Cartridge Filters 6 to 12" deep m ay use lofted or paper media.
10	50-55%	>95%	Milled Flour Auto Emissions	Hospital Laboratories	
9	40-45%	>90%	Welding Fumes		
8	30-35%	>90%	3.0-10.0 pm Particle Size	Commercial Buildings	**Pleated Filters**- Disposable, extended surface area, thick with cotton-polyester blend media, cardboard frame
7	25-30%	>90%	Mold Spores Hair Spray	Better Residential	**Cartridge Filters**- Graded density, viscous coated cube or pocket filters, synthetic media
6	<20%	85-90%	Fabric Protector Dusting Aids	Industrial Workplace	**Throwaway**- Disposable synthetic panel filter.
5	<20%	80-85%	Cement Dust Pudding Mix	Paint Booth Inlet	
4	<20%	75-80%	>10.0 pm Particle Size Pollen	Minimal Filtration	**Throwaway**- Disposable fiberglass or synthetic panel filter.
3	<20%	70-75%	Dust Mites Sanding Dust	Residential	**Washable**- Aluminum Mesh
2	<20%	65-70%	Spray Paint Dust		
1	<20%	<65%	Textile Fibers Carpet Fibers	Window A/C Units	**Electrostatic**- Self charging woven panel filter.

Increasing Filtration - Concerns

Increasing filter efficiency:

- Will increase the static pressure or resistance of the system
- Will decrease the velocity across the filter
- Will decreases the total airflow being delivered
- May freeze coils if velocity is too low
- Require the fan to work harder to make-up the losses
  - Note smaller systems may not have fan capacity to do so
- Have a licensed mechanical engineer or professional verify the existing system can accommodate

Other Considerations and Concerns

Keeping Systems running longer:

- Increases energy usage – analyze cost versus health benefit
- Potential for overcooling the space.
- Adjusting control settings, namely night setback settings, may assist

Portable Room Air Cleaners with HEPA filters:

- May provide benefit but no current data to support if benefit outweighs the cost

Other Recommendations:

- Consider the addition of "touchless" interactions where applicable.
- Consider future upgrades to equipment and controls to incorporate some of the HVAC strategies to mitigate transmission of viruses.

Other Considerations and Concerns – UVGI / Bi-polar Ionization

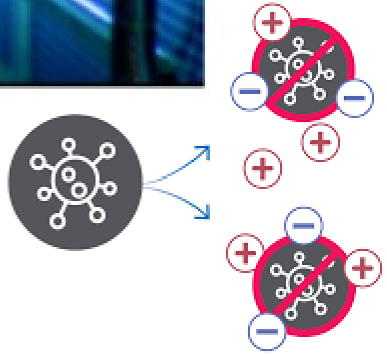
ASHRAE's Position

Regarding UVGI (ultraviolet germicidal irradiation) strategies:

"While UVGI is well researched and validated, many new technologies are not. ASHRAE's PD itself does not make a recommendation for or against the use of UV energy in air systems for minimizing the risks from infectious aerosols; however, the CDC has approved UVGI as an adjunct to filtration for reduction of tuberculosis risk and has published a guideline on its application."

Regarding bi-polar ionization strategies:

- *Systems are reported to range from ineffective to very effective in reducing airborne particulates and acute health symptoms.*
- *Convincing scientifically-rigorous, peer-reviewed studies do not currently exist on this emerging technology; manufacturer data should be carefully considered.*
- *Systems may emit ozone, some at high levels. Manufacturers are likely to have ozone generation test data.*



ASHRAE Position Document on Infectious Aerosols, Section 3.2.
https://www.ashrae.org/technical-resources/filtration-disinfection

Additional Resources

American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE)
https://www.ashrae.org/technical-resources/resources

Centers for Disease Control
https://www.cdc.gov/coronavirus/2019-ncov/index.html
https://www.cdc.gov/coronavirus/2019-ncov/php/building-water-system.html
https://www.cdc.gov/legionella/wmp/toolkit/index.html

United States Environmental Protection Agency
https://www.epa.gov/coronavirus
https://www.epa.gov/sites/production/files/2020-05/documents/final_maintaining_building_water_quality_5.6.20-v2.pdf
https://www.epa.gov/sites/production/files/2020-05/documents/final_checklist_for_maintaining_building_water_quality_5-6-2020.pdf?_ga=2.96967903.1136673869.1591027116-219983195.1590669390

World Health Organization
https://www.who.int/emergencies/diseases/novel-coronavirus-2019/technical-guidance

Association of State Drinking Water Administrators
https://www.asdwa.org/covid19/

Additional Resources

American Industrial Hygiene Association (AIHA)
https://aiha-assets.sfo2.digitaloceanspaces.com/AIHA/resources/Public-Resources/RecoveringFromCOVID-19BuildingClosures_GuidanceDocument.FINAL.pdf?_ga=2.63762799.1136673869.15910271162199831 95.1590669390

U.S. Department of Labor
https://www.osha.gov/SLTC/covid-19/controlprevention.html#solidwaste

International Association Plumbing and Mechanical Officials
https://www.iapmo.org/ibu/whats-new/coronavirus-resources

Water Resources Foundation
https://www.waterrf.org/event/impact-prolonged-shutdown-buildings-water-quality-perspective

Water Environment Federation
https://www.wef.org/coronavirus?_ga=2.87472472.1136673869.1591027116-219983195.1590669390#trusted

American Water Works Association (AWWA)
https://www.awwa.org/Resources-Tools/Resource-Topics/Coronavirus#10681543-shutoffs-and-return-to-service-guidance

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Links to Published Article

https://vertexeng.com/insights/vertexs-scott-katzer-discusses-covid-19-recommendations-for-hvac-systems/ (Full paper here)

https://vertexeng.com/insights/hvac-system-considerations-in-the-covid-19-era-part-1-cdc-and-ashrae-guidelines/

https://vertexeng.com/insights/hvac-system-considerations-in-the-covid-19-era-part-2-increasing-outdoor-air-ventilation/

https://vertexeng.com/insights/hvac-system-considerations-in-the-covid-19-era-part-3-increasing-filtration/

https://hvacinsider.com/discussing-covid-19-cdc-guidelines-for-hvac-systems/

https://www.achrnews.com/articles/143009-discussing-the-cdc-and-ashrae-recommendations-for-hvac-systems

https://www.esmagazine.com/articles/100336-discussing-the-cdc-and-ashrae-recommendations-for-hvac-systems

HVAC 101

STANDARD RESIDENTIAL AC and FURNACE UNIT

By adding a cooling coil and a means for delivering cold fluid to it, the conventional furnace becomes a conventional – SPLIT SYSTEM.

INSIDE UNIT (AIR HANDLER)

Ductwork Return Air

Filter Section

Blower fan/motor

Heating section (electric, gas or hot water)

Cooling Coil (refrigerant evaporator or chilled water)

Flue (for combustion furnaces) - exhaust

Condensate Management

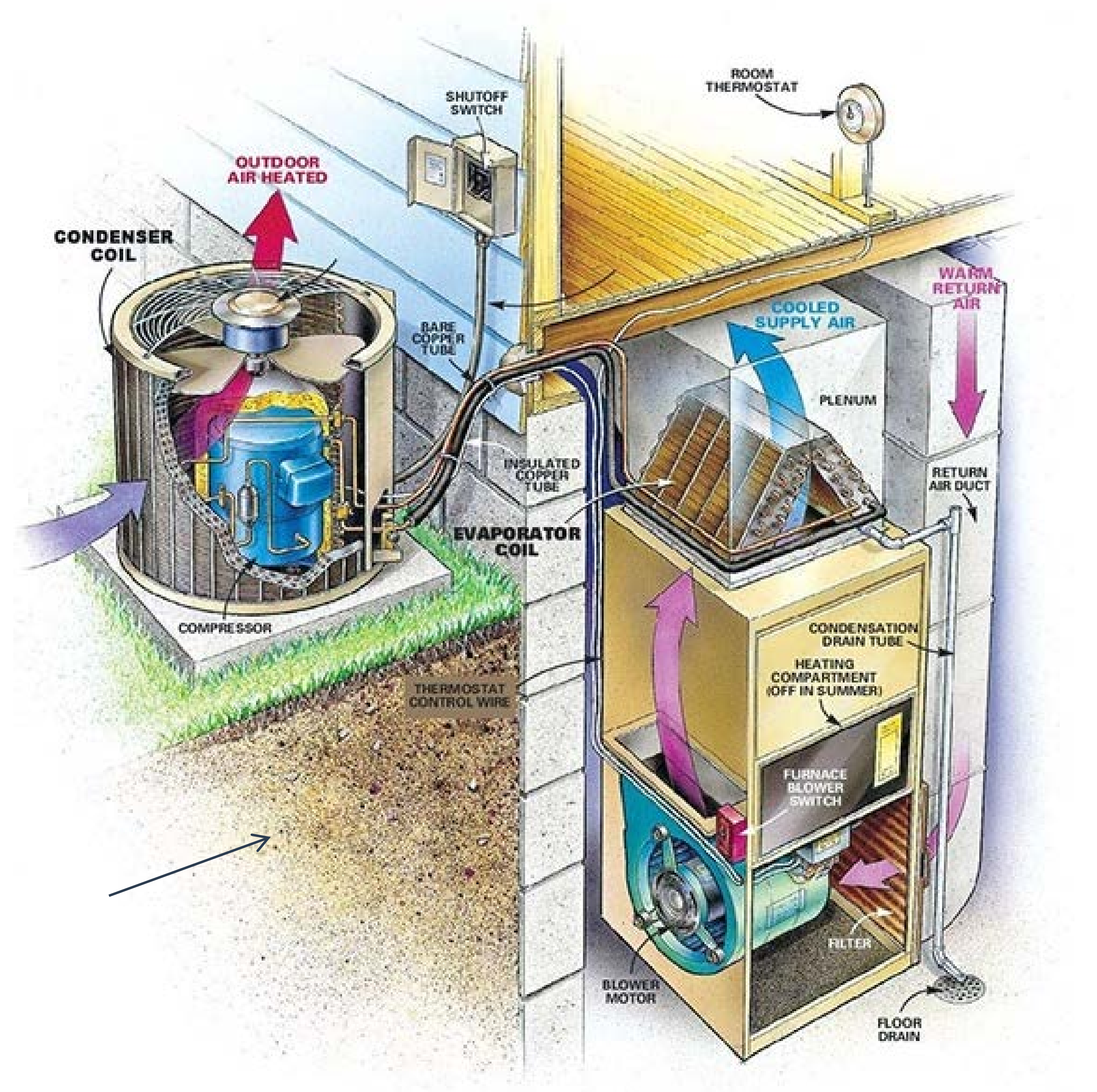
Ductwork for Supply Air

OUTSIDE UNIT (CONDENSER)

Compressor

Coil

Blower Fan



Video: Basics of the refrigeration cycle

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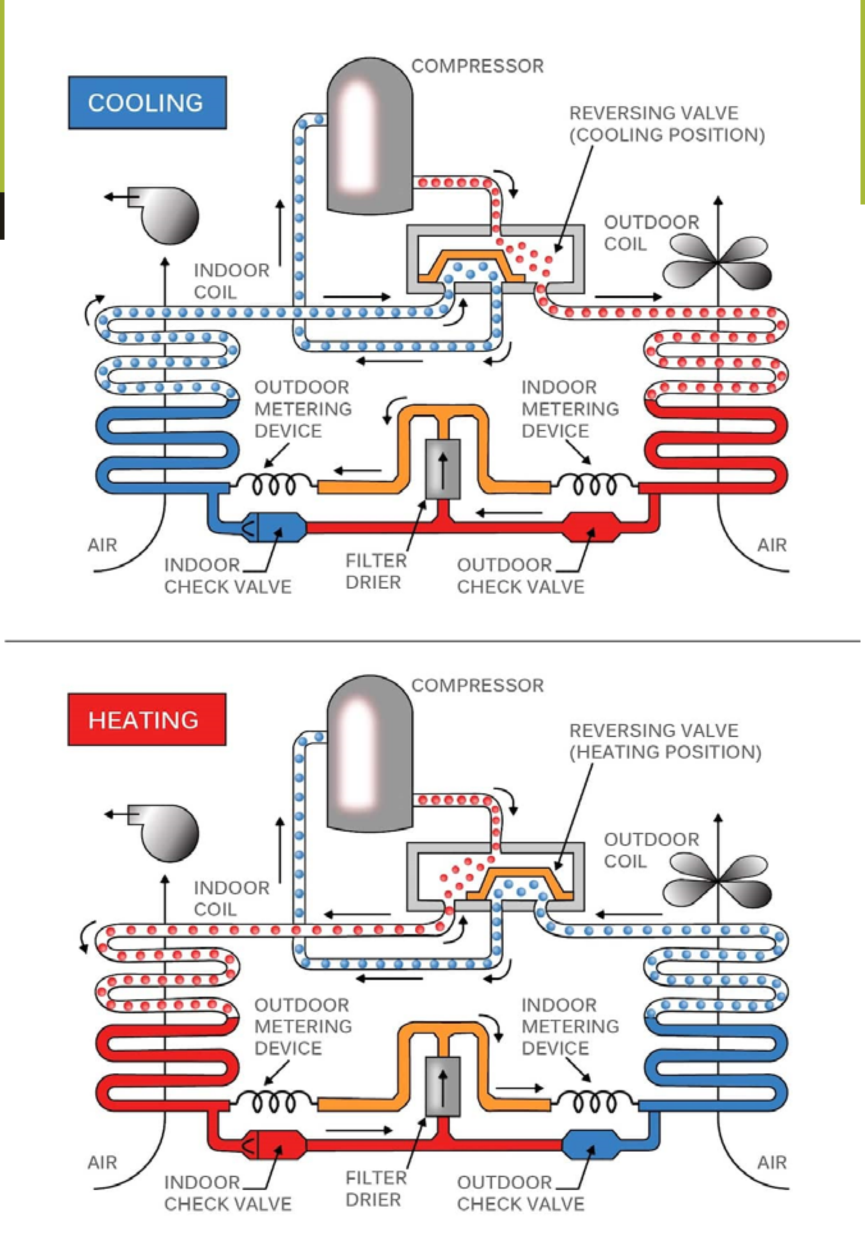
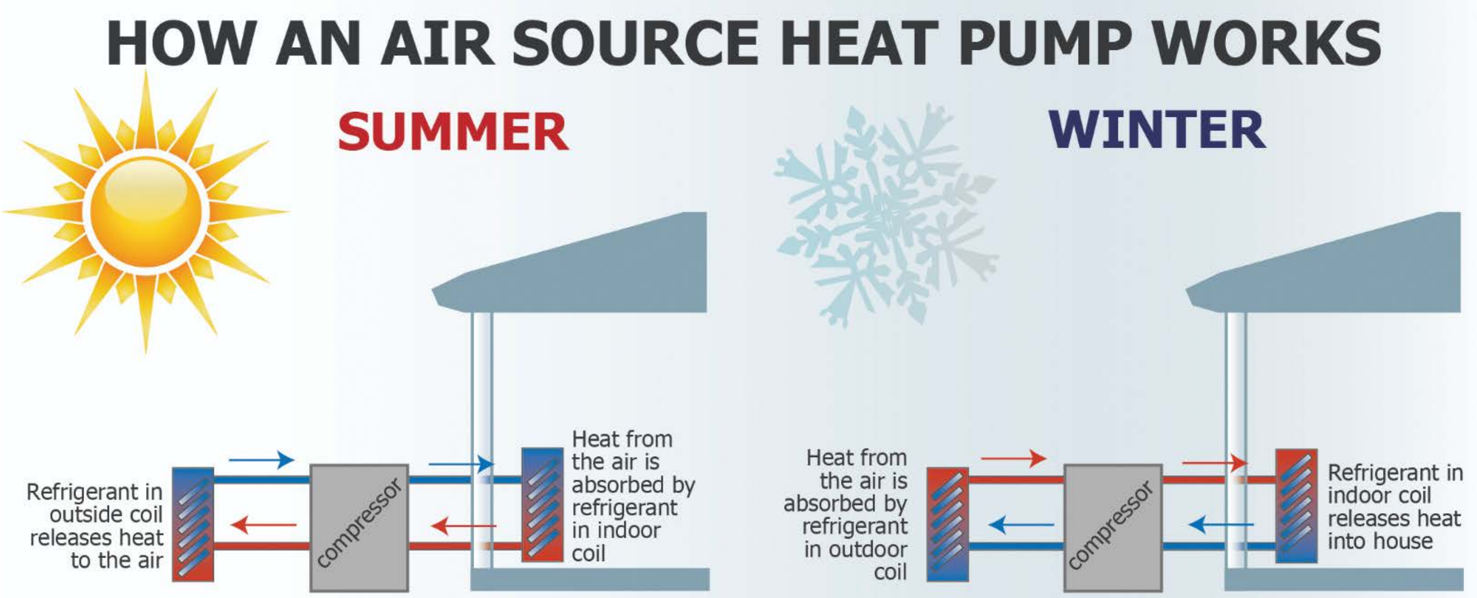
Condensing unit versus Heat Pump

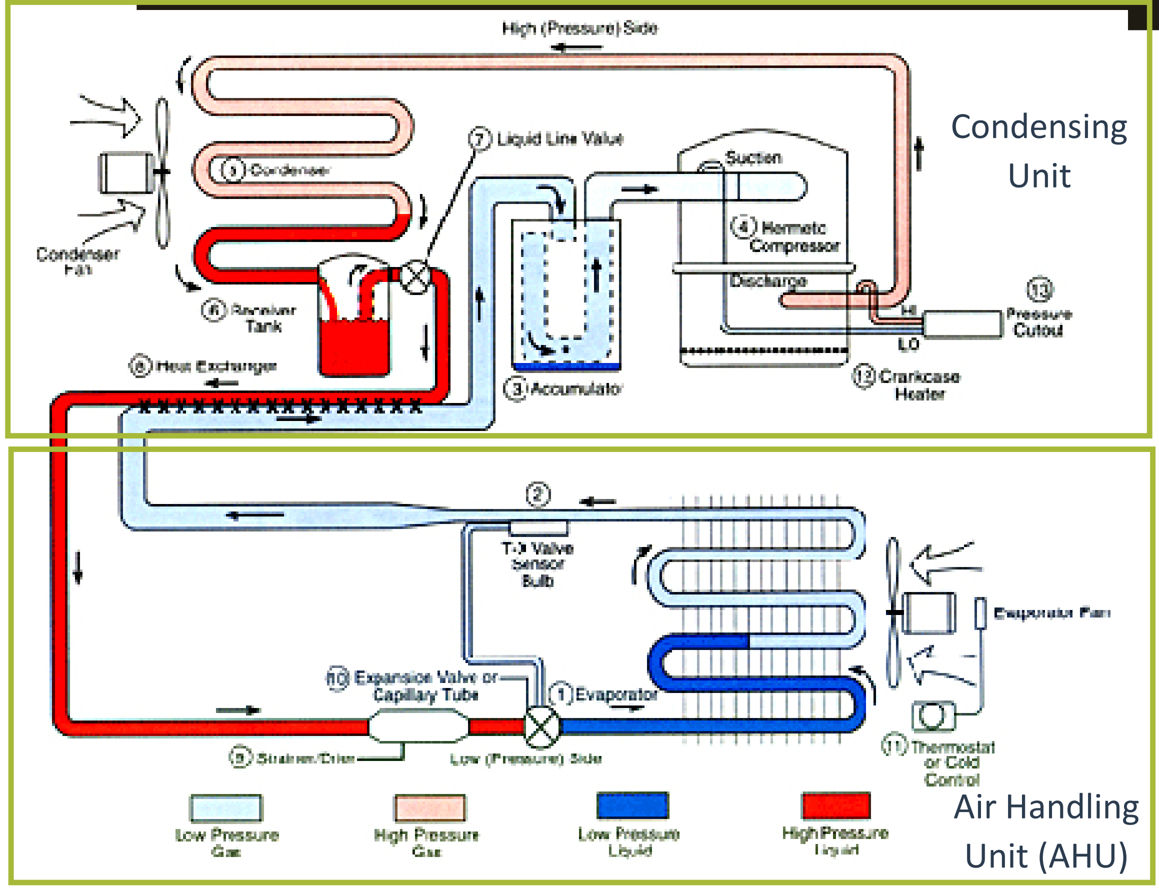
- Going to be difficult to tell the two apart just by observation. Need to get model information
- Both Condensing and heat pump equipment can be air or water cooled (from a cooling tower or well)
- Some heat pumps do not have a heating element at the AHU since heating can be achieved via the reversing valve (but some may)

Heat Pumps can operate in reverse cycle meaning they can both heat and cool. Condensing units can only cool

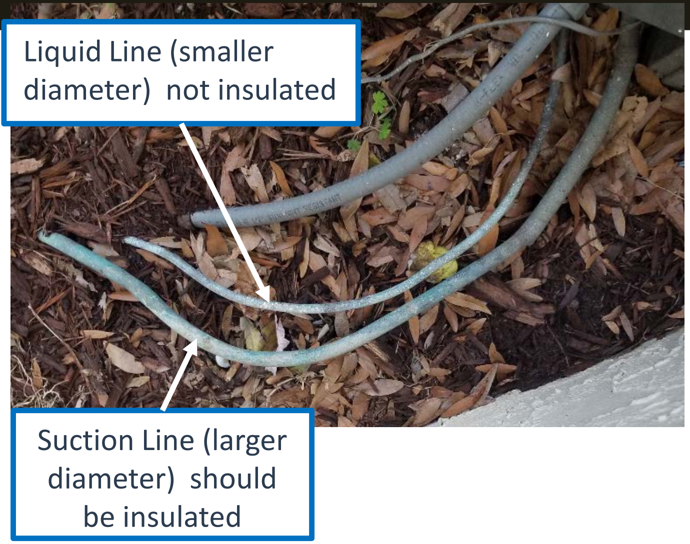


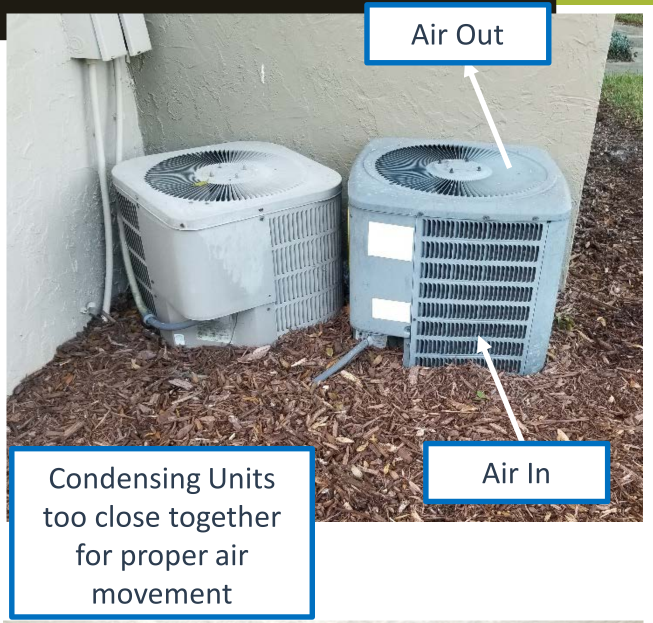


HVAC – Split (DX) System



Refrigeration Cycle





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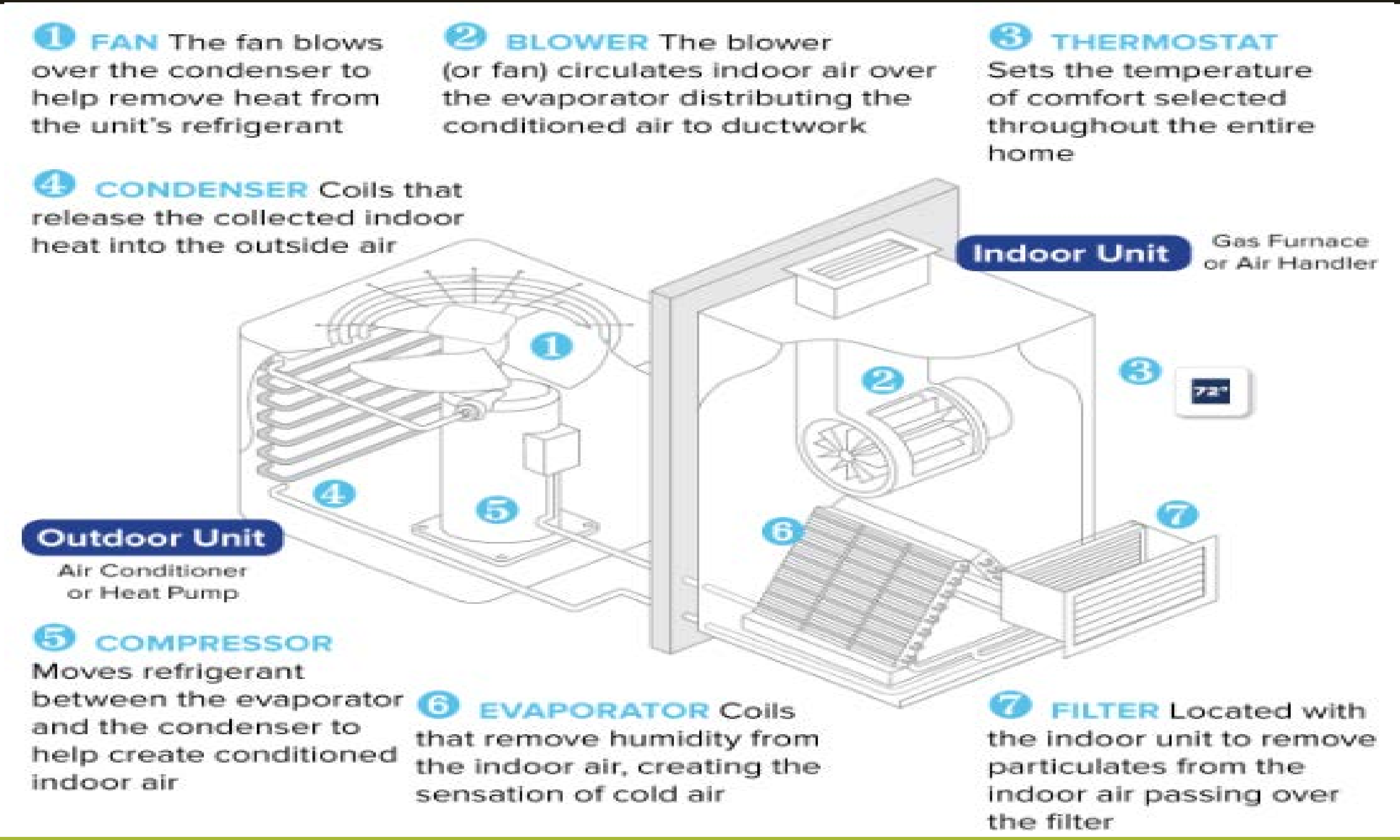
HVAC – Split (DX) System



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PACKAGE UNIT
(ROOF OR GROUND)

This is a typical package unit. It is an outside unit located on the ground or on a roof. All of the components of a split system are combined in the same outdoor unit, except for the ductwork.

Ductwork Return Air

Economizer Fresh Air

Mixing Chamber

Filter Section

Blower fan/motor

Heating section (electric, gas or hot water)

Flue (for combustion furnaces) - exhaust

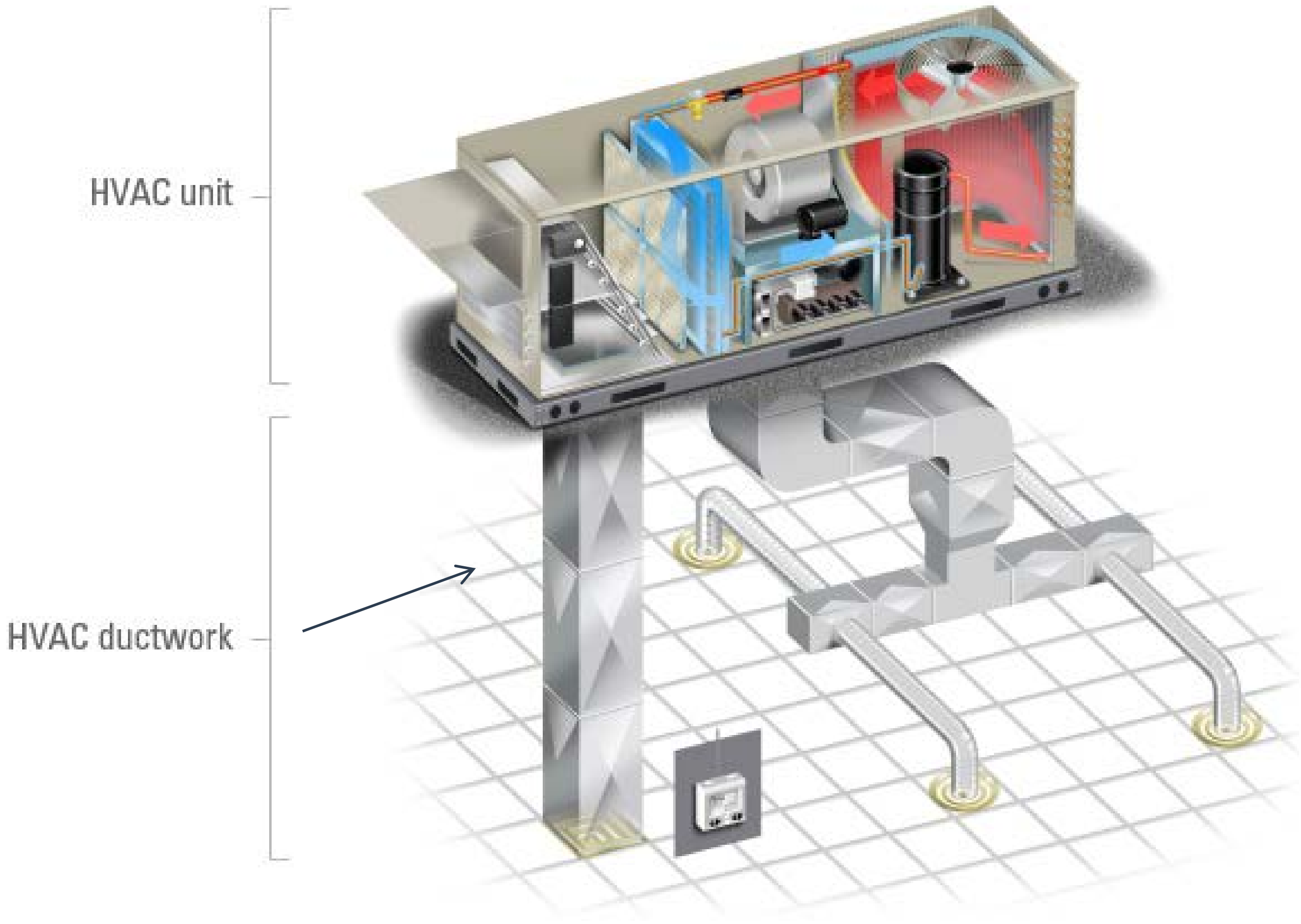
Cooling Coil (refrigerant evaporator or chilled water)

Compressor

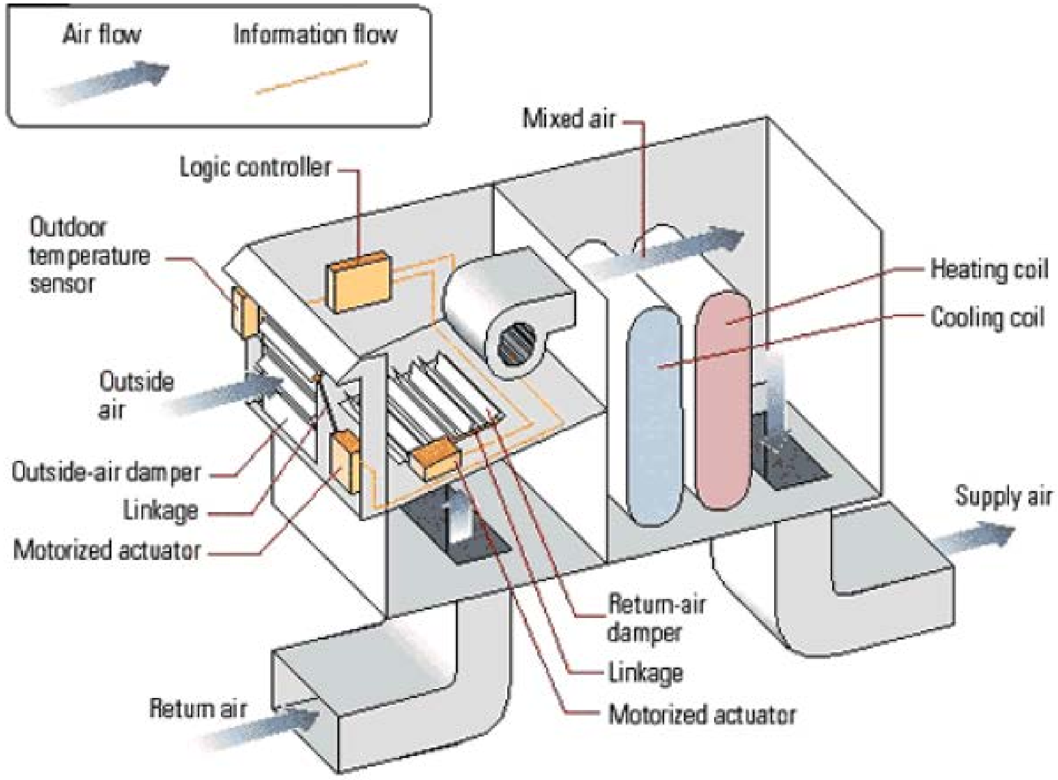
Compressor Fan

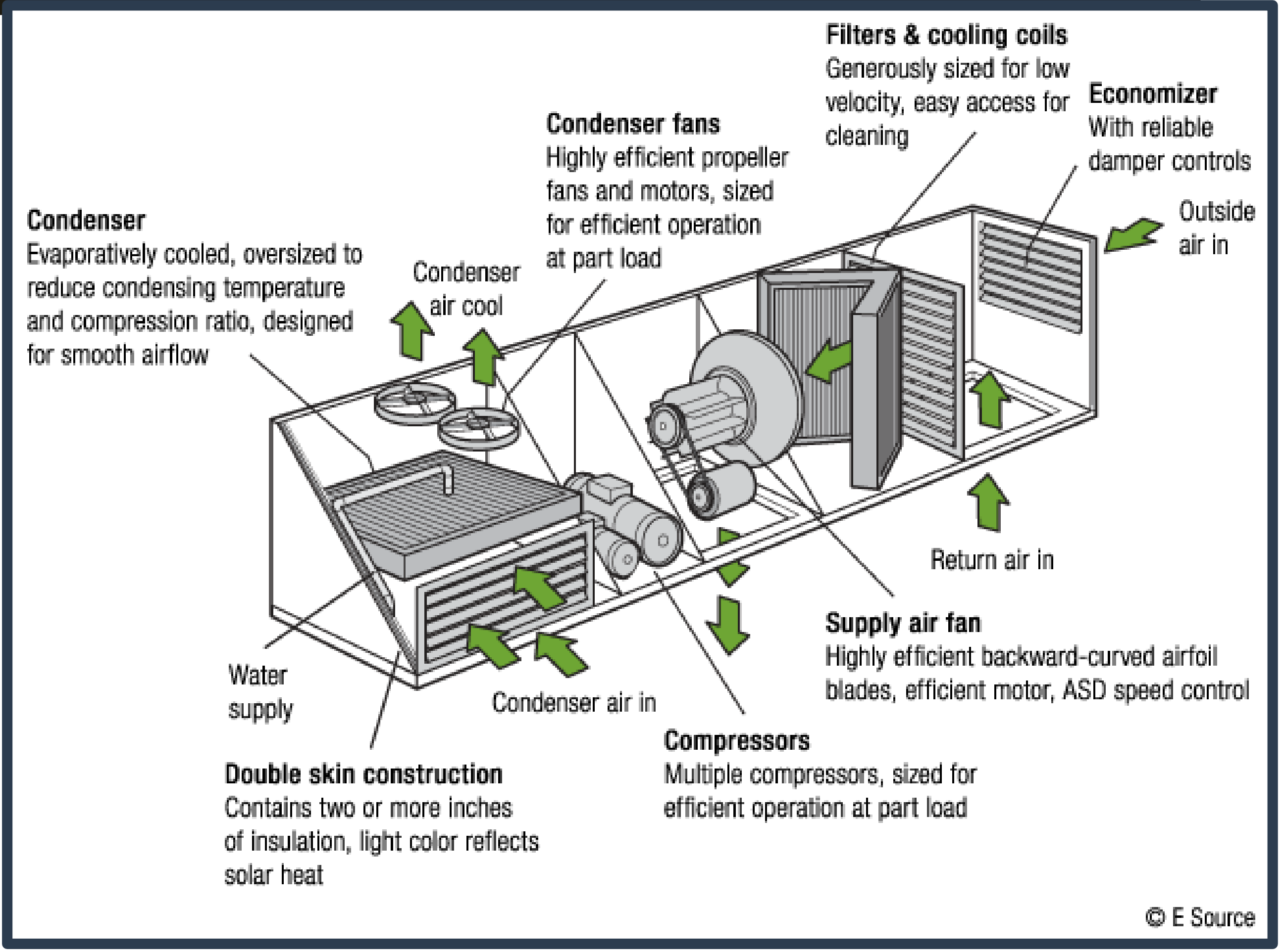
Condensate Management

Ductwork for Supply Air



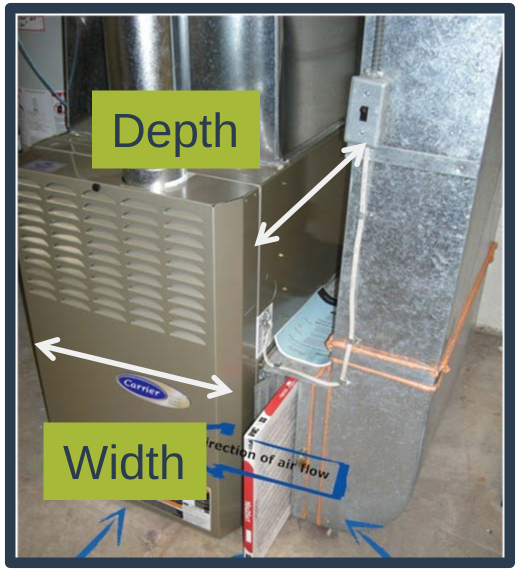
HVAC





- Cooling
  - Central chiller
  - Water cooled or air cooled
  - Water cooled requires cooling tower or heat rejection

Mechanical Issues



MECHANICAL – WHAT IF NO NAMEPLATE DATA

1. **Measure width and height of unit (width and depth of indoor unit) to get approximate coil size (in sq. ft)**
2. **Multiply by 500 feet per minute to get cubic feet per minute (cfm)**
3. **Determine type of building and approximate as follows:**
   a. Most Commercial facilities, rooftop units – 325 cfm per ton
   b. Most Residential Buildings, interior apartment units – 450 cfm per ton

Example: Rooftop unit on warehouse building

1. **Measured 36" high by 50" wide = 1,800 sq. in = 12.5 sq. ft.**
2. **12.5 x 500 = 6,250 cfm**
3. **Assume 325 cfm/ton, therefore = 6250/325 = 19.2 tons (say 15-25 tons as range)**

DISCLAIMER!!!!!!

1. **Only to be used as an estimate. Never use if need definitive answer**
2. **Can only be used on recirculating air handling units. Cannot be used for chillers, cooling towers, condensing units, boilers, etc.**
3. **Cannot be used for 100% outdoor air handling units. (May need to ask owner representative if cannot determine)**

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AIR HANDLING EQUIPMENT

Interior unit equipped with a filter, fan, and heating and/or cooling coils
Heating coils can be hot water, steam, electric, natural gas
Cooling coils can be refrigerant or chilled water, glycol

CHILLERS – Air Cooled

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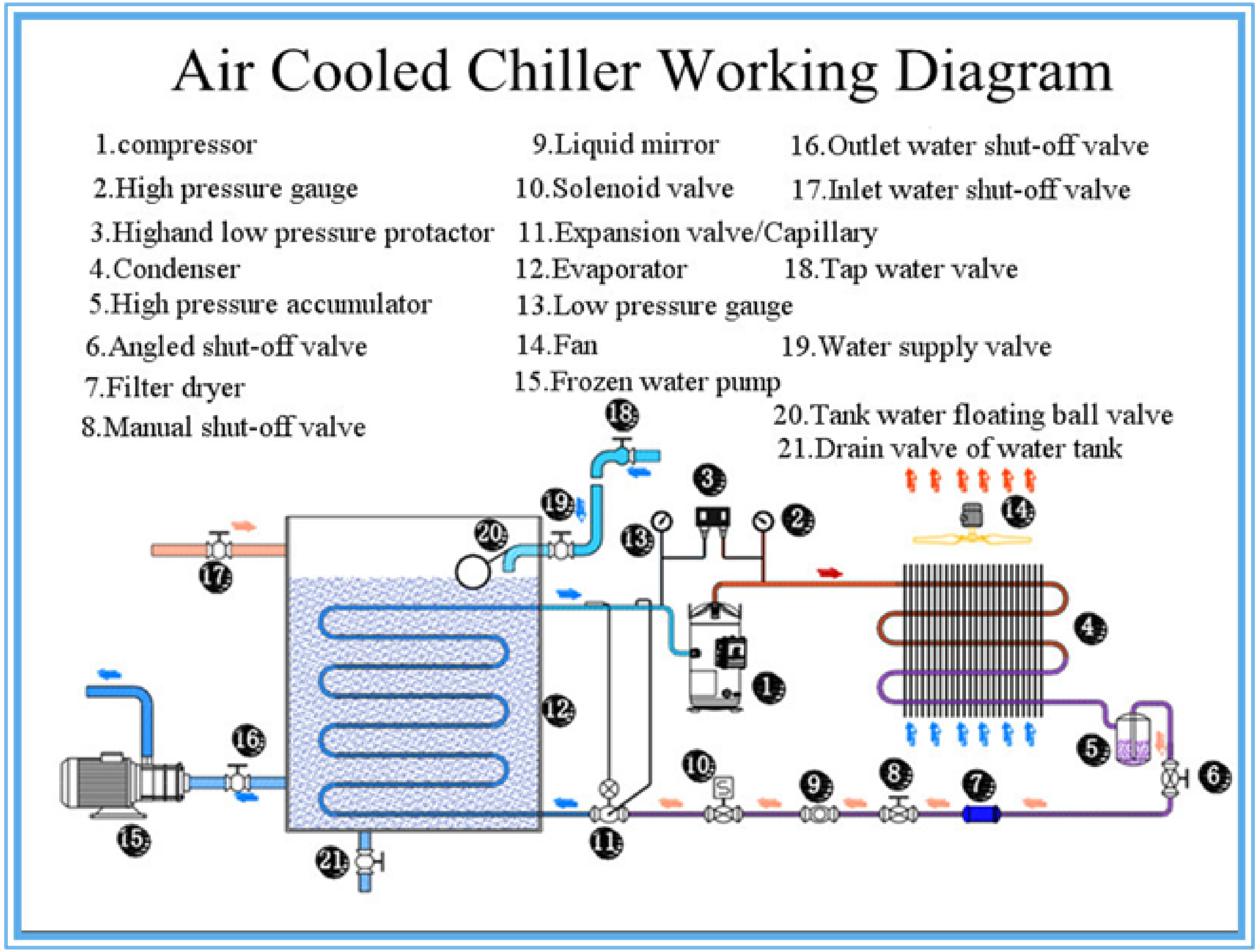
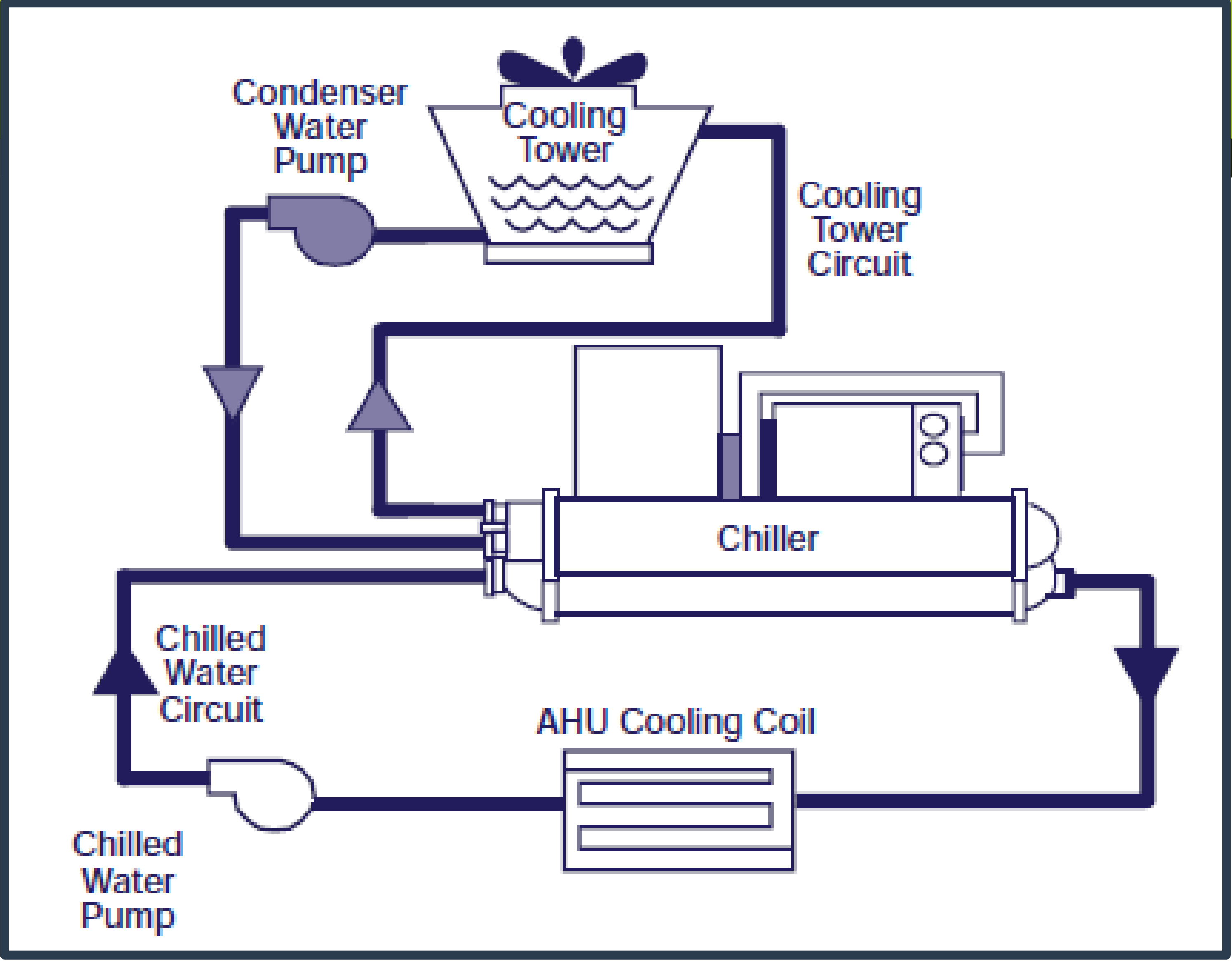

Air Cooled Chiller Working Diagram
1.compressor
2.High pressure gauge
3.Highand low pressure protactor
4.Condenser
5.High pressure accumulator
6.Angled shut-off valve
7.Filter dryer
8.Manual shut-off valve
9.Liquid mirror
10.Solenoid valve
11.Expansion valve/Capillary
12.Evaporator
13.Low pressure gauge
14.Fan
15.Frozen water pump
16.Outlet water shut-off valve
17.Inlet water shut-off valve
18.Tap water valve
19.Water supply valve
20.Tank water floating ball valve
21.Drain valve of water tank

CHILLERS – Water Cooled

HVAC

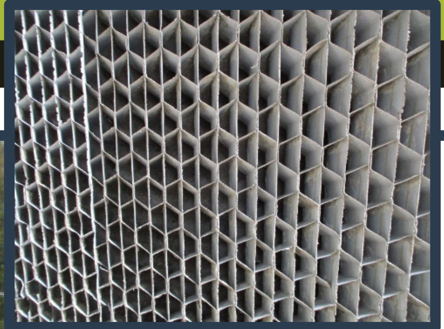
CHILLERS – Water Cooled
Working with Cooling Tower and AHUs

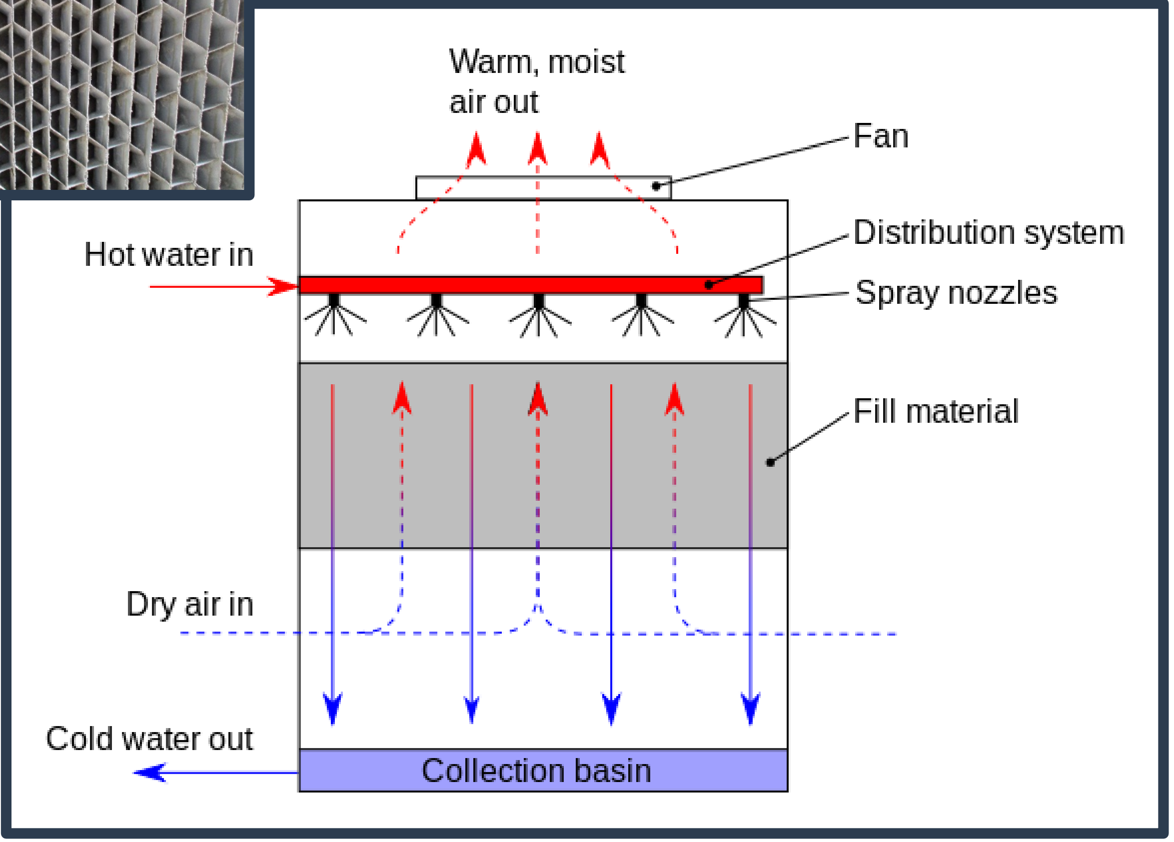


COOLING TOWERS

Forced draft type cooling tower – fans blowing thru condenser coils

COOLING TOWERS





Induced draft type cooling tower – fans drawing air across condenser coils (more common)

Pumps – Chiller, Hot Water, Condenser (Cooling Tower)

Base Mounted Chilled Water Pump
(Chilled Water Pumps usually insulated;
Condenser water pumps are not)

Base Mounted Hot Water Pump
to AHUs (from boiler or heat
Exchanger – usually insulated but some may not)

Pumps – Chiller, Hot Water, Condenser (Cooling Tower)

Inline – Motor may be vertical or horizontal

Split Case – Horizontal or Vertical depending on position of inlet/outlets

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BOILERS


Condensing Boilers

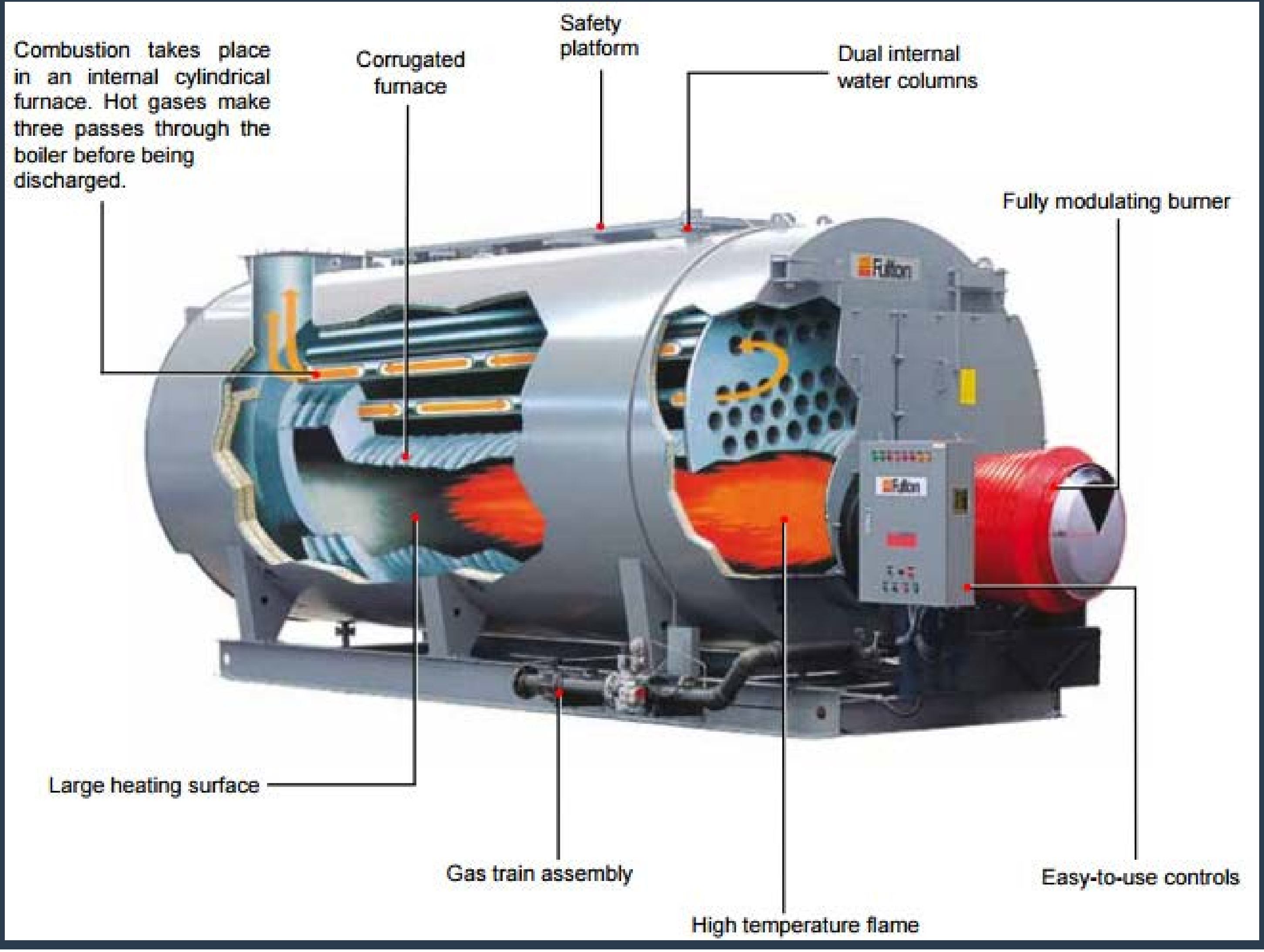
Types:
- Modular
- Condensing
- Cast Iron
- Fire Tube

Boilers fueled by electric, natural gas, fuel oil
- Some larger boilers are dual fuel (i.e. Natural gas and fuel oil)

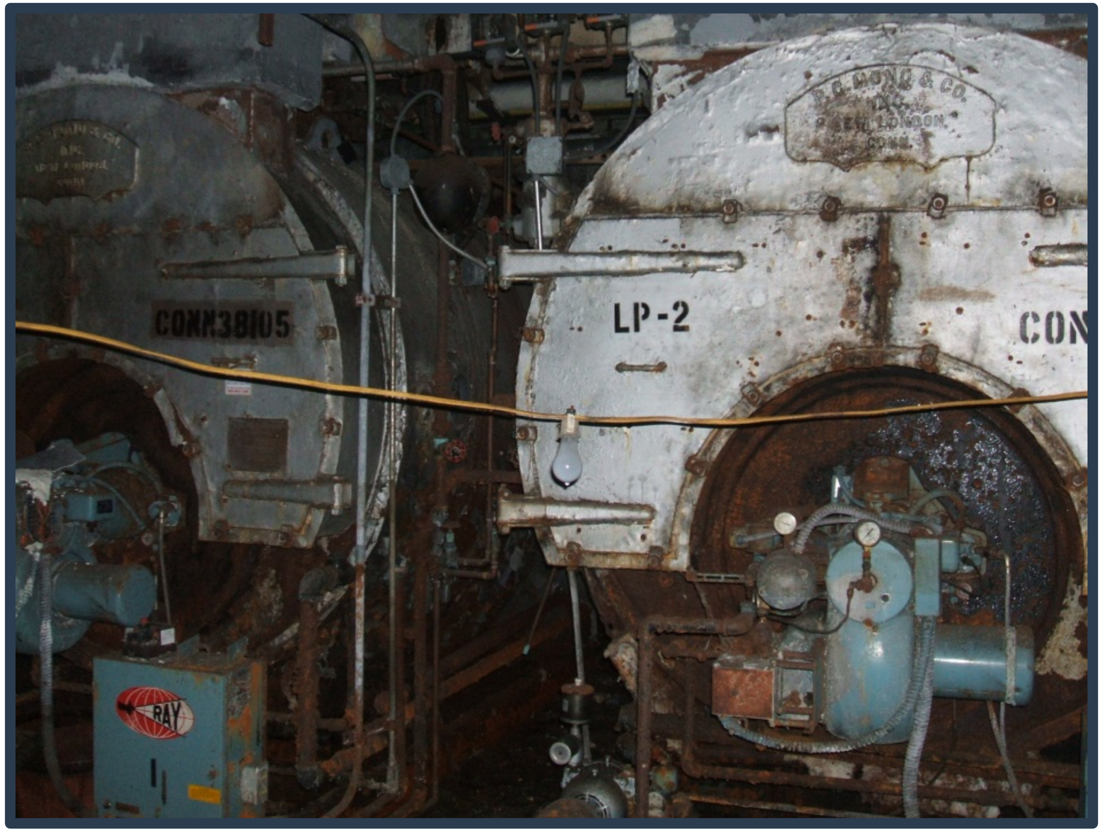
Typically used for:
- Heating Hot Water
- Domestic Hot Water
- Process Heating – i.e. manufacturing

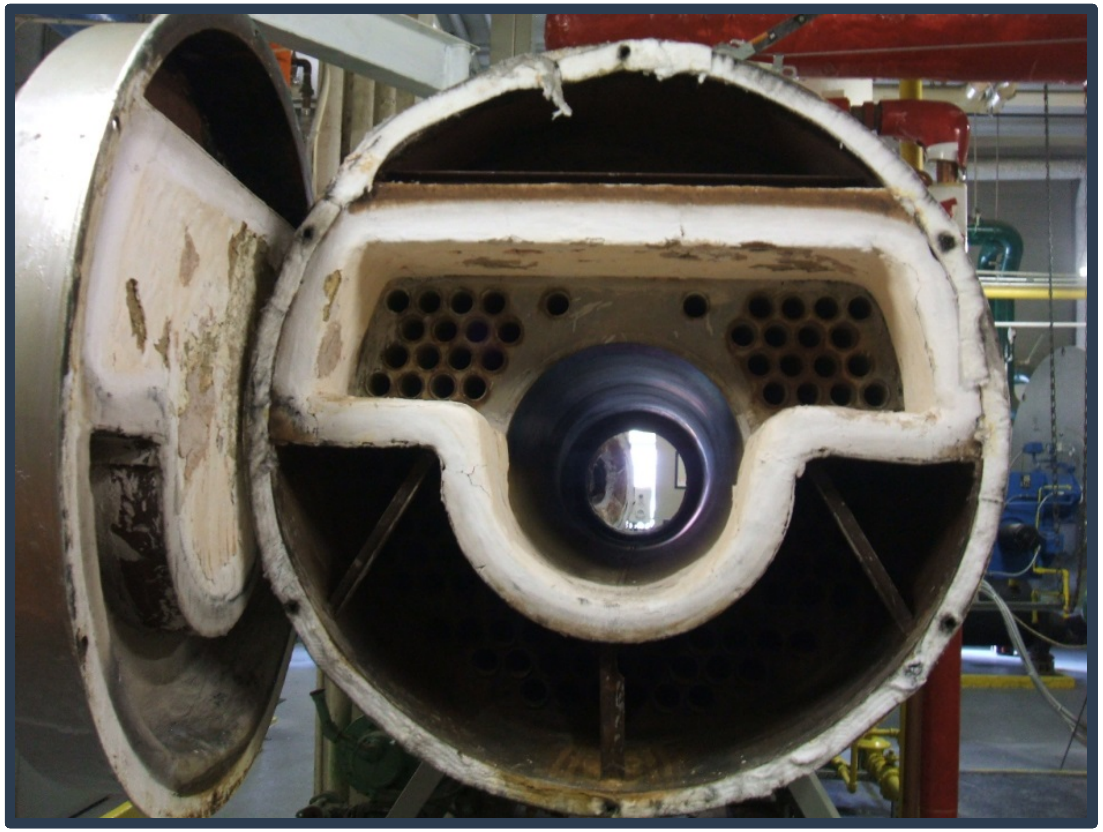
BOILERS - Modular

BOILERS – Fire Tube



BOILERS – Fire Tube





BOILERS – Cast iron

UNIT HEATER

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INFRARED TUBE HEATER

Gas or electric – look for a flue (gas); no flue = electric

RADIANT SPACE HEATING

DIRECT FIRED HEATER

KITCHEN VENTILATION

HVAC CONTROLS

HVAC CONTROLS

Water Vapor Diffusion

(Stop blaming the AC guy!)

Water Losses & More Water Losses

Investigation of Complex Building Water Damage

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Water Vapor Diffusion

- The process by which water vapor spreads or moves through permeable materials caused by differences in water vapor pressure
- Vapor pressure is essentially the portion of atmospheric air pressure attributable to water vapor. The amount of which depends on the atmospheric conditions (i.e. temperature) in which it resides.

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Vapor Diffusion Factors

Exterior Conditions:

• Liquid water from weather/precipitation (i.e. rain, snow, hail)

•Liquid water and/or water vapor from the ground

• Water vapor from the exterior infiltrating into the building (and from interior leaking out of the building)

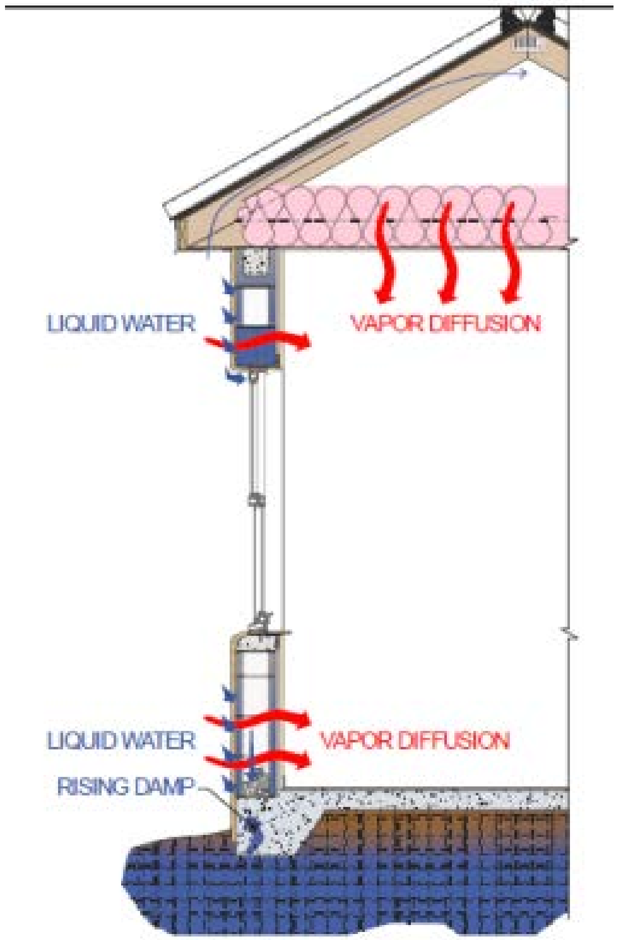
Interior Conditions:

• Water vapor from interior leaking out of building via heating, activities and/or processes within the building (i.e. high heat loads)

Building Envelope:

• Insulation Properties

•Quality of Construction



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Water Vapor Diffusion

- Vapor Pressure: Portion of water vapor within air. Amount depends on atmospheric conditions.
  - Warmer air has higher vapor pressure than cooler air
  - Higher vapor pressure moves toward areas with lower vapor pressure
  - Natural tendency of air to move from warm to cold. Process is called “Diffusion”
- Can occur if a space is both too warm AND too cold

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Specific vs. Relative Humidity

- Specific Humidity (sometimes referred to as Absolute Humidity) is the specific amount of moisture air can hold at a particular environmental condition.
- Relative humidity is the amount of moisture air can hold compared to the maximum amount of moisture the air can hold at a specific temperature.
- Dewpoint temperature is the temperature at which water vapor condenses in the air. (100% RH)

Increasing Outdoor Air Ventilation – Specific vs Relative Humidity

Air Molecule at 60° F

Air Molecule at 90° F

Air at 60° F:

Quantity or specific moisture/humidity = 8 ounces

Relative Humidity = **100%**

(cannot accommodate additional water vapor without condensing)

Air at 90° F:

Quantity or specific moisture/humidity = 8 ounces

Relative Humidity = **50%**

(room for additional moisture)

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What does ASHRAE really say about temperature and humidity?

Two current ASHRAE standards regarding space temperature and humidity relating to interior and comfort levels:

- ASHRAE Standard 55, Thermal Environmental Conditions for Human Occupancy
- ASHRAE Standard 62.1, Ventilation for Acceptable Indoor Air Quality

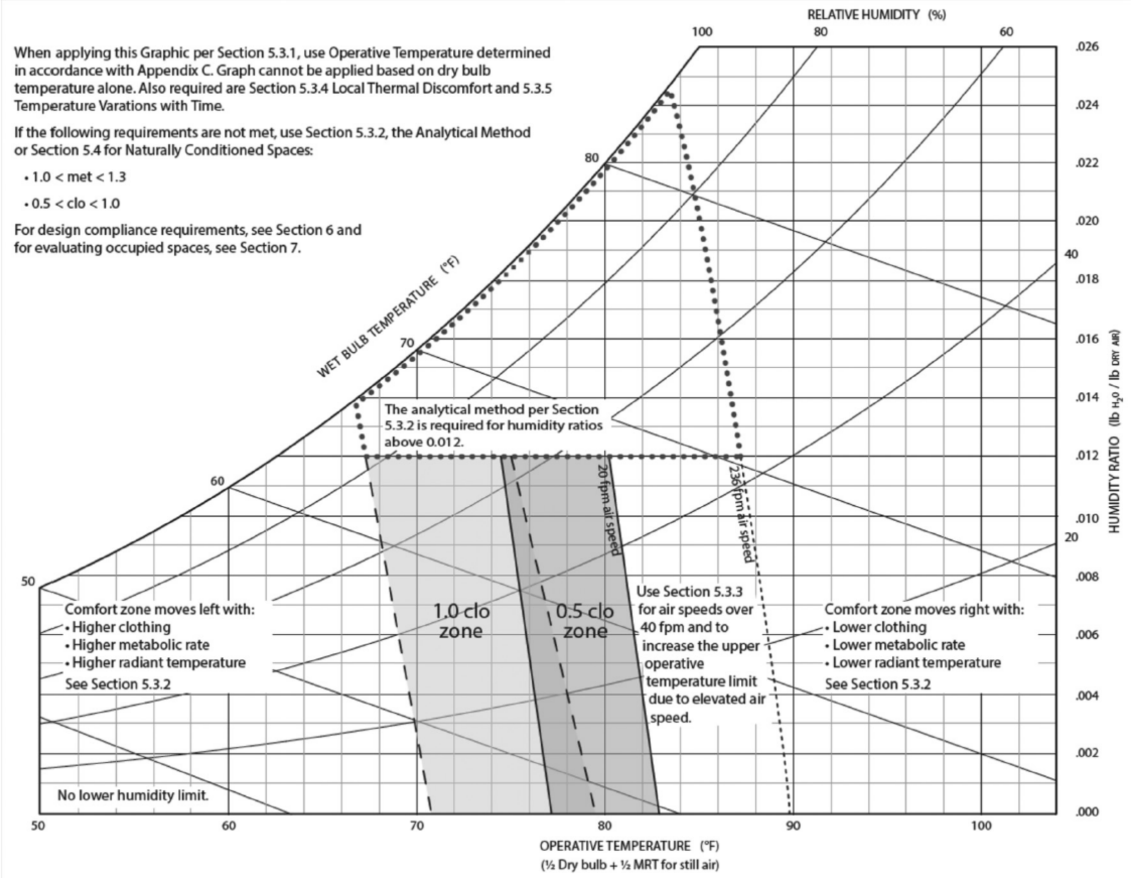
What does ASHRAE really say about temperature and humidity?

ASHRAE Standard 55:

- Does not specifically mention a thermal comfort range.
- Shows only a chart basically saying that interior comfort levels can be as low as 67 degrees F and as high as 83 degrees F depending on clothing, air speed, metabolic rates and radiant temperatures.
- Does not specifically state an actual humidity level to be maintained, only a recommendation that the humidity ratio to be at or below 0.012 lb water /lb dry air which corresponds to a dew point temperature of 62.2 degrees F.
- “No lower humidity limit” for thermal comfort is specifically noted.

What does ASHRAE really say about temperature and humidity?

ASHRAE Standard 55



5.3.1 Graphic Comfort Zone Method

5.3.1.1 Applicability. Use of this method shall be limited to representative occupants with metabolic rates between 1.0 and 1.3 met and clothing insulation (I_{cl}) between 0.5 and 1.0 clo. Average air speed (V_a) greater than 0.2 m/s (40 fpm) requires the use of Section 5.3.3.

The Graphic Comfort Zone is limited to a humidity ratio at or below 0.012 kg·H_2O/kg dry air (0.012 lb·H_2O/lb dry air), which corresponds to a water vapor pressure of 1.910 kPa (0.277 psi) at standard pressure or a dew-point temperature (t_{dp}) of 16.8°C (62.2°F).

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What does ASHRAE really say about temperature and humidity?

ASHRAE Standard 62.1

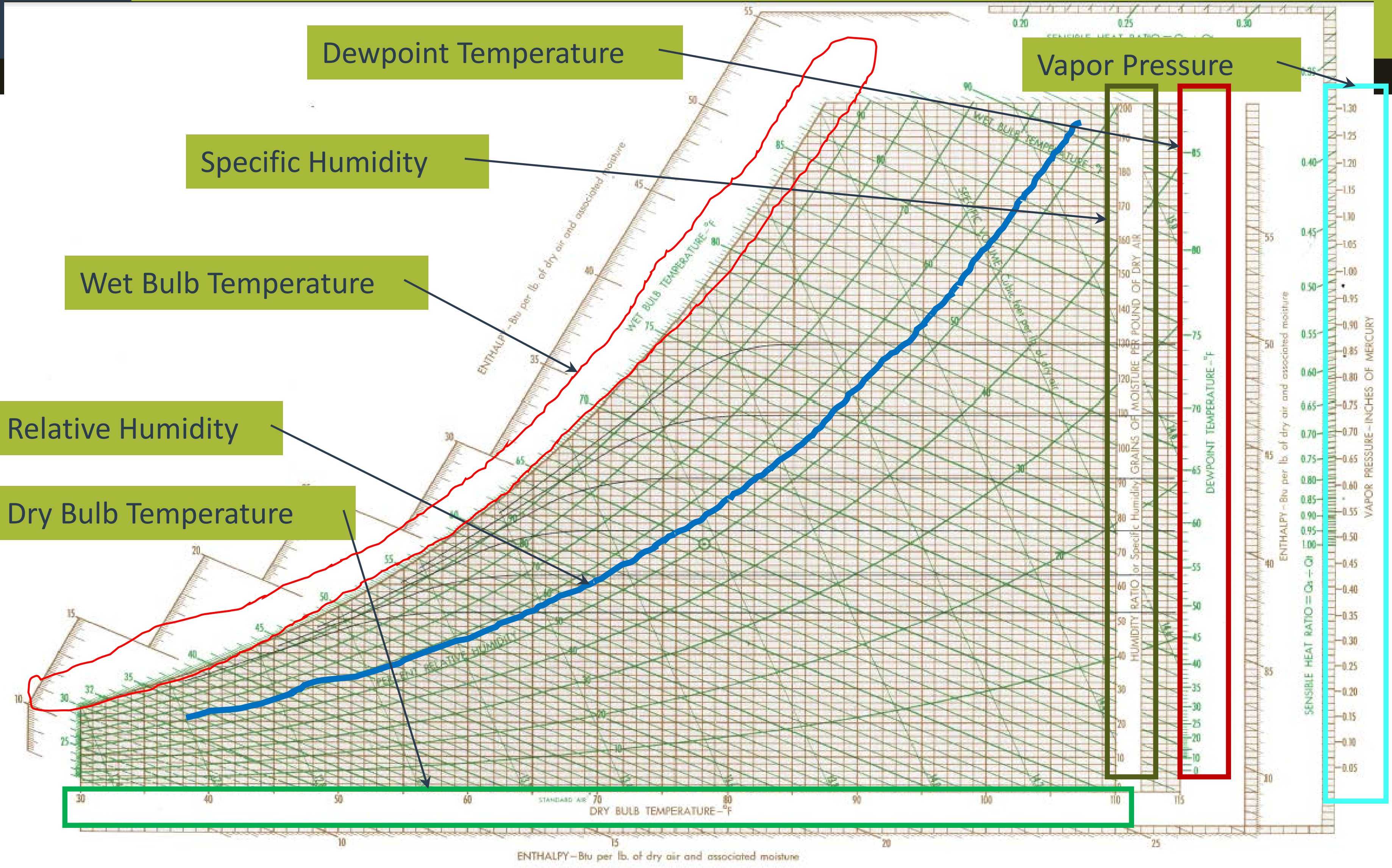
5.9.1 Relative Humidity. Occupied-space relative humidity shall be limited to 65% or less when system performance is analyzed with outdoor air at the dehumidification design condition (that is, design dew-point and mean coincident dry-bulb temperatures) and with the space interior loads (both sensible and latent) at cooling design values and space solar loads at zero.

Note: System configuration and/or climatic conditions may adequately limit space relative humidity at these conditions without additional humidity-control devices. The specified conditions challenge the system dehumidification performance with high outdoor latent load and low space sensible heat ratio.

Exception: Spaces where process or occupancy requirements dictate higher humidity conditions, such as kitchens, hot-tub rooms that contain heated standing water, refrigerated or frozen storage rooms and ice rinks, and/or spaces designed and constructed to manage moisture, such as shower rooms, pools, and spas

No mention of specific temperature ranges.

DANGER (Science stuff) - Psychrometrics



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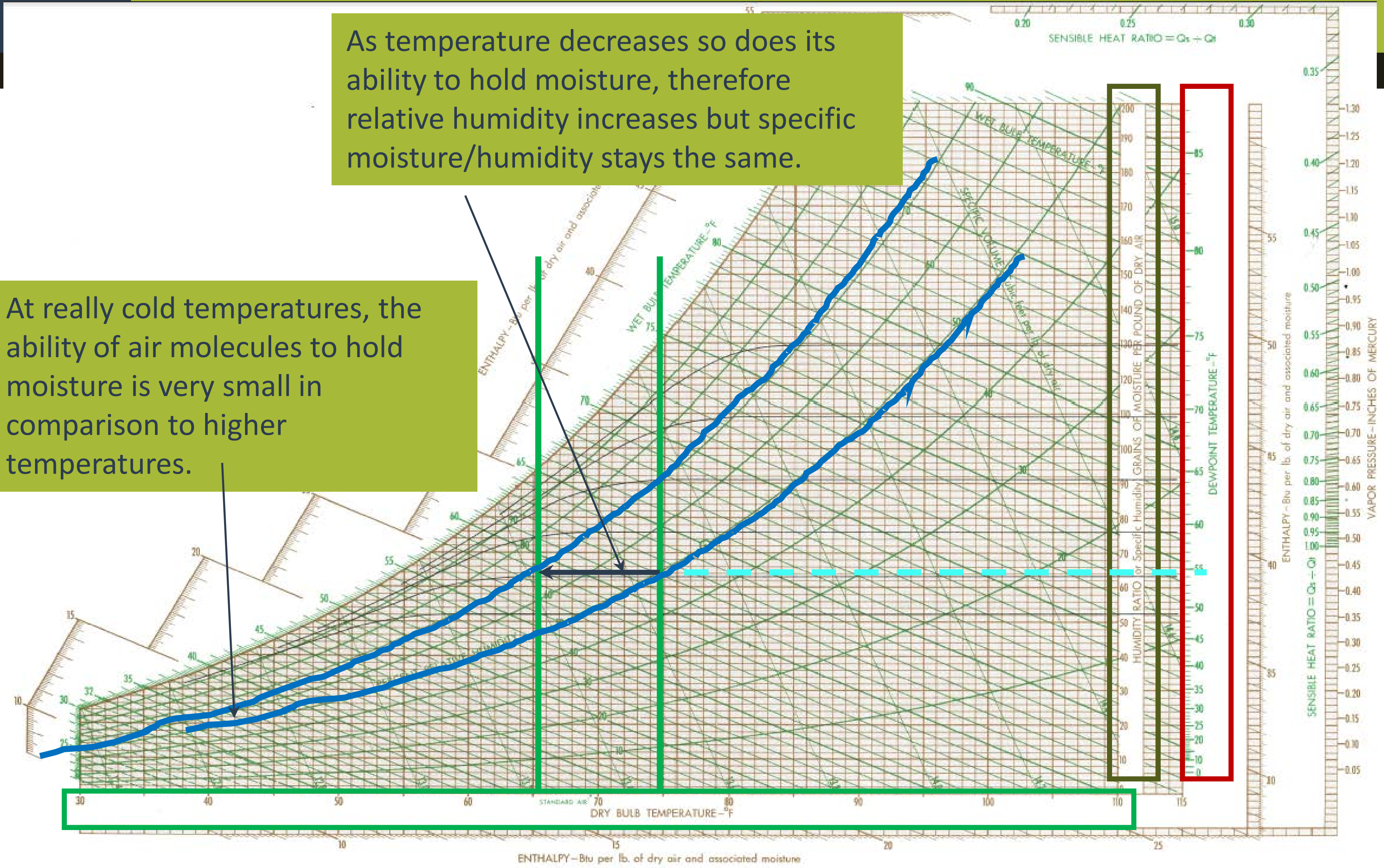
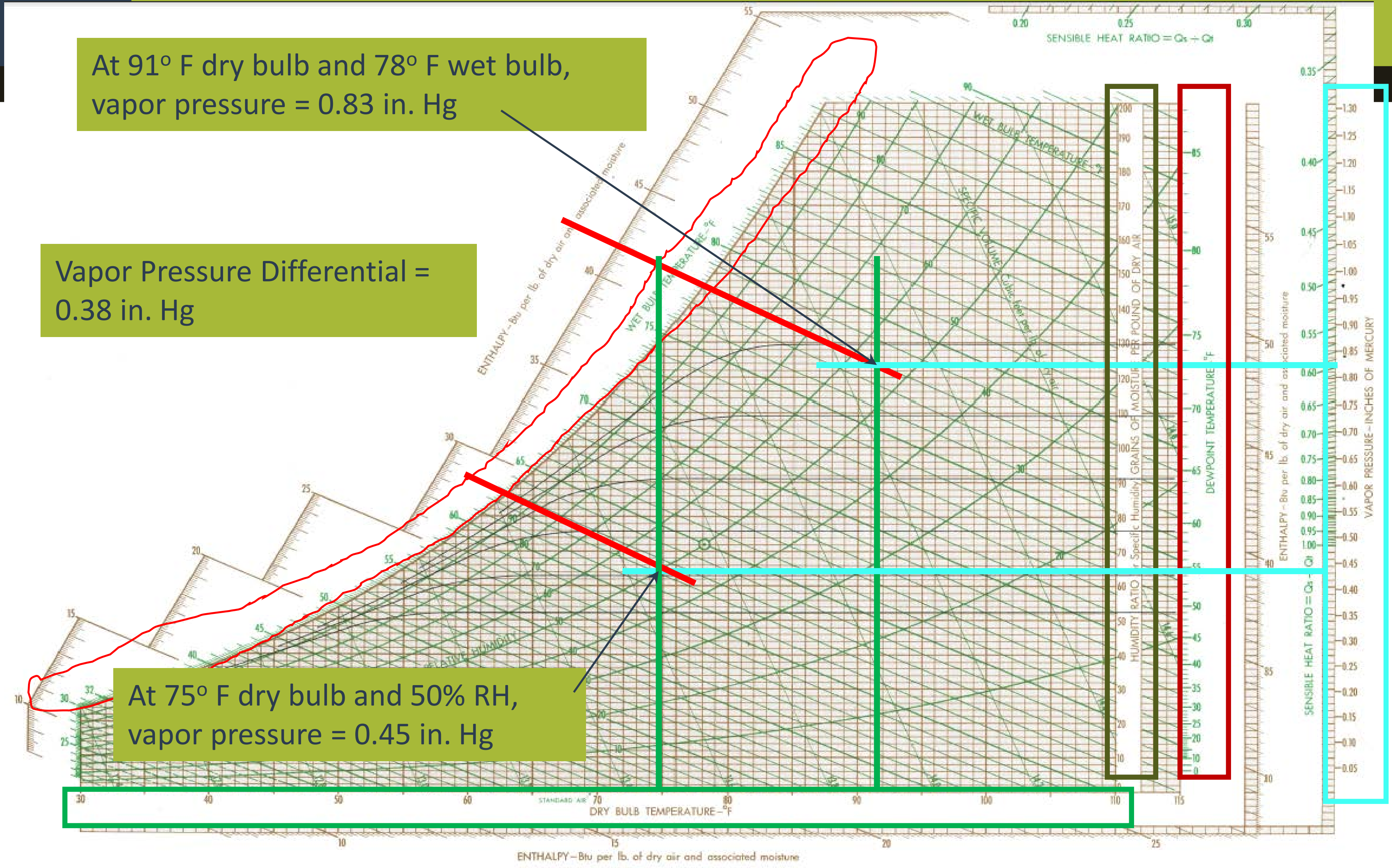
Psychrometrics

As temperature decreases so does its ability to hold moisture, therefore relative humidity increases but specific moisture/humidity stays the same.

At really cold temperatures, the ability of air molecules to hold moisture is very small in comparison to higher temperatures.



Psychrometrics



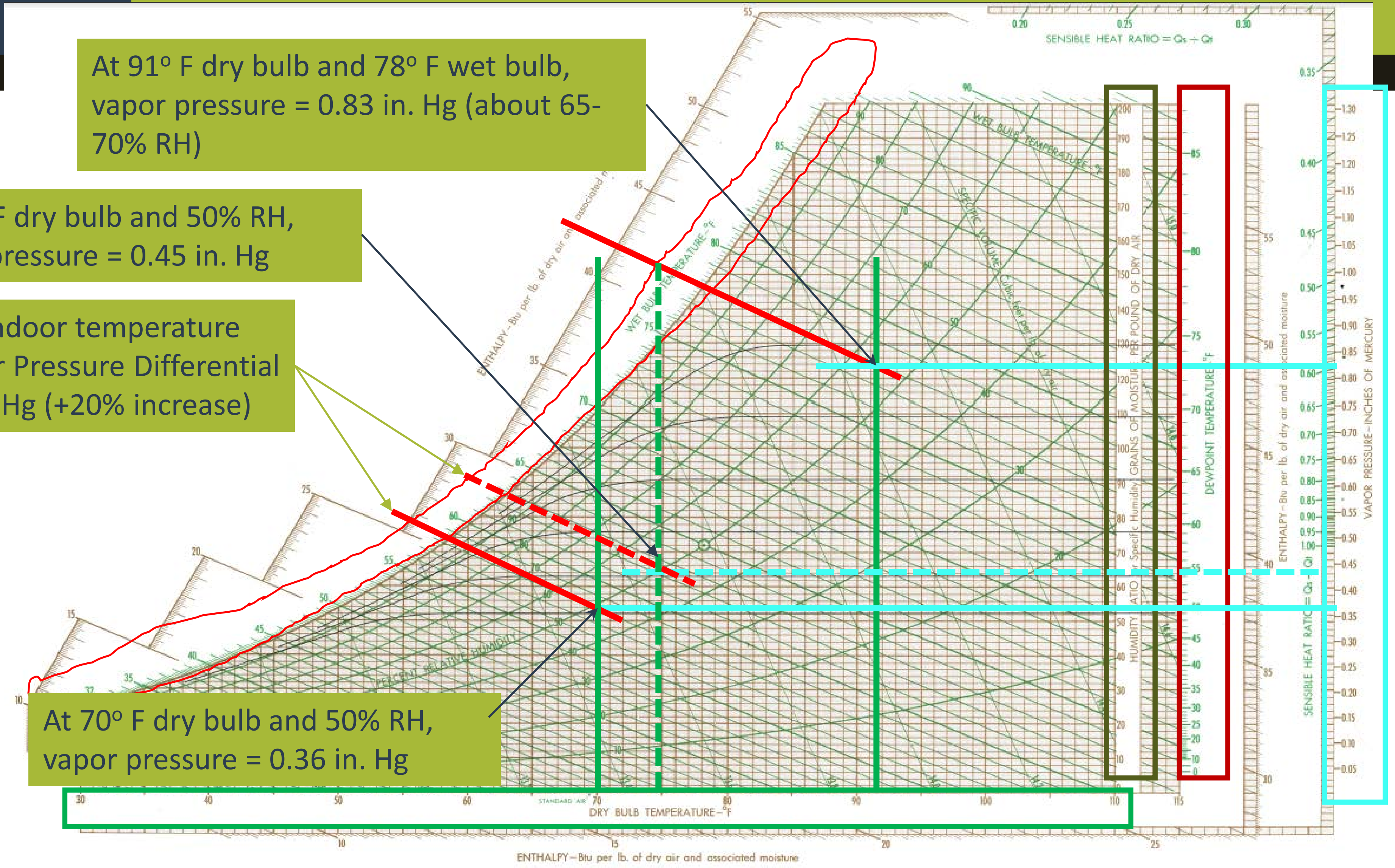
Psychrometrics

At 91° F dry bulb and 78° F wet bulb, vapor pressure = 0.83 in. Hg (about 65-70% RH)

At 75° F dry bulb and 50% RH, vapor pressure = 0.45 in. Hg

If lower indoor temperature 5°F, Vapor Pressure Differential = 0.47 in. Hg (+20% increase)

At 70° F dry bulb and 50% RH, vapor pressure = 0.36 in. Hg



Diffusion – Residence
Cutler Bay, Florida

Diffusion – Residence Cutler Bay, Florida

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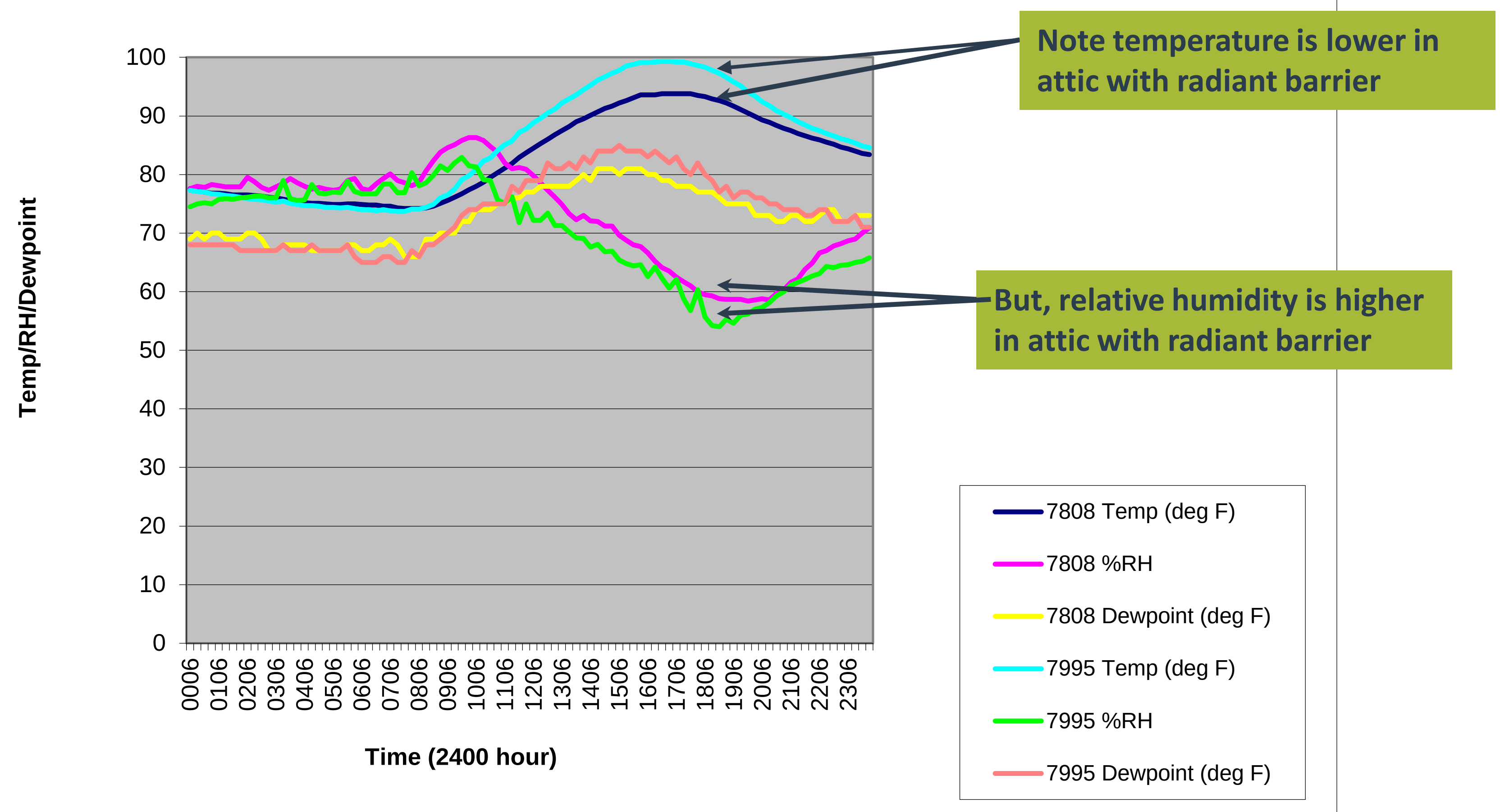
Cutler Bay, Florida

Diffusion – Residence
Cutler Bay, Florida

Diffusion – Residence Cutler Bay, Florida

Attic Space Datalogger Readings (7808 – with radiant barrier; 7995 – without radiant barrier)



Diffusion – Golf Pro Shop
Estero, Florida

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Diffusion – Golf Pro Shop
Estero, Florida

Diffusion – Golf Pro Shop
Estero, Florida

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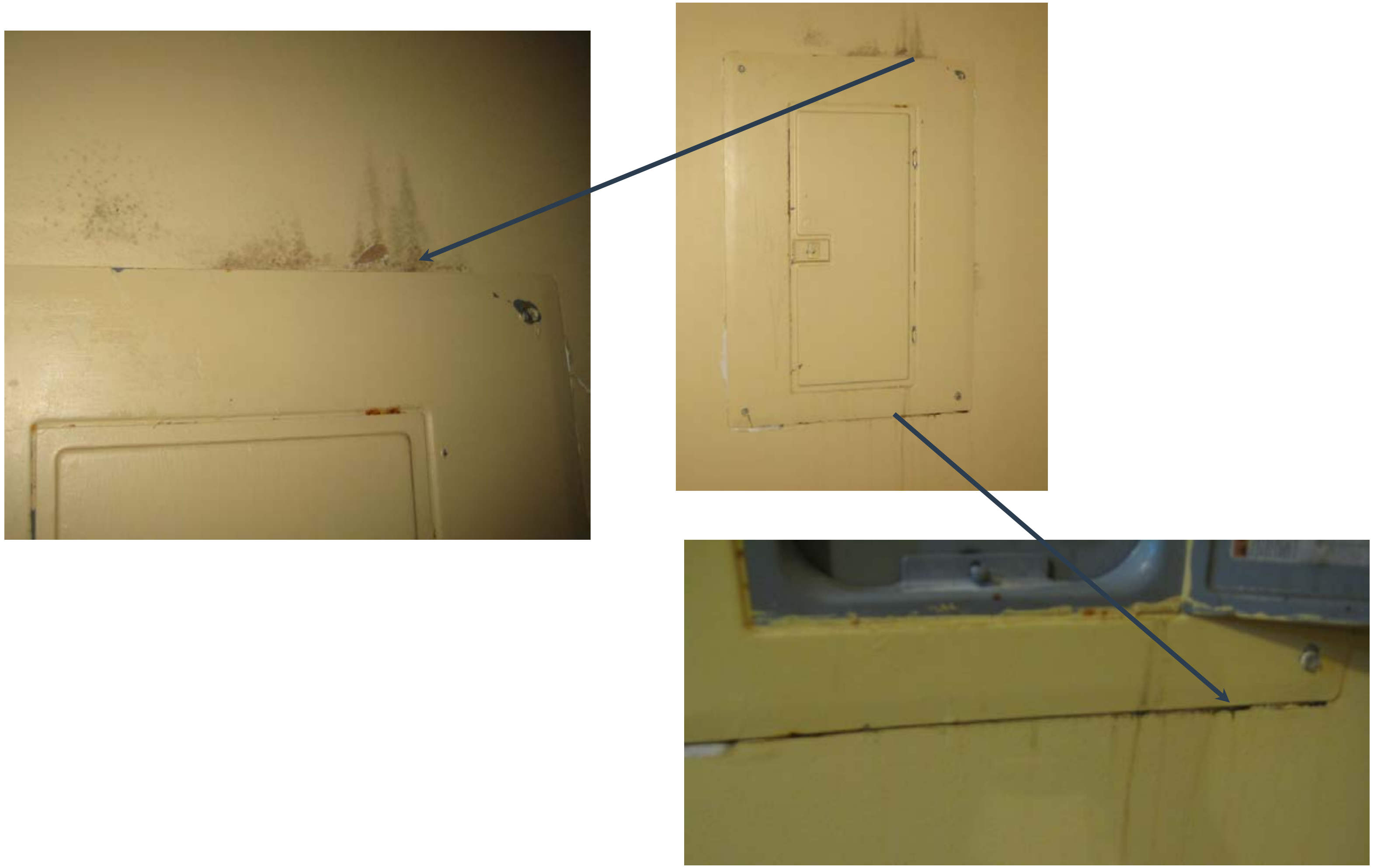

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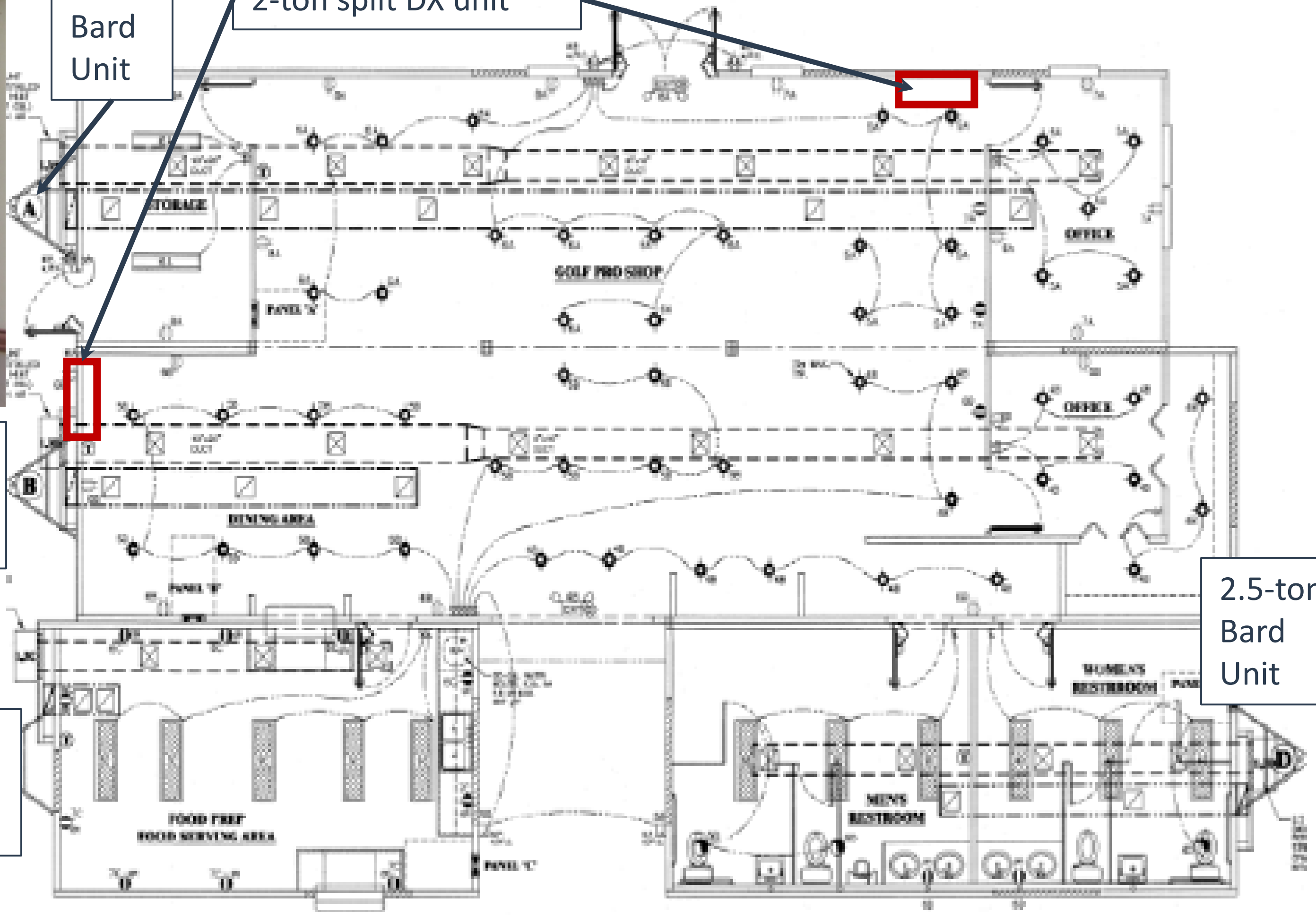
Diffusion – Golf Pro Shop
Estero, Florida



5-ton Bard Unit

2-ton split DX unit

4-ton Bard Unit

17 tons of AC load for a 2700 sf space. Way oversized.

1.5-ton Bard Unit

2.5-ton Bard Unit

Vapor Pressure Diffusion – Residence Nashua, New Hampshire

Vapor Pressure Diffusion – Residence Nashua, New Hampshire

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Vapor Pressure Diffusion – Residence
Nashua, New Hampshire

Cold Exterior Air from non-sealed penetrations

Warmer interior conditions from below entering attic space

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Vapor Pressure Diffusion – Residence Nashua, New Hampshire

Algae staining due to loss of heat through attic

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Conclusions - What can you do?

- Vapor Diffusion can be a factor depending on environmental conditions, construction quality and end users but usually are a combination of several components including but not limited to the building envelope and HVAC systems. Note observations but also ask questions about how the person lives or facility is used. It can really help explain a lot of issues.
- Spot checking temperature/humidity is OK but should not be relied on as a true understanding of the issues. Datalogging of a space provides some excellent data but requires time to get the data to be analyzed.
- Most people will be quick to blame the HVAC system when mold or the inability to maintain comfort levels is present. Many times it’s a building envelope issue and not directly related to the HVAC system. Usually issues are related to a combination of factors that have to happen simultaneously in order for the problem to occur.

Safe Operation of HVAC Systems – It's Not Always the HVAC Systems Fault

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