Introduction to HVAC Systems

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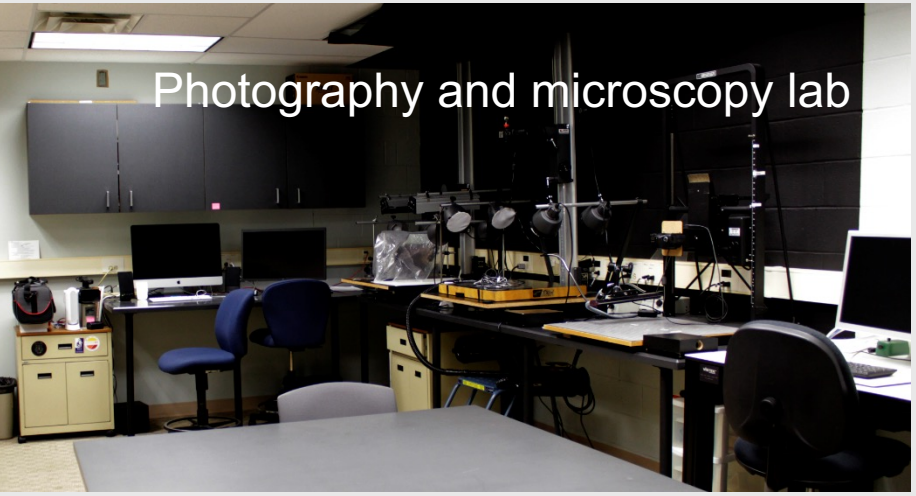
Photography and microscopy lab


Incubation lab
ESPEC
1
2
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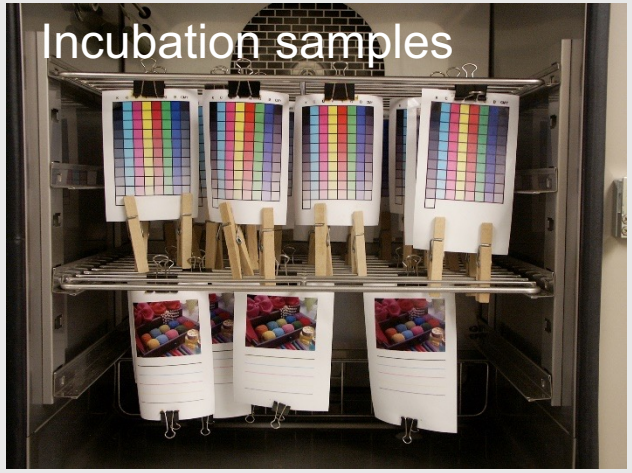
21
Pollution lab


Webinar classroom


Incubation samples


Study collection and classroom

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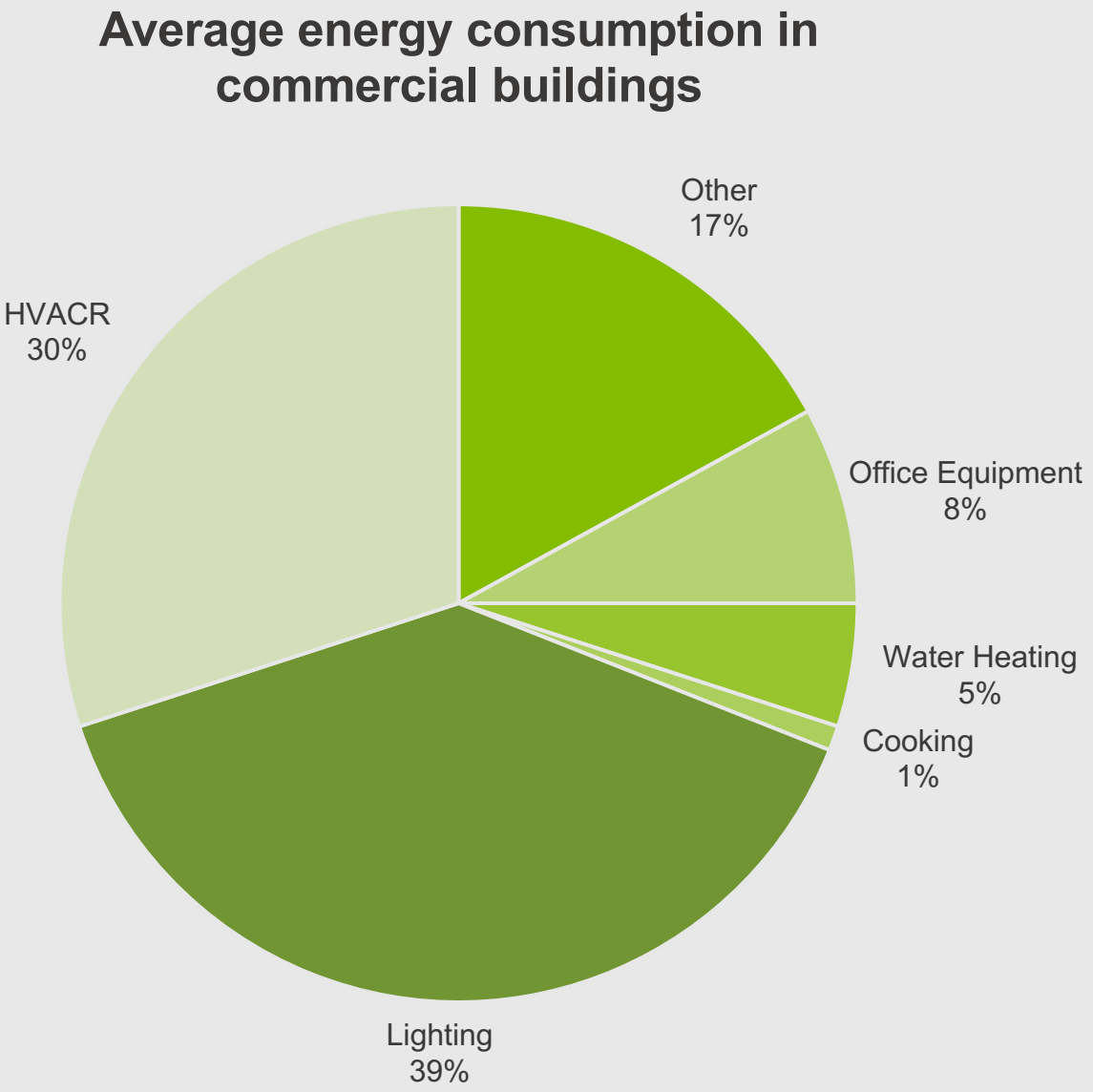
Average Energy Consumption in Commercial Buildings

Average Energy Consumption in Commercial Buildings

- HVAC is responsible for a significant share of the energy use
  - 25% - 30% (or more) of the total energy consumed in many building types
  - Many facilities have HVAC systems that were installed at times when energy efficiency was not a priority



What is an HVAC system

- The system of motors, ducts, fans, controls, and heat exchange units which delivers heated or cooled air to various parts of a facility.
- The purpose of the HVAC system is to add or remove heat and moisture in order to maintain the desired environmental conditions.
- The HVAC also provides ventilation and air movement even when no heating or cooling load is present.

Source: AEE, CEM training

Safety Precautions

When Working Around Air Handling Units

- **Always follow your facility's safety procedures**
- **Have a facility or HVAC representative on hand**
- **Always carry a flashlight and your cell phone**
- **Leave everything in the unit as you found it**

- Be aware that some mechanical rooms can be small and your **mobility may be limited.**
- Many mechanical rooms have low pipes or ductwork inside **- always watch your head**.
- Many mechanical rooms have plumbing running along the floor **- watch your step**.
- Mechanical rooms can be noisy – **wear proper hearing protection** if necessary.

When Working Around Air Handling Units

- **Keep your hands and feet away from any moving parts**
- **Do not leave any foreign objects inside the units**
- **Do not attempt to make any changes to the units on your own.**
- **Report any issues to a facilities representative as soon as possible.**

Do not touch any part of the unit you are not familiar with.

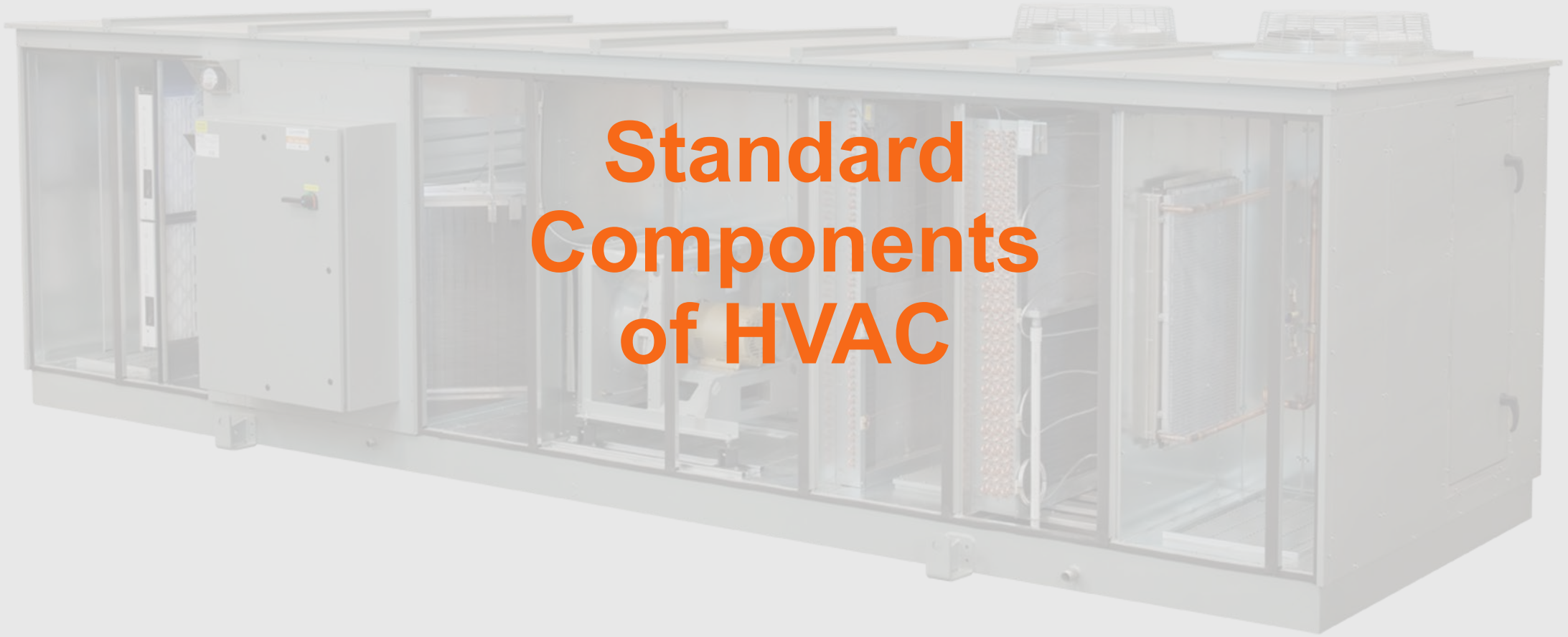
If you have the authority to enter the unit:

- Watch your head when entering or exiting any unit.
- Ensure the units are turned off before opening any access door.
- Be aware of any screws or nails that can rip clothing or cause harm.
- When opening any access door be sure not to wear any loose or dangling items (i.e. ties, lanyards, scarves, necklaces etc.) as these items may be pulled downstream by the air or become entangled in the fan or motor.
- Be careful when working in or around a humidifier as the lines may be hot and can burn very quickly.
- If the system is not shut down, there is the possibility that the humidifier may operate while you are working near it.

Sensible and Latent Heat

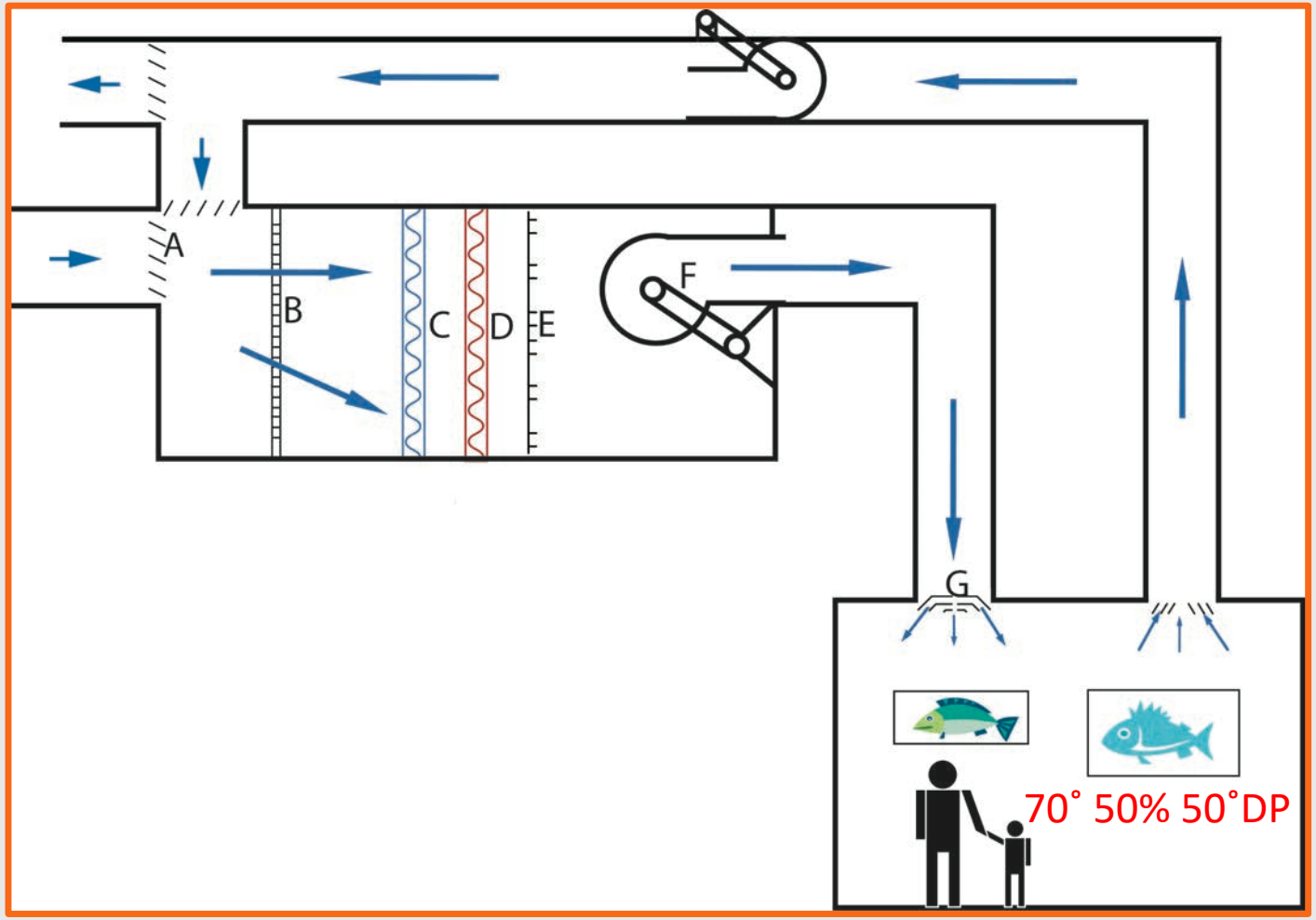
- **Sensible Heat** – A change of temperature with no change in moisture content

- **Latent Heat** – The heat that is required to change the phase of a substance – condensation at the cooling coil
  - This refers to the energy required to/release from the change of moisture content



Standard Components of HVAC

Air Handling System



Dampers

Dampers are the metal doors inside ductwork that help regulate air flow.

- Can be manually controlled
- Can be controlled by motors or actuators that open or close them.

Outside Air

Untreated air that is brought into a system from the outside to make up for any air lost to exhaust or exfiltration.

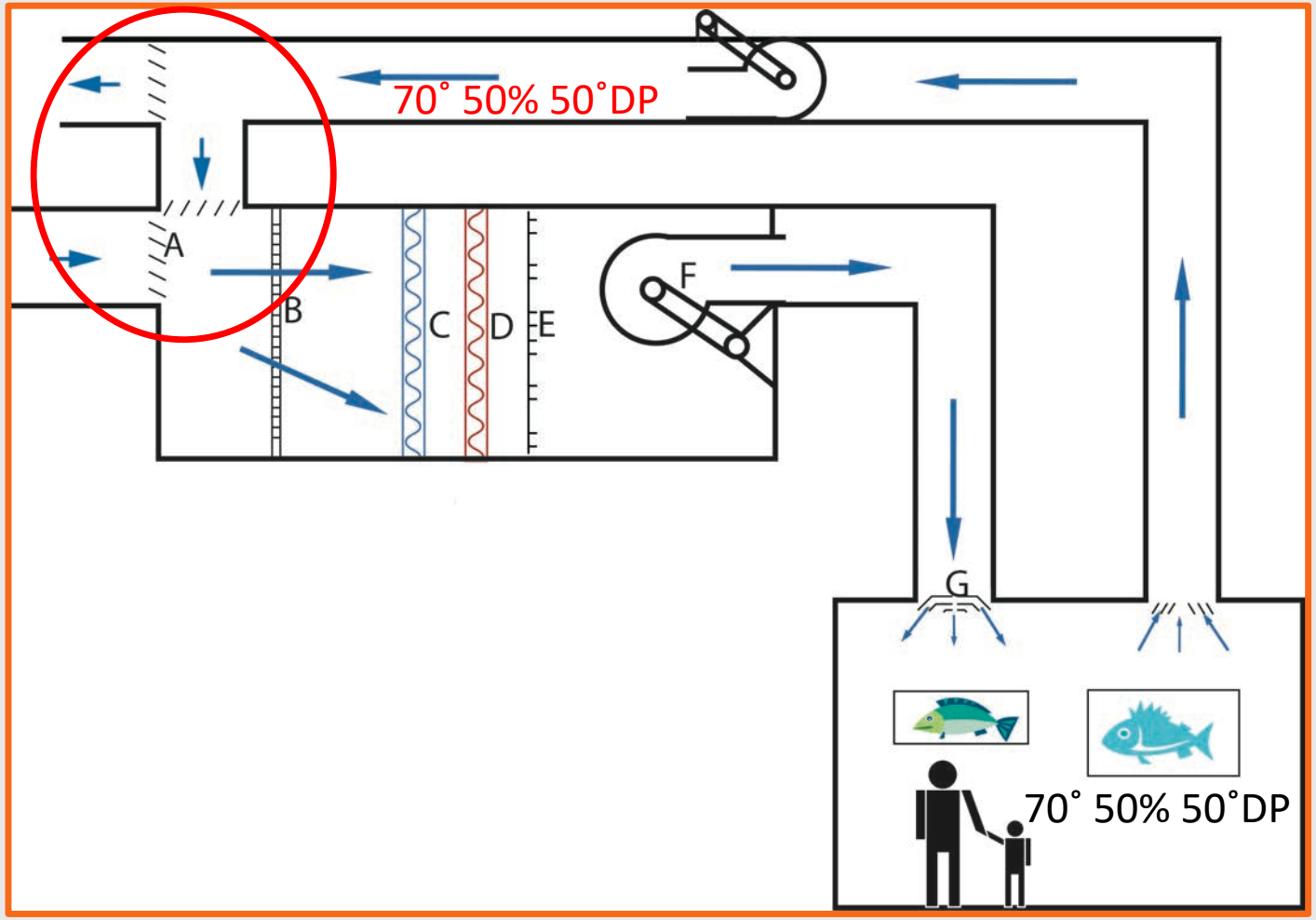
- The location of the facilities outside air intake may play a major factor

- Is the intake too close to a major source of pollution
  - Bus stop
  - Smoker station
  - Building exhaust

Air Handling System

A: Dampers

30%
80˚ 68% 74˚DP



Filters

- Designed to trap pollutants, dirt, dust, molds, bacteria etc., and to prevent these materials from entering the system and contaminating the environment.
- Filters can be made from felt, cloth, cellulose, fiberglass, foam, paper, silk, etc., and can filter out varying levels of contaminants based on their construction.

Merv Rating Chart

Standard Air Filters

Classification	Arrestance	US ASHRAE 52.2	European Union EN779 Class		Typical Controlled Contaminant	Application
PRE Filter (G Class)	< 65%	MERV 1	G1	Am < 65%	Particle bigger than 10.0 µm • Pollen • Spanish moss • Dust mites • Sanding dust • Spray paint dust	• Minimal filtration • Residential • Window A/C units
	65-70%	MERV 2	G2	65% ≤ Am < 80%		
	70-75%	MERV 3				
	75-80%	MERV 4				
	80-85%	MERV 5	G3	80% ≤ Am < 90%	Particle size within 3.0 µm-10.0 µm • Mold • Spores • Hair spray • Cement dust • Snuff • Powdered milk	• Commercial buildings • Better residential • Industrial workplace • Paint booth inlet
	85-90%	MERV 6				
	25-30%	MERV 7	G4	90% ≤ Am		
	30-35%	MERV 8				
MEDIUM Filter (F Class)	40-45%	MERV 9	F5	40% ≤ Em < 60%	Particle size within 1.0 µm-3.0 µm • Lead dust • Milled flour • Coal dust • Auto emissions • Nebulizer drop • Welding fumes	• Superior residential • Better commercial buildings • Hospital laboratories
	50-55%	MERV 10				
	60-65%	MERV 11	F6	60% ≤ Em < 80%		
	70-75%	MERV 12				
	80-85%	MERV 13	F7	80% ≤ Em < 90%	Particle size within .3 µm-1.0 µm • All bacteria • Cooking oil • Most smoke	• General surgery • Hospital inpatient care • Smoking lounges
	90-95%	MERV 14	F8	90% ≤ Em < 95%		
	> 95%	MERV 15	F9	95% ≤ Em	• Copier toner • Most face powder • Most paint pigments	• Superior commercial buildings
		MERV 16				

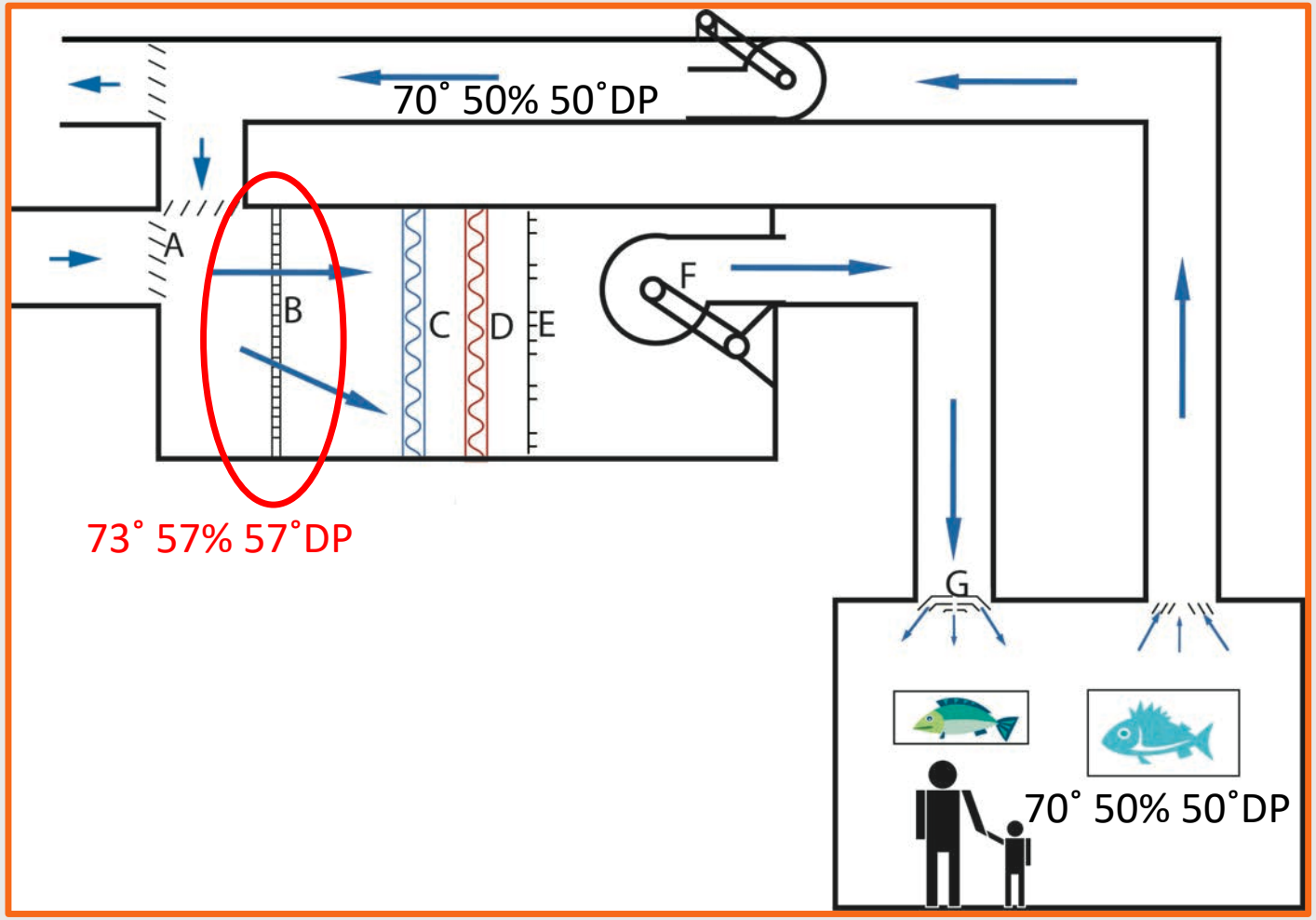
Am: Average arrestance efficiency for coarse filters Em: Average efficiency for fine filters

Air Handling System

A: Dampers

B: Filters

30%
80˚ 68% 74˚DP



Cooling Coils

Also known as ***evaporator coil***

Connected to a source of cooled refrigerant, i.e. chiller, cooling tower, etc., these coils are used to absorb heat from the air that passes over them.

Depending on the temperature of the water in the coil, they can cause condensation to occur when air with a higher dew point passes over it.

Refrigerant/Coolant

- **Direct Expansion (DX)**
  - Refrigerant
- **Chilled water**
  - Chilled Water
  - Chilled water/glycol

Difference in types of cooling

- **DX**
  - HCFC gases
  - Multiple types of refrigerant
  - Each type is capable of achieving a different dew point
  - Dew point using refrigerant can be very low, but can get expensive
  - Requires a compressor

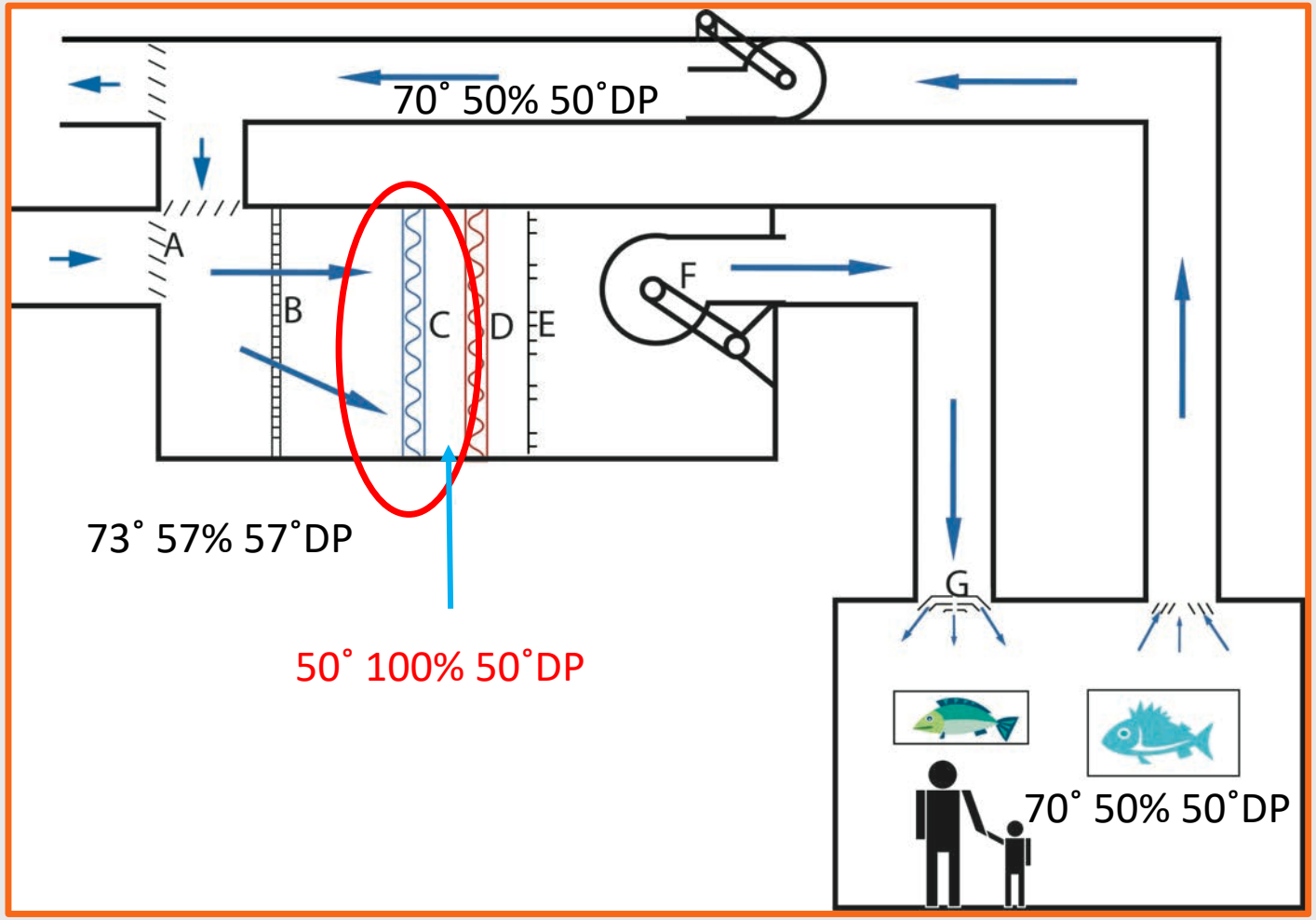
- **Chilled Water**
  - Can get as low as 34°F
  - Can be mixed with glycol to achieve lower temps
  - Requires a pump

Air Handling System

A: Dampers

B: Filters

C: Cooling Coil



Heating Coils/Reheats

Connected to a heat source, i.e. boiler or electric heaters, these coils are used to reject heat to the air that passes over them.

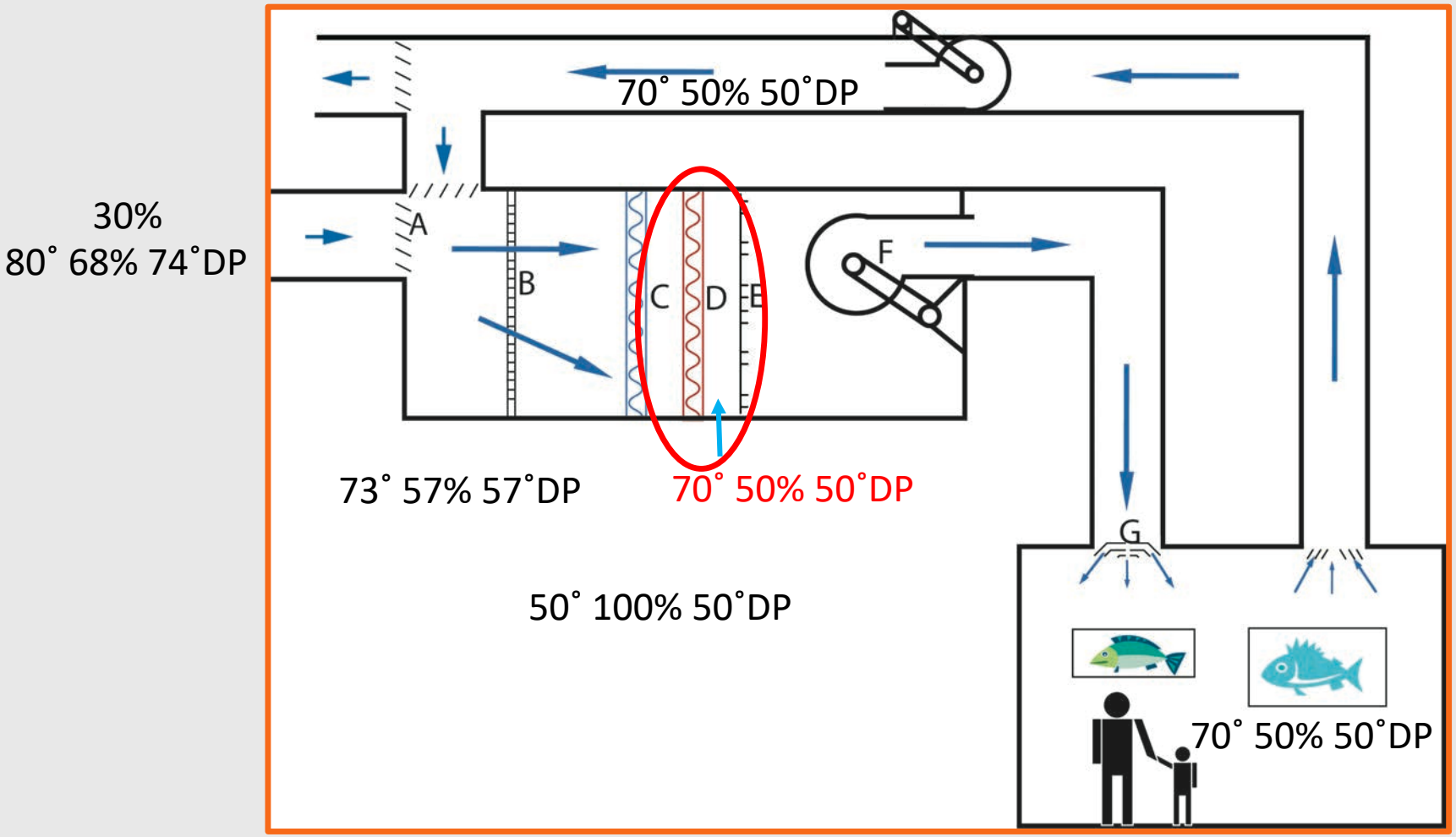
Air Handling System

A: Dampers

B: Filters

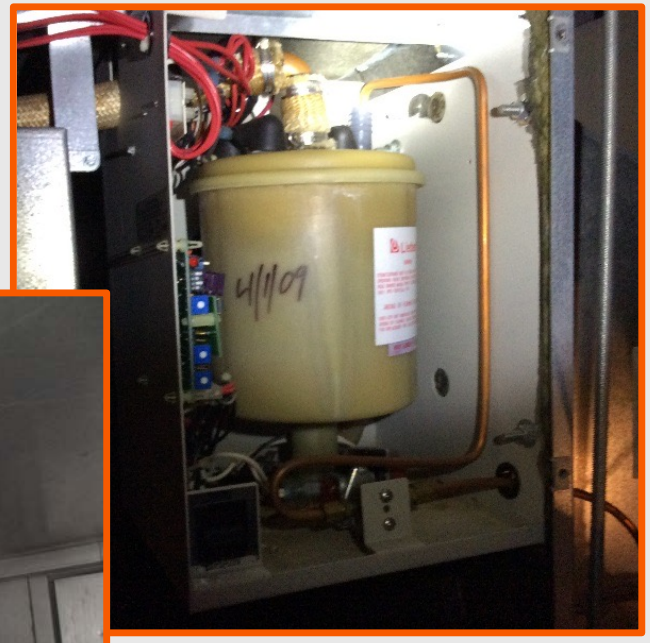
C: Cooling Coil

D: Heating Coil



Humidifiers

A mechanism used to add moisture to the air. In HVAC settings there are four dominant methods for raising the moisture content of air.



Air Handling System

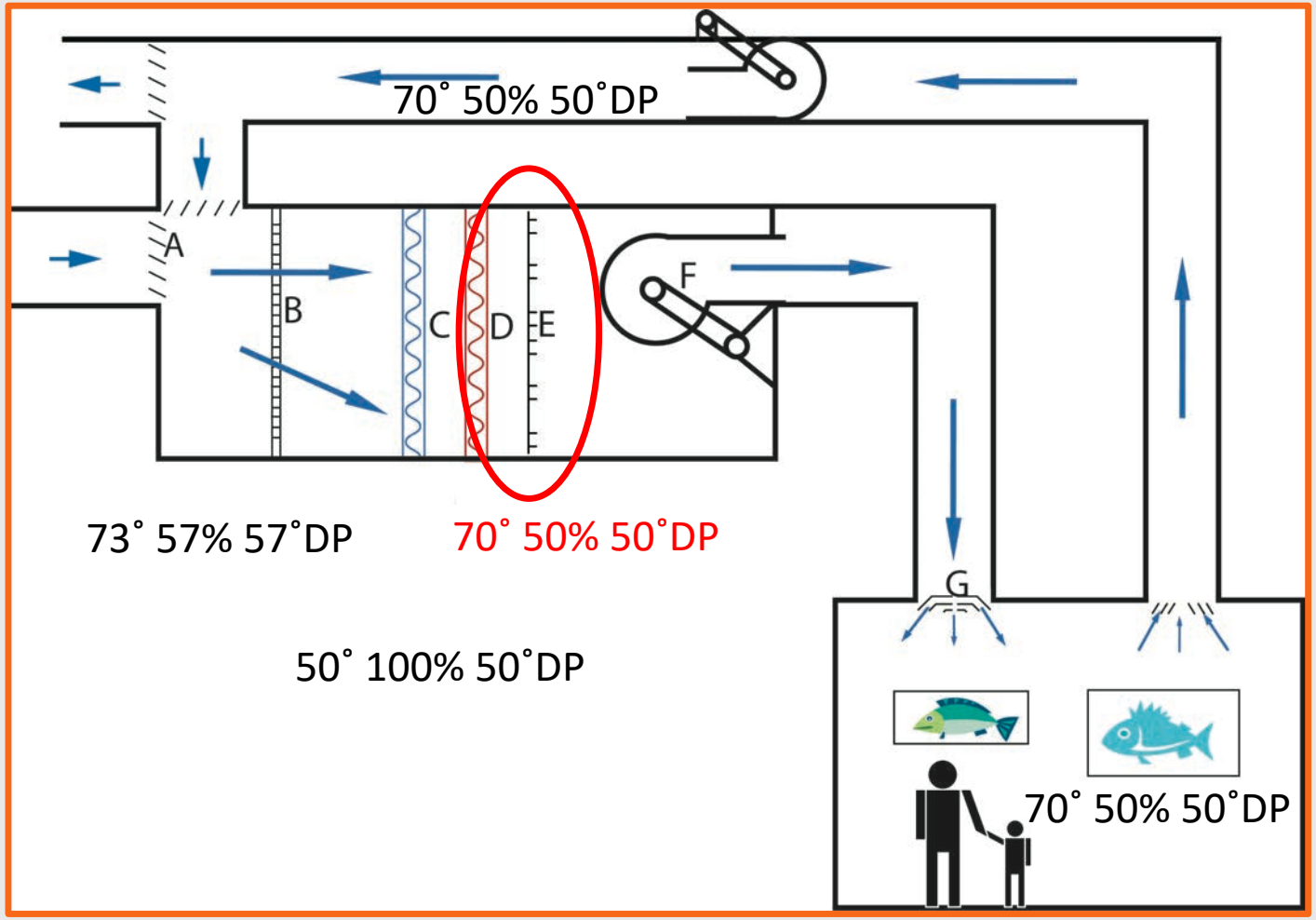
A: Dampers

B: Filters

C: Cooling Coil

D: Heating Coil

E: Humidifier



Fans

Fans are motor driven assemblies found inside of the air handling systems that help move air through the system.

Fan motor

The motor drives the fan

This item can add up to 1°F of heat to the passing air

Air Handling System

A: Dampers

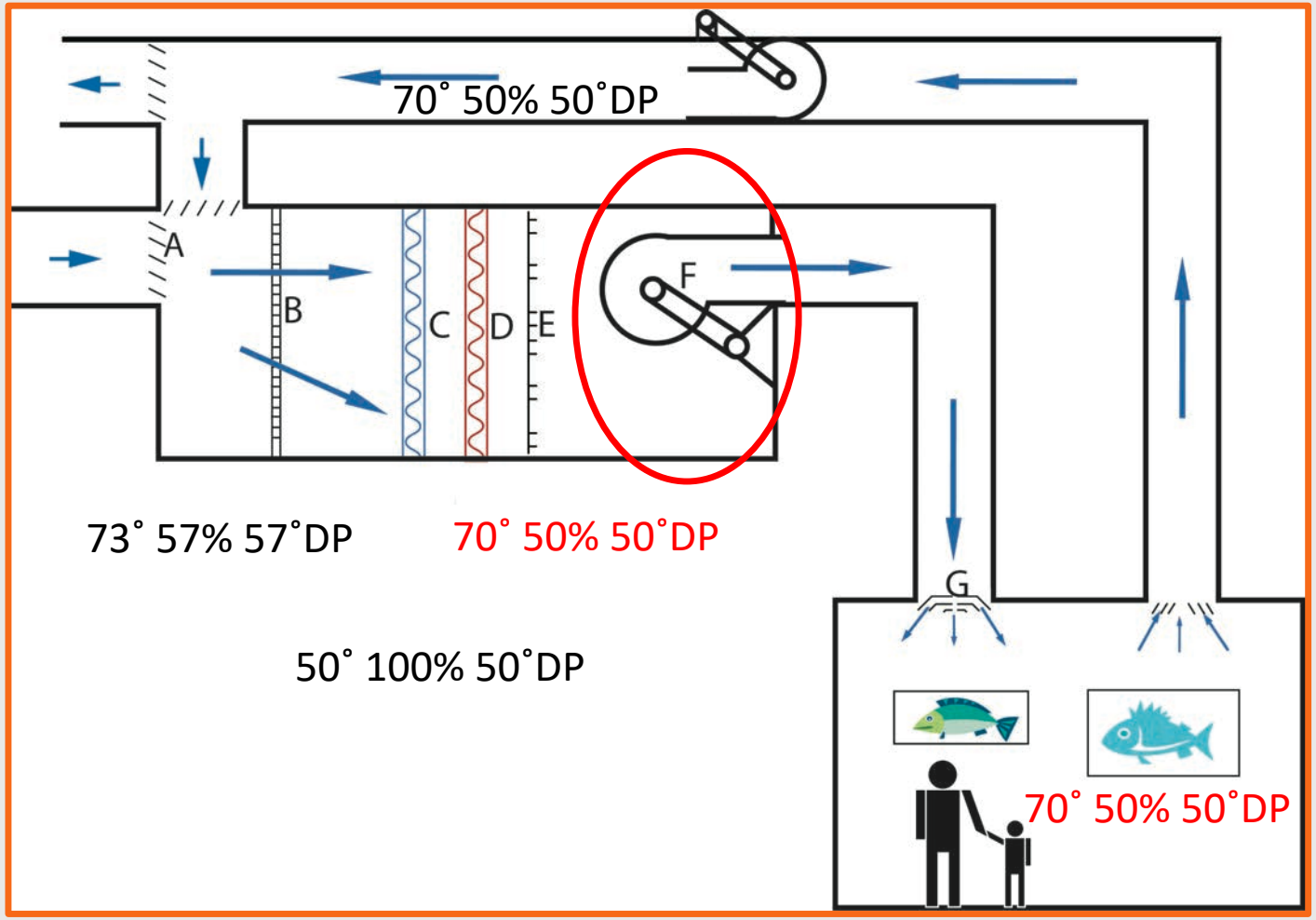
B: Filters

C: Cooling Coil

D: Heating Coil

E: Humidifier

F: Supply Fan



Additional Components

Additional Components

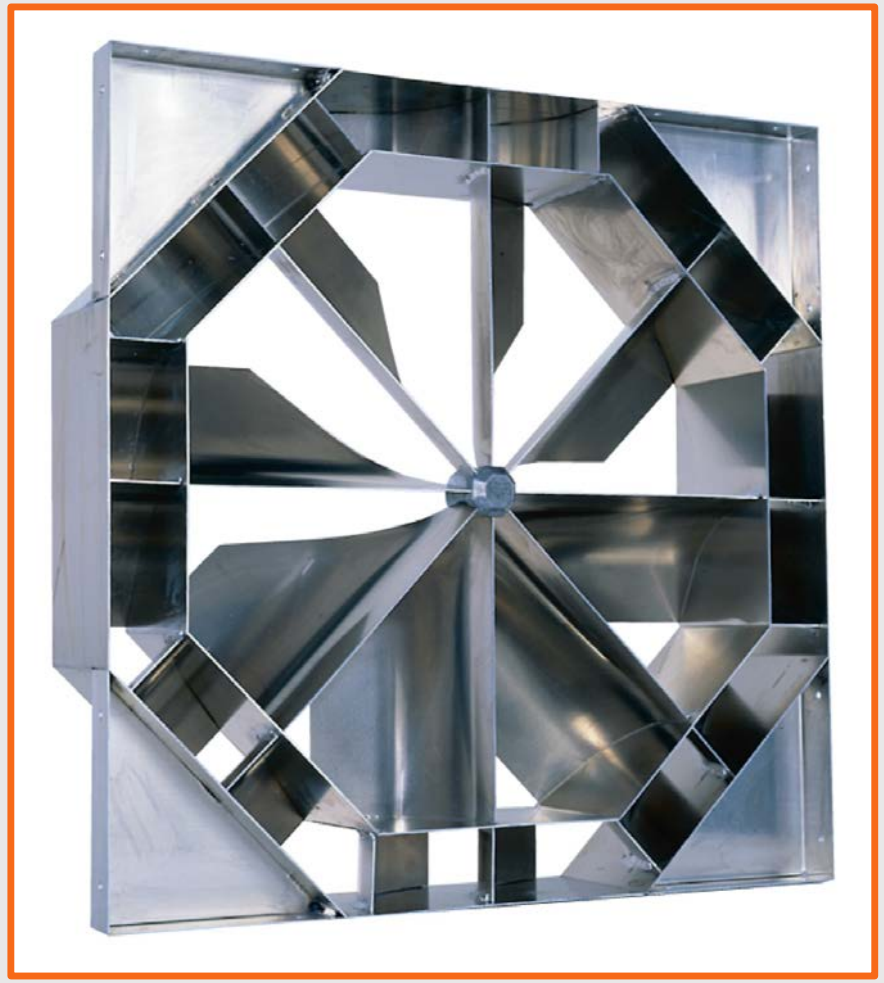
Turning vanes

Stationary metal devices inside duct work that are used to direct the flow of air and reduce turbulence in the ductwork

Additional Components

Air mixer

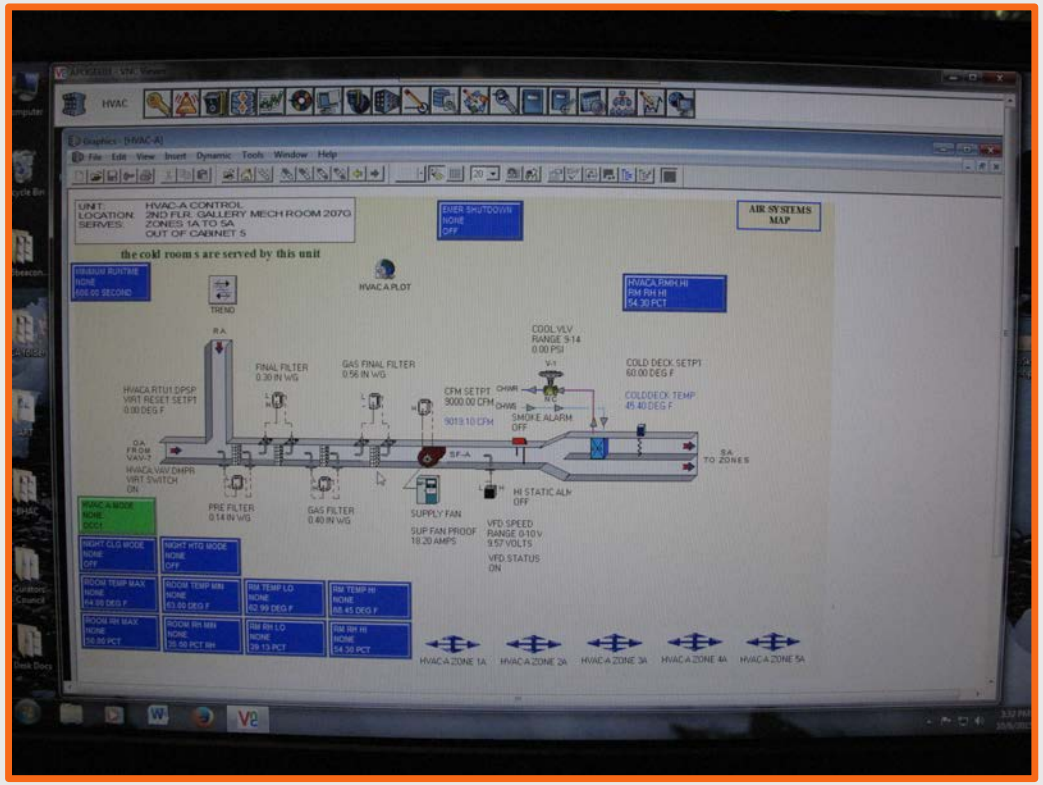
Metal devices in an air handling unit that are used to mix or blend the passing air. Usually located after the outside air intake or after a bypass in the system.



Building Management Systems

The computer based control system that can automate the HVAC, lighting, security, and life safety systems of a facility.

BMS, BAS, EMS, BCS, BAC



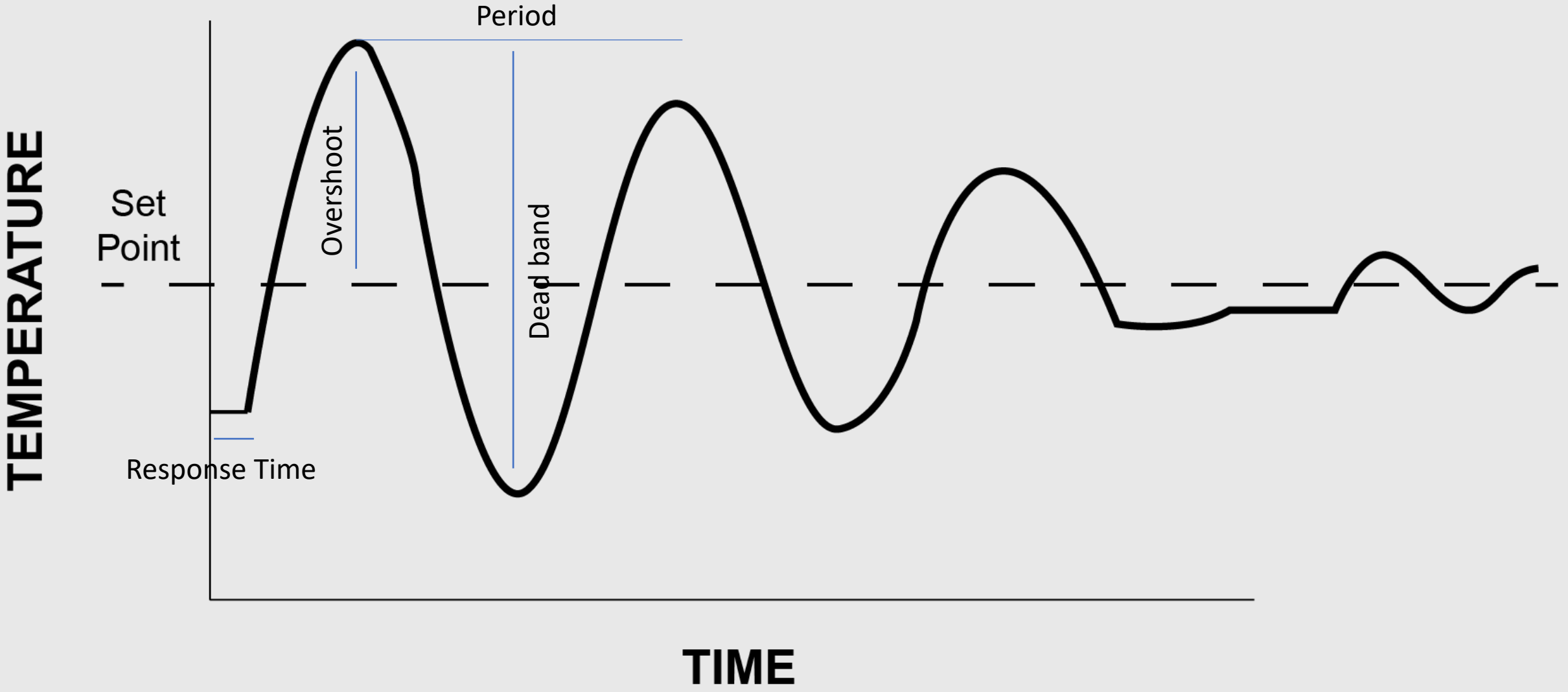
Controls/Stats

Equipment used to control or regulate an HVAC system

- **Thermostat** – An instrument used to regulate the temperature in a space. The device can activate the HVAC system to operate.
- **Humidistat** – An instrument used to regulate the relative humidity in a space. The device can activate the HVAC system to operate. Primarily the cooling coil and the humidifier or dehumidifier.
- **Thermidistat** – An instrument that is used to measure temperature and humidity in a space. The device can activate the HVAC system to operate.

Key Vocabulary

- **Set point** - the temperature point at which a thermostat has been set
- **Response time** – time required for the control point to reach a new set point following a change
- **Overshoot** – the amount the control goes beyond a set point following a change in load or set point
- **Dead Band** – the temperature range that utilizes no heating or cooling


Period
Overshoot
Dead band
Set Point
Response Time
TEMPERATURE
TIME

VFD

Variable Frequency Drive (VFD) or Variable Speed Drive (VSD)

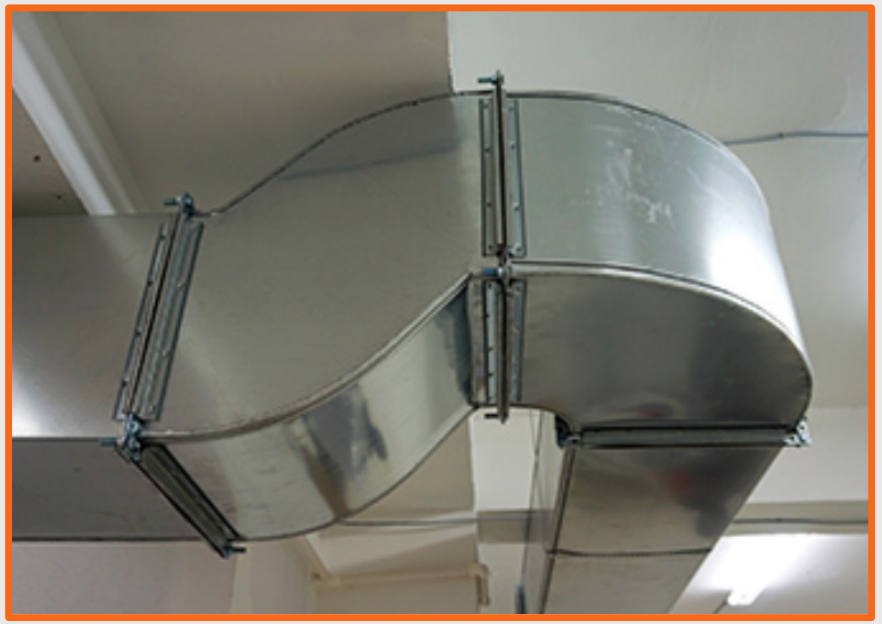
A digital control device used on air handling units to control the speed and torque of the supply, return, or relief fans in the unit.

Desiccant Air Dryer

A device that uses hygroscopic material to remove moisture from air that is drawn into it.

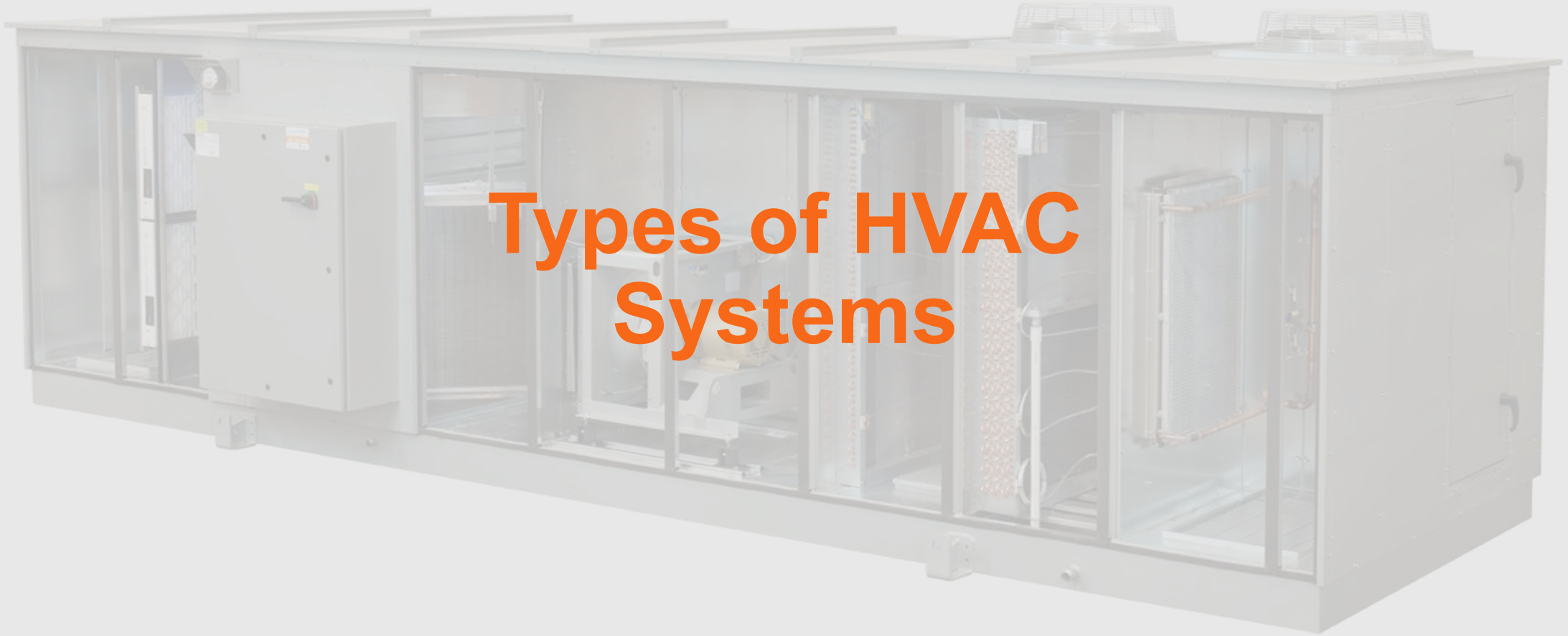
Open plenum design

- Air is returned to the HVAC system through the ceiling of the space without the use of ductwork.
- Not recommended for collection spaces
- The air can change temperature and moisture conditions due to unconditioned or untreated air that it may mix with in the ceiling



Economizing

- An economizer is a part of a building's cooling system that uses cool outdoor air to cool the building instead of operating the air conditioning components
  - This is typically employed when the outside air is cooler than the cooling set point temperature.



Types of HVAC Systems

DX System (Air Conditioning System)

A: Condensation Coil

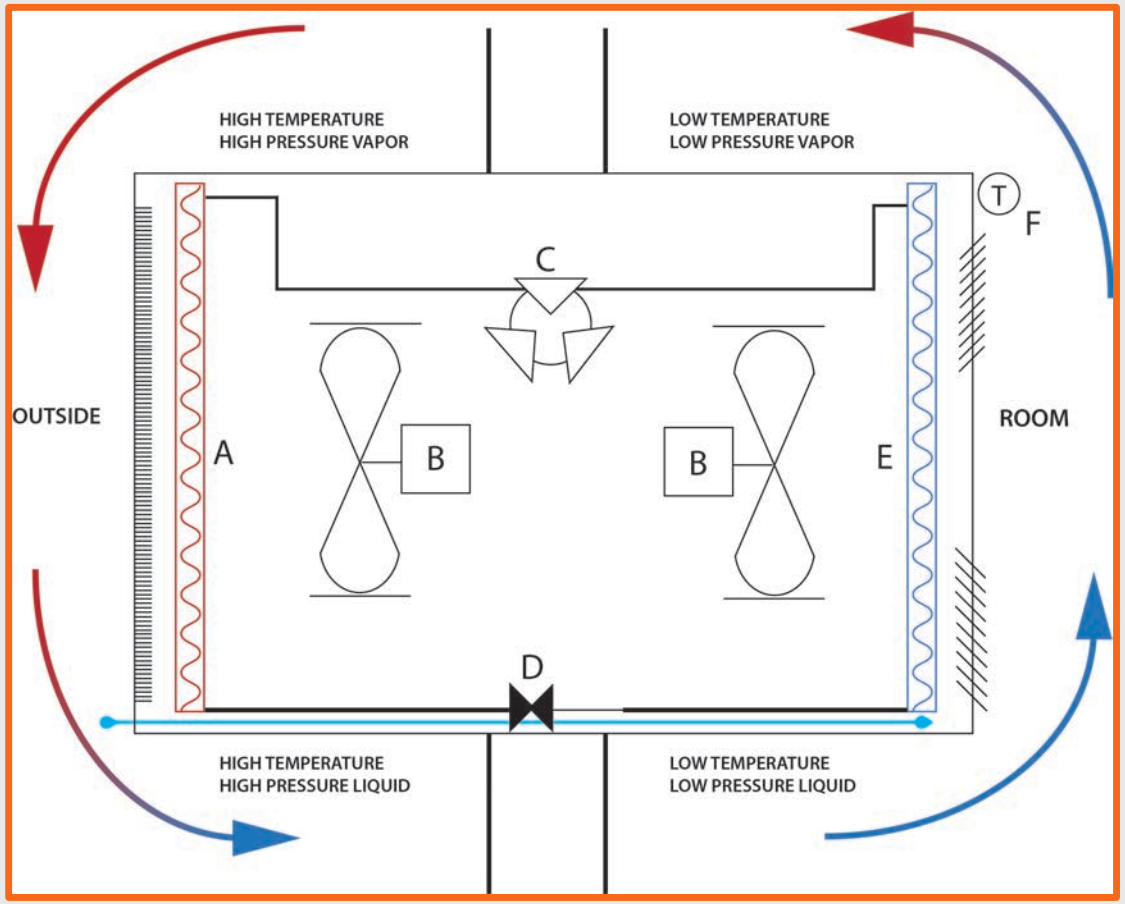
B: Fans

C: Compressor

D: Expansion Valve

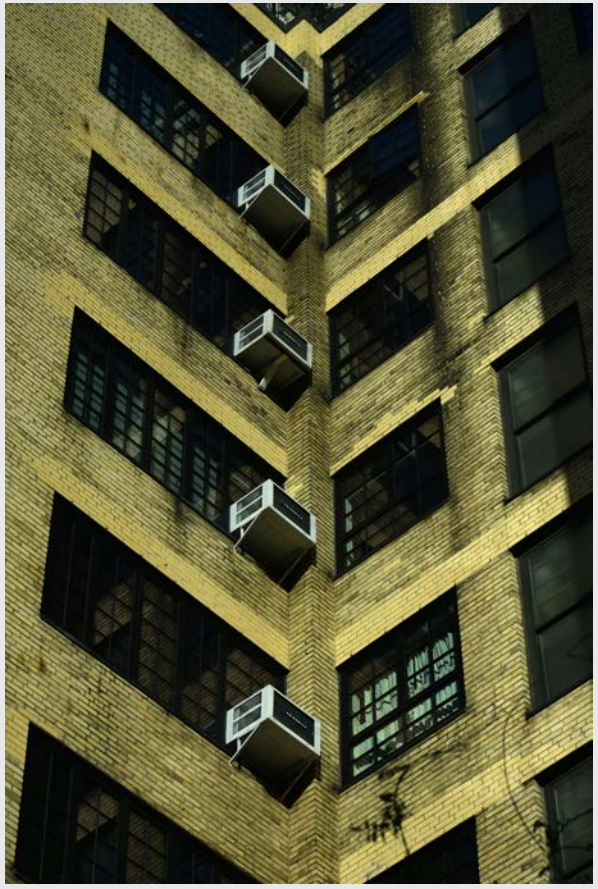
E: Evaporator Coil

F: Thermostat



- Types of units that use direct expansion

Window AC units



Split Systems

Packaged or Cabinet units

Single Zone Air Handling System

A: Dampers

B: Filters

C: Cooling Coil

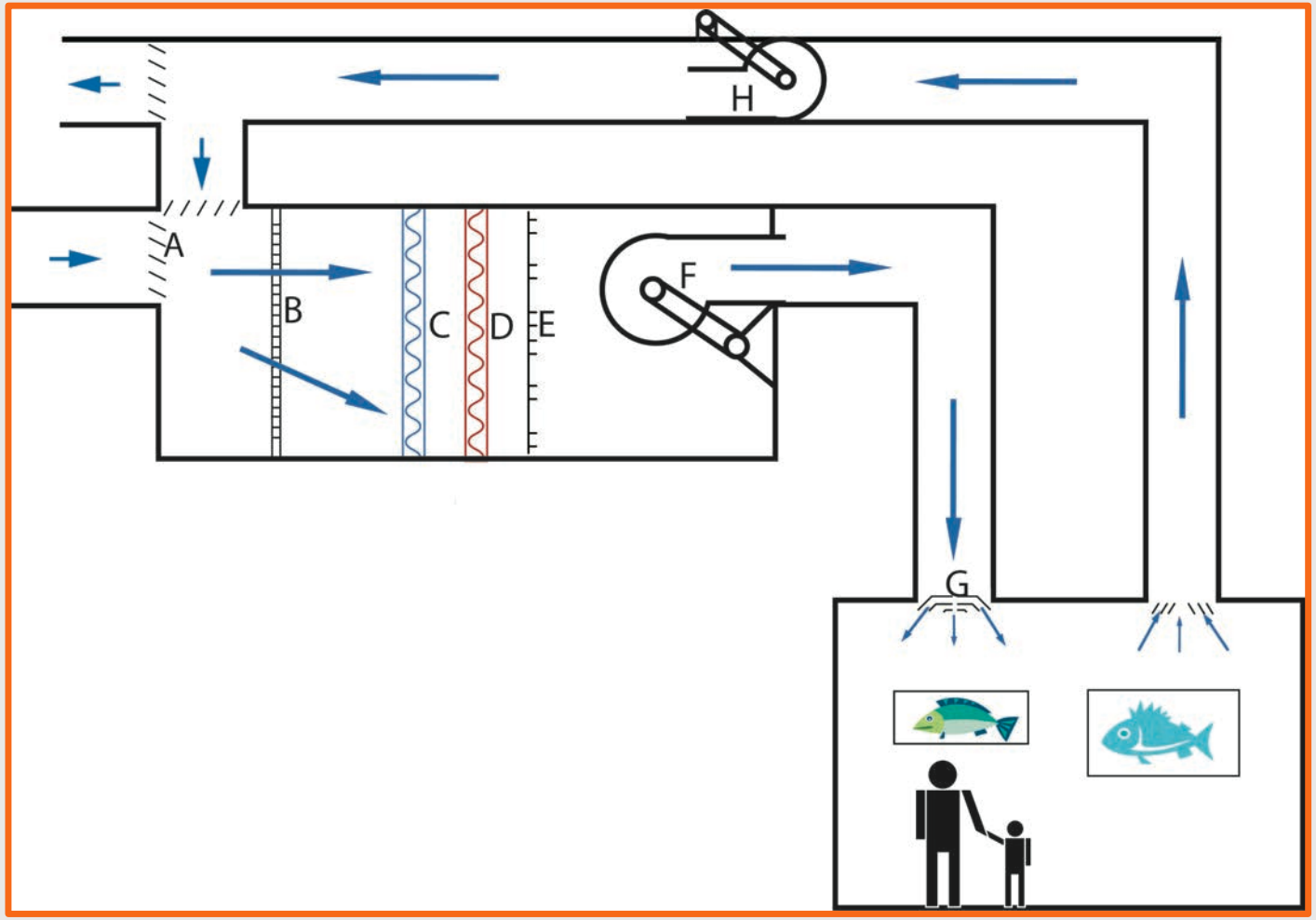
D: Heating Coil

E: Humidifier

F: Supply fan

G: Diffusers

H: Return Fan



Multizone Air Handling System

A: Dampers

B: Filters

C: Cooling Coil

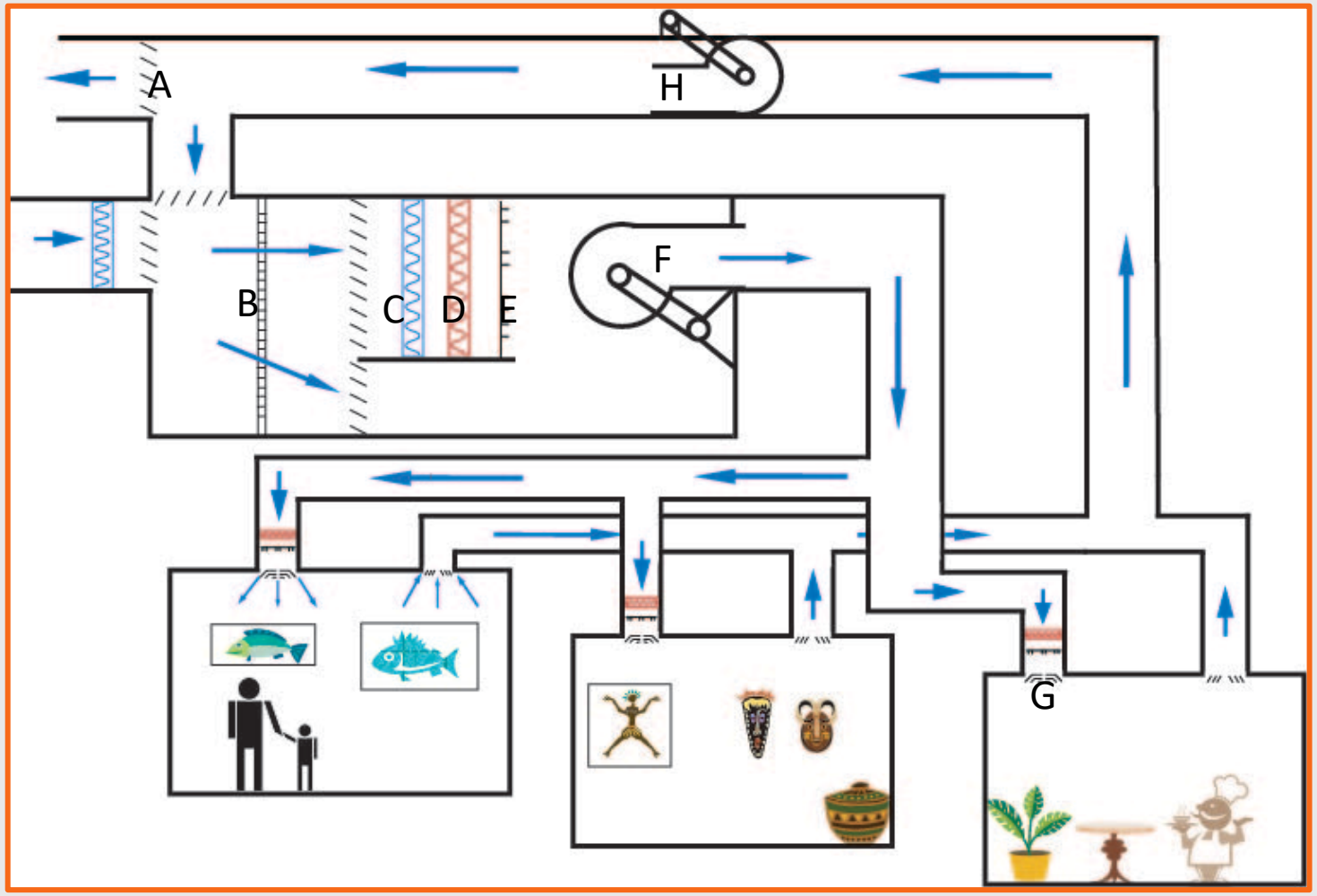
D: Heating Coil

E: Humidifier

F: Supply fan

G: Diffusers

H: Return Fan



Dual Duct Air Handling Unit

A: Filters

B: Supply Fan

C: Cooling Coil

D: Heating Coil

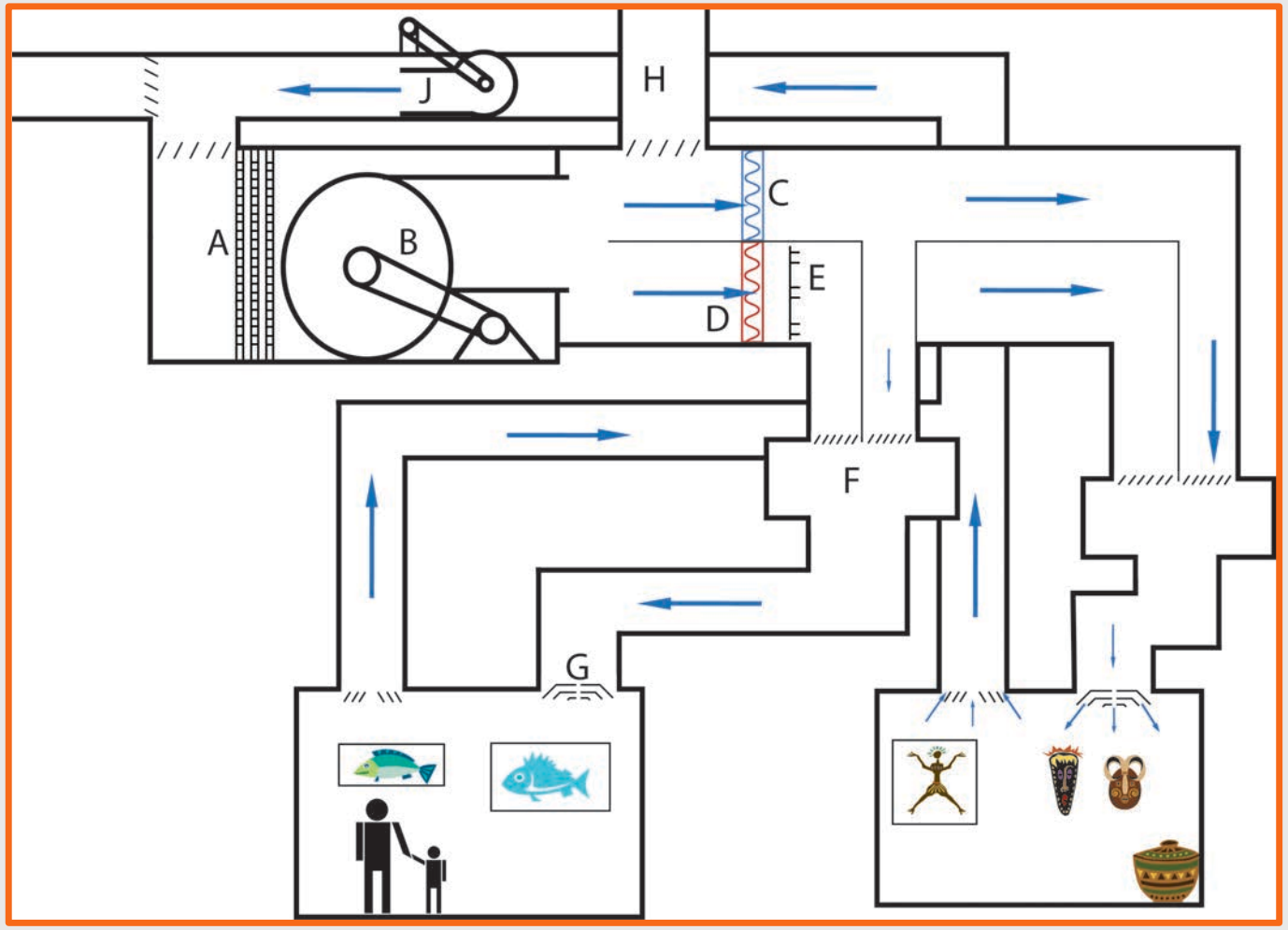
E: Humidification Coil

F: Mixing Box

G: Diffuser

H: Outside Air

J: Return Fan



Forced Air Heating and Cooling

A: Exhaust Fan

B: Compressor

C: Condenser Coil

D: Expansion Valve

E: Evaporator Coil

F: Heating Coil

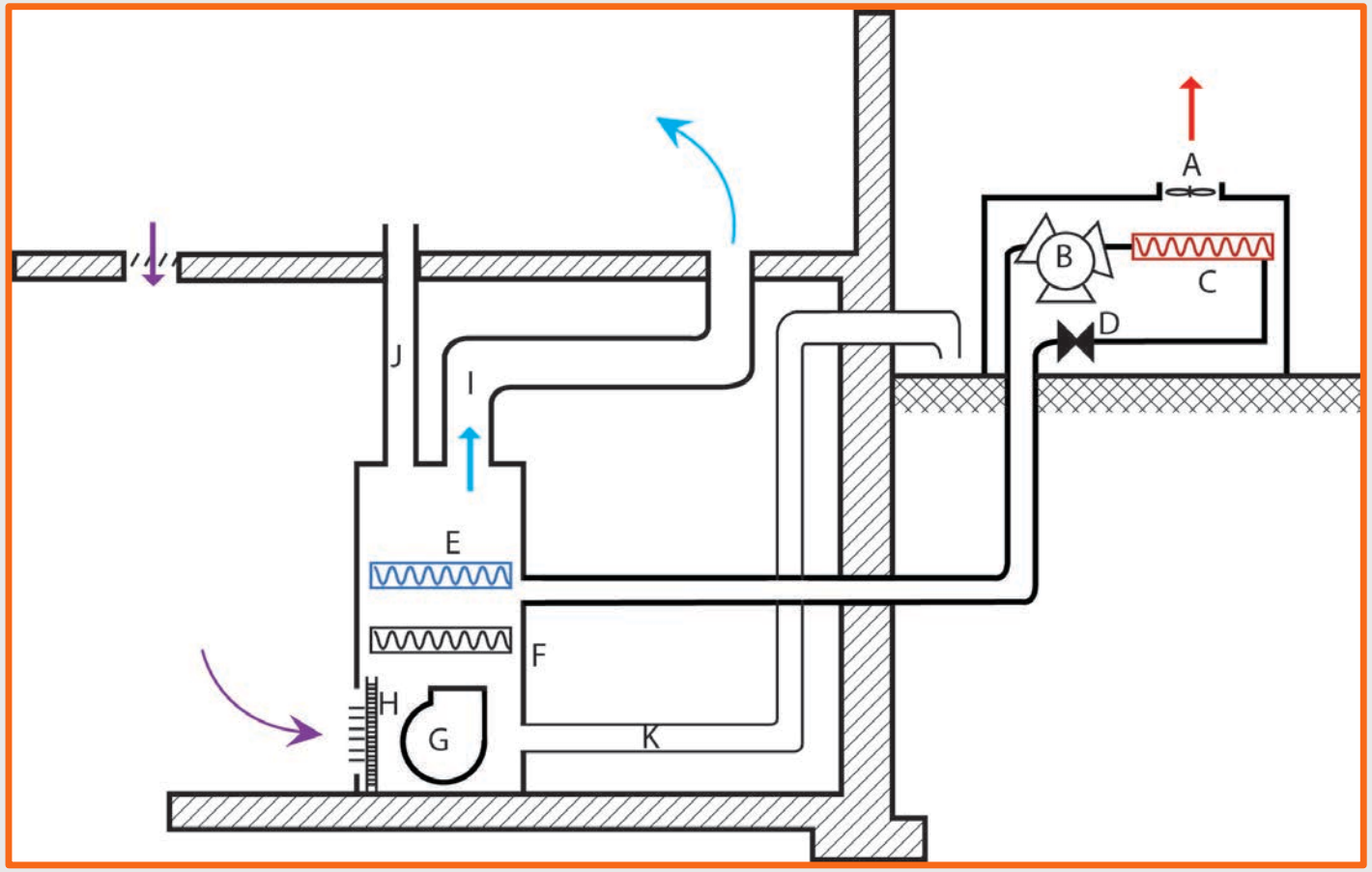
G: Blower Fan

H: Filter

I: Supply Duct

J: Vent

K: Outside Air Intake



Induction Heating Unit

A: Thermostat

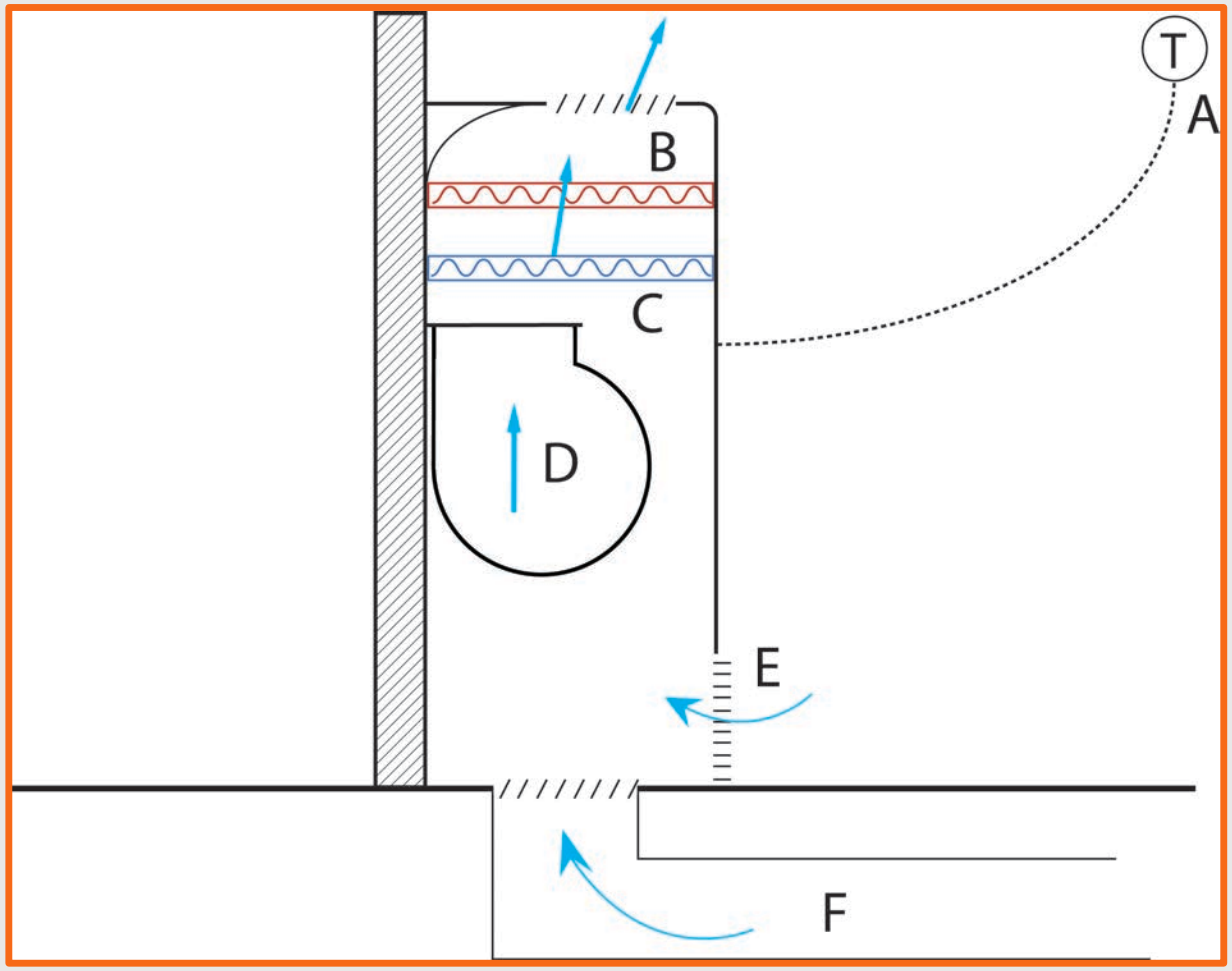
B: Heating Coil

C: Cooling Coil

D: Fan

E: Return Air

F: Pre-treated Air



Desiccant Air Dryer

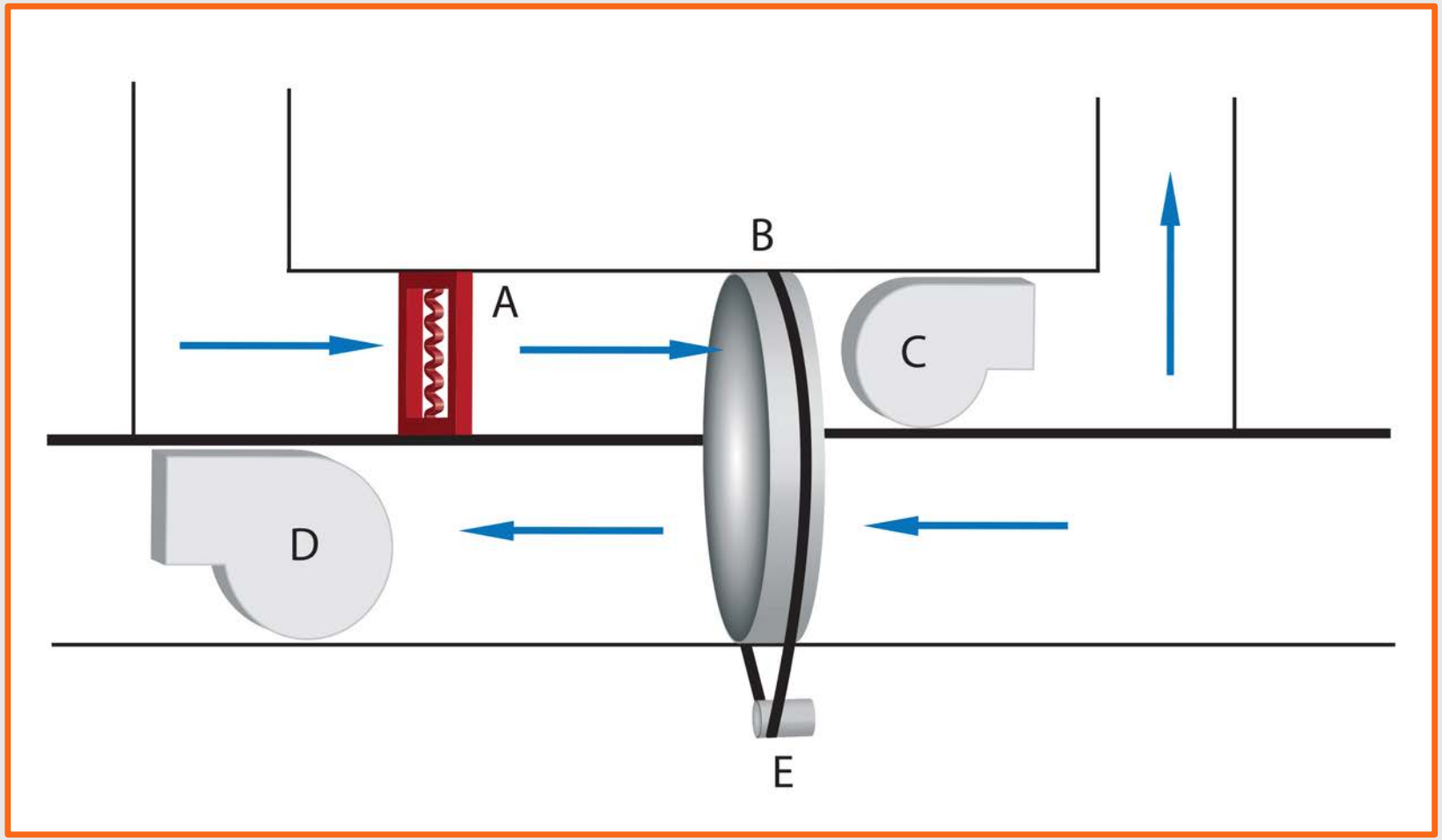
A: Heating Coil

B: Desiccant Wheel

C: Exhaust Fan

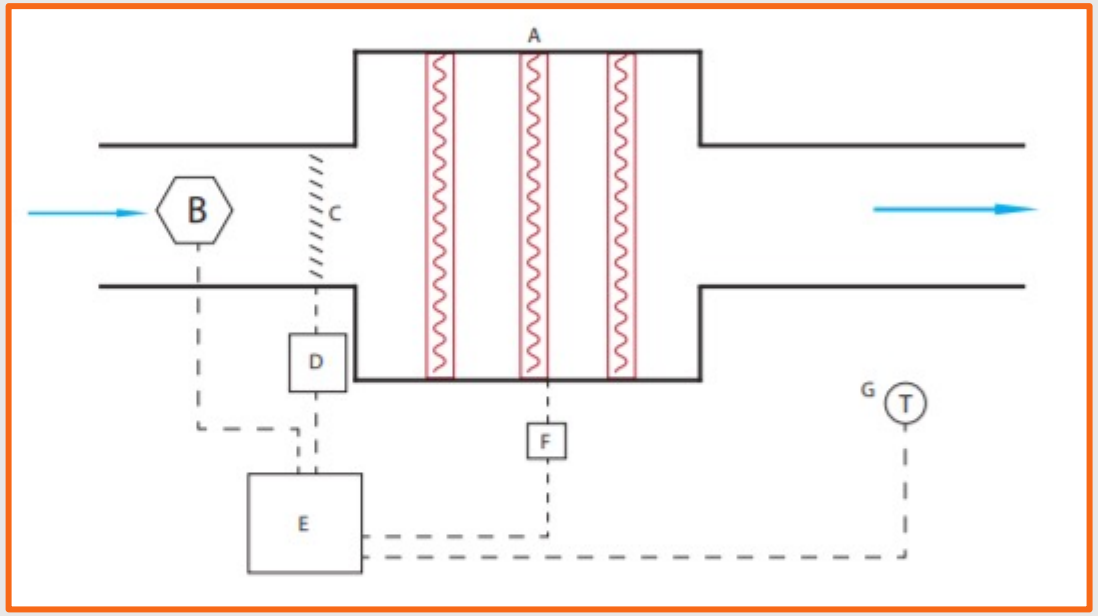
D: Supply Fan

E: Fan Motor



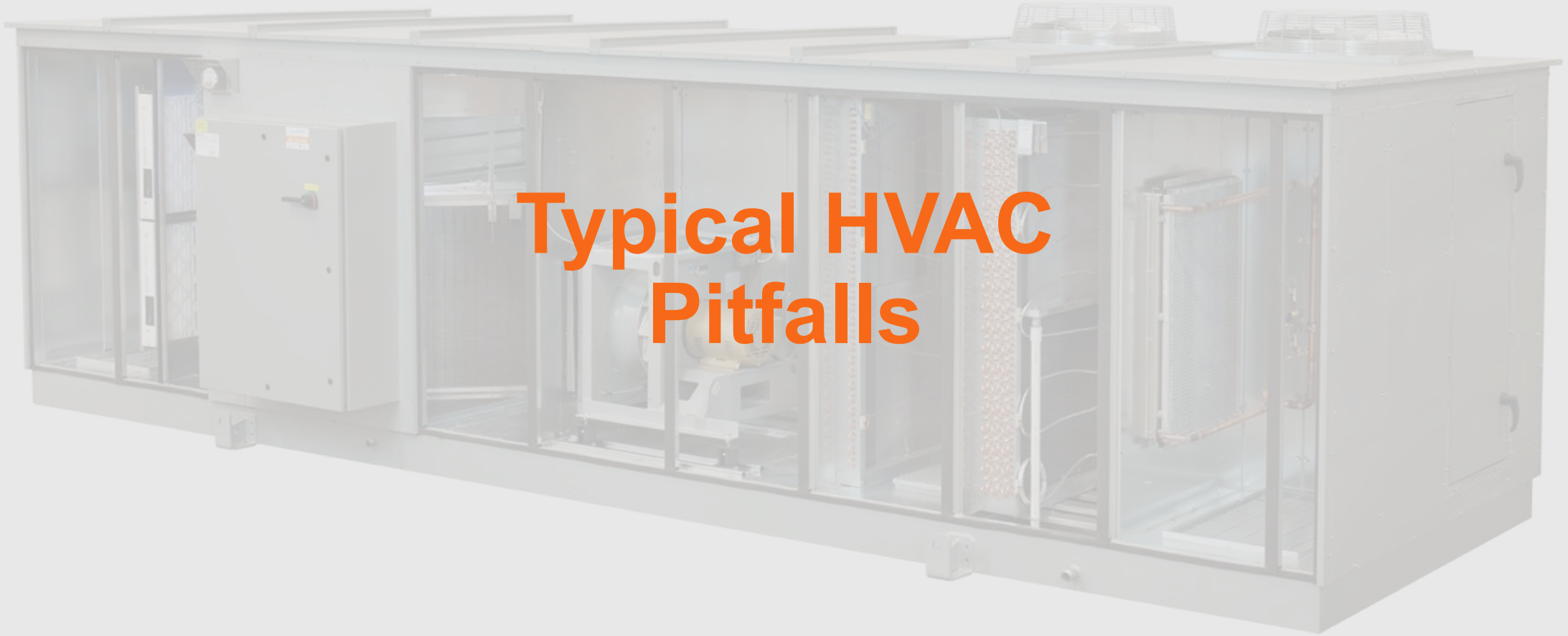
Variable Air Volume (VAV) System

- Temperature is controlled by controlling the volume of air that is discharged into the space
- Energy efficient and widely used
- Usually combined with VSD on the fan



Dedicated Outside Air Unit

- Pretreats outside air before sending it to other AHUs
- Designed to remove latent loads



Typical HVAC Pitfalls

Blocking supply and return vents

- Boxes stacked too high or materials, blocking air vents
- Dampers on vents closed restricting air flow
- All supply or return vents should have at least 18 inches of clearance around them

Dirty/ Missing Filters

- Filters should be routinely changed or cleaned
- Fouled or dirty filters should be replaced when they are found
- An HVAC system should never operate without filters in place
- Upsizing the filter my result in low airflow if the system was not designed to use that filter

Broken Dampers

- Broken dampers can restrict airflow through a system
- They can stop air from entering a room or space
- A seized damper can allow too much air into a space if it has seized in the open positon

Unbalanced System

- When a building or room is designed the HVAC system is balanced to ensure that a designed amount of air flows to each space
- Over time as a building functions adjustments to the system are made and it can become unbalanced
- If there are questions about airflow the balanced of the system should be checked

Sensors not calibrated

- Sensors on an HVAC system should be calibrated at least once every 5-7 years
- Poor sensor calibration can lead to temp and RH issues in a space
- Sensor calibration can be compared to data from a new logger

What You Can Do

What You Can Do

- Monitor the space
  - Collect temp and RH data
  - Conduct regular walkthroughs
- Communicate and collaborate with facilities staff
  - Report concerns as soon as they arise
- Don’t block vents
- Understand risks
  - Establish reasonable set points

How to Manage Outside Air

- On demand ventilation or demand controlled ventilation
  - Sensors are used to measure the concentration of pollutants in the air and adjust the amount of outside air used by a the HVAC system to compensate. Controls ventilation rate to maintain a specific indoor air quality. Normally based off of CO_2 levels
    - Will work for human occupied spaces
    - Helps keep CO_2 and other pollutant levels low
    - Helps reduce energy use

Contaminated Outside Air

- **If the event is short term**
  - Turn the system off if possible
  - Reduce outside air consumption

- **If the event is long term**
  - If possible close the outside air dampers
  - If possible add filters MERV 13 or higher – the higher the rating the greater the removal capacity – the higher the rating the more it will impact airflow
  - Possibly add gas phase filters – same hindrance to air flow as MERV filters

Support Continual Maintenance

- Ensure that all belts are tight and in good shape and bearings are lubricated
- Ensure that all filters are cleaned and replaced regularly
- Ensure that all heat transferring surfaces (heating and cooling coils) are clean
- Ensure that the system is balanced
- Keep all humidification equipment in working order
- Keep all faults and alarms working properly

Benefits of Commissioning

- Buildings and systems are functioning as intended
- Identify defects before they go out of warranty
- Reduced energy consumption, costs and environmental impact
- Facility will have thorough documentation for ongoing operations and for any future facility changes
- Achieve the best quality preservation environment from the system

Work With Us

IPI offers a range of remote and onsite preservation consulting services based on
35+ years of applied research

Sustainability and Resilience Services

Data Analysis

Film Storage Assessment

Mechanical System Analysis and Optimization

Mechanical System Design Consultation

Preservation Commissioning

Grants/Funding

- NEH Sustaining Cultural Heritage Collections
- NEH Preservation Assistance Grants for Smaller Institutions
- IMLS Museums for America
- IMLS Inspire! Grants for Small Museums
- AIC Collections Assessment for Preservation (CAP)
- Database of State Incentives for Renewables & Efficiency®
  - DSIRE

Workshops

- Planning a series of 2 day sustainability workshops
- A brief survey will appear at the end of this presentation

Webinar

- Next Webinar will be December 3rd
  - Best tools to use for evaluating your facility

Thank you!

https://ipisustainability.org
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