Fans, Ducts and Air Handling Systems: Design, Performance and Commissioning Issues

Evaporative Cooling

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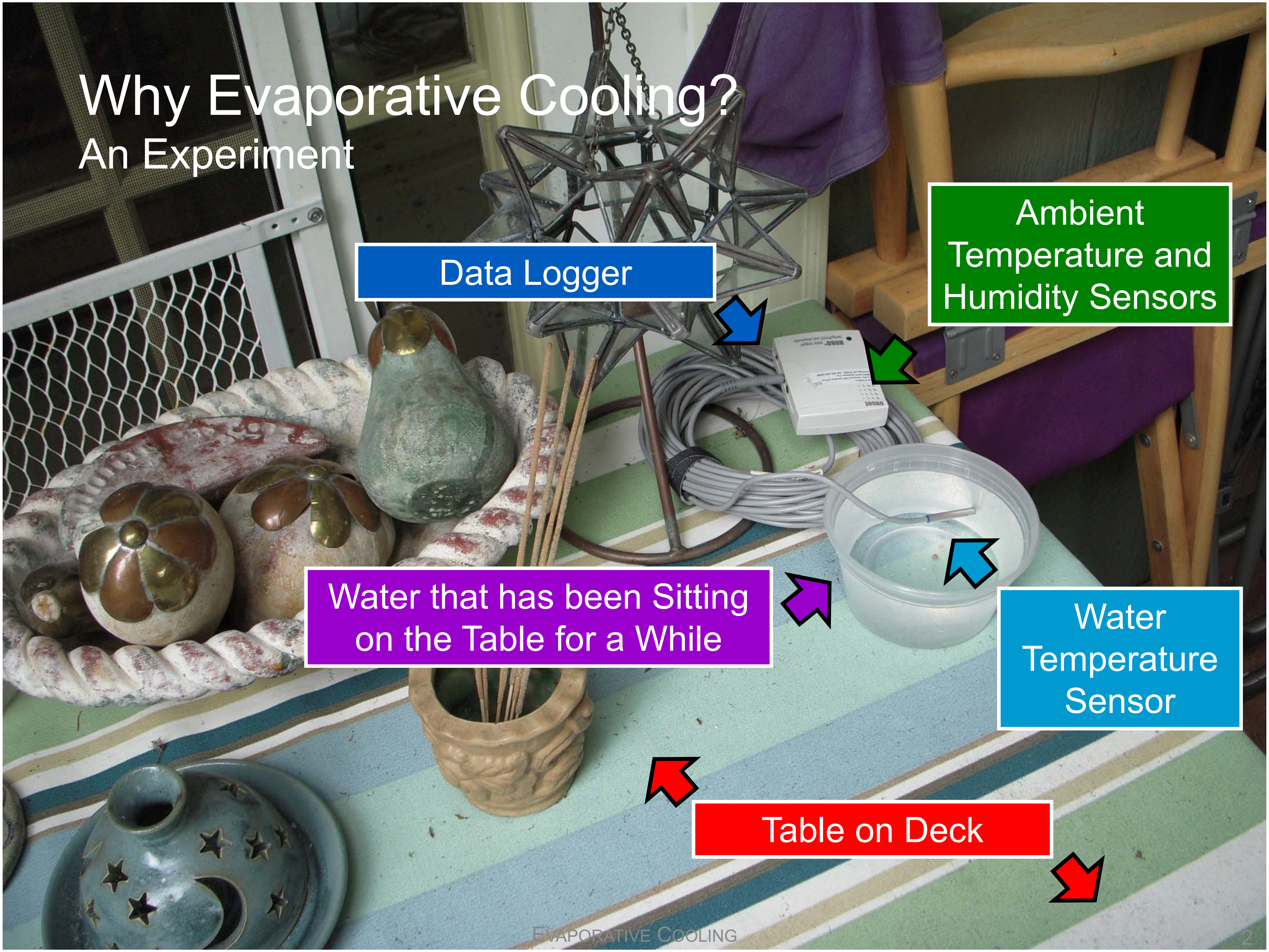
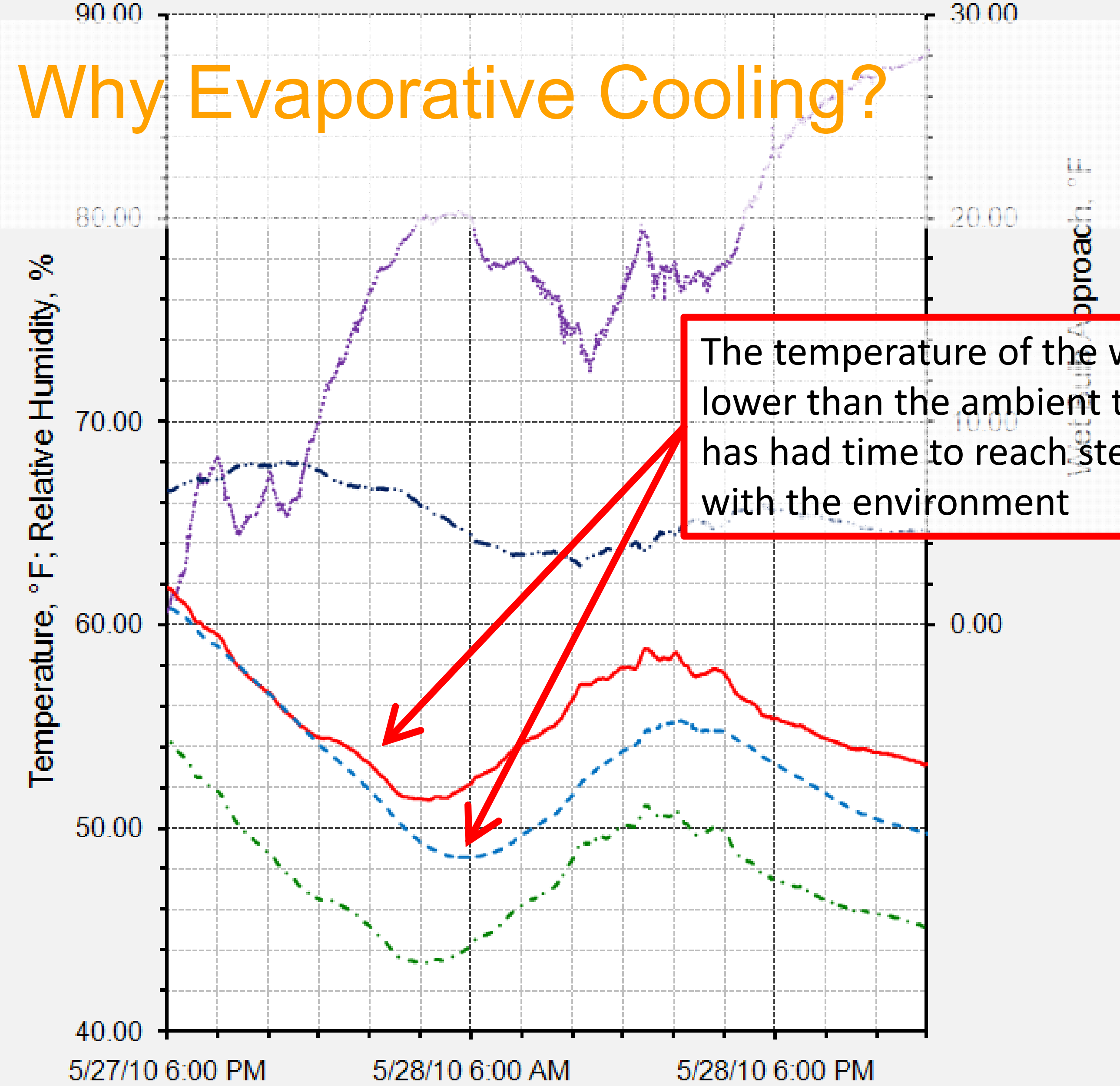
Why Evaporative Cooling?
An Experiment

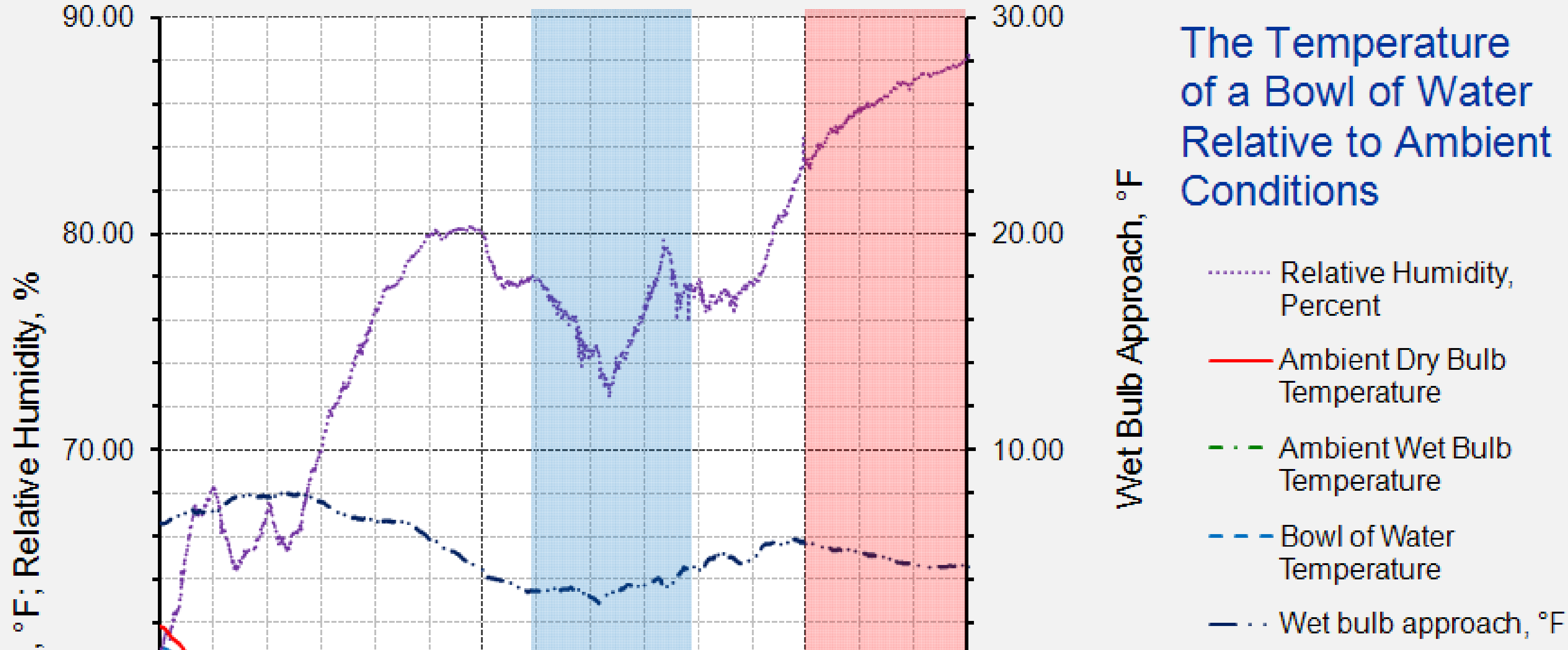


Why Evaporative Cooling?



The temperature of the water in the bowl is lower than the ambient temperature once it has had time to reach steady state conditions with the environment

The Temperature of a Bowl of Water Relative to Ambient Conditions



At low relative humidity, the approach to wet bulb temperature is closer than at high relative humidity

Characteristics of Free Cooling via an Evaporative Process

Water is not free

- Evaporating 1 lb of water at 75°F = 970 Btu
- 1 ton of cooling = 12,000 Btu/hr
- 1 ton of cooling = 1.49 gallons of water
- 1 ton of cooling = $0.005 (Portland Oregon rates, 02/2011)

Producing 100 tons of cooling for 24 hours using an evaporative process would cost about $13 for water

Characteristics of Free Cooling via an Evaporative Process

Water quality needs to be maintained

- Basin water is a good breeding ground for microorganisms
- Evaporation leaves minerals behind
  - Minerals will form scale
  - Scale degrades the equipment

Characteristics of Free Cooling via an Evaporative Process

- Maintaining water quality
  - Make up extra water to dilute solids by “blowing down” the system when solids build up
  - Inspection and cleaning required on a regular basis
  - Treat water for biological growth

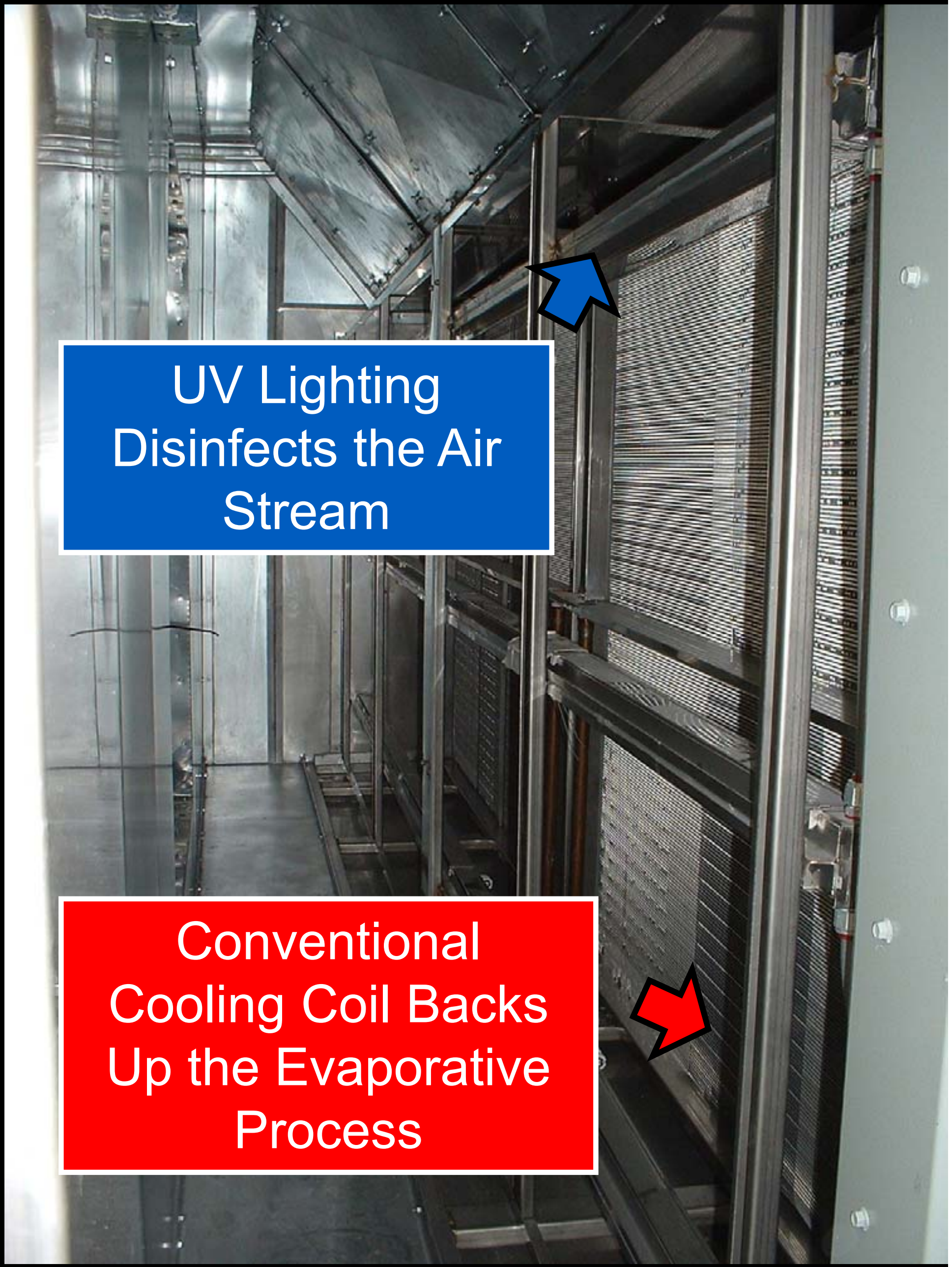
Characteristics of Free Cooling via an Evaporative Process

Systems will be 100% Outdoor air

- Other utilities will have to deal with 100% outdoor air
- Filters will have to deal with 100% outdoor air

Back up systems erode some of the savings potential

- Extra coils = Extra first cost = longer payback
- Extra coils = Extra pressure drop = More fan energy = More fan heat = More cooling required



Characteristics of Free Cooling via an Evaporative Process

Cooling is produced by evaporating water into the air stream

- Discharge temperatures approach the web bulb temperature entering the evaporative process
- All other things being equal, spaces served with evaporative cooling will be more humid than spaces served by conventional cooling

Some Definitions

Direct Evaporative Cooling

The system air comes in direct contact with the water that is evaporated to provide cooling

- *Cools but adds humidity to the primary air stream*

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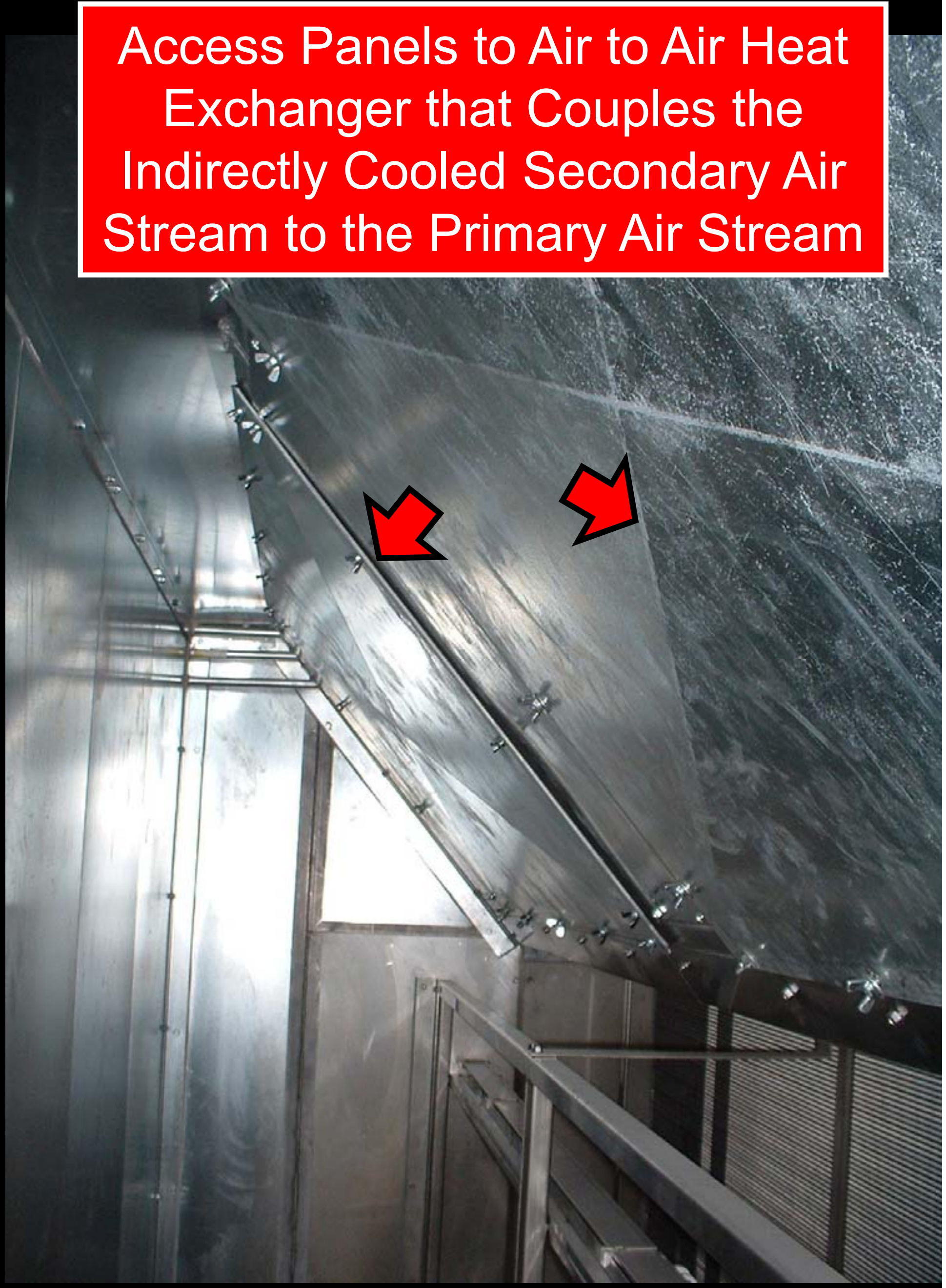
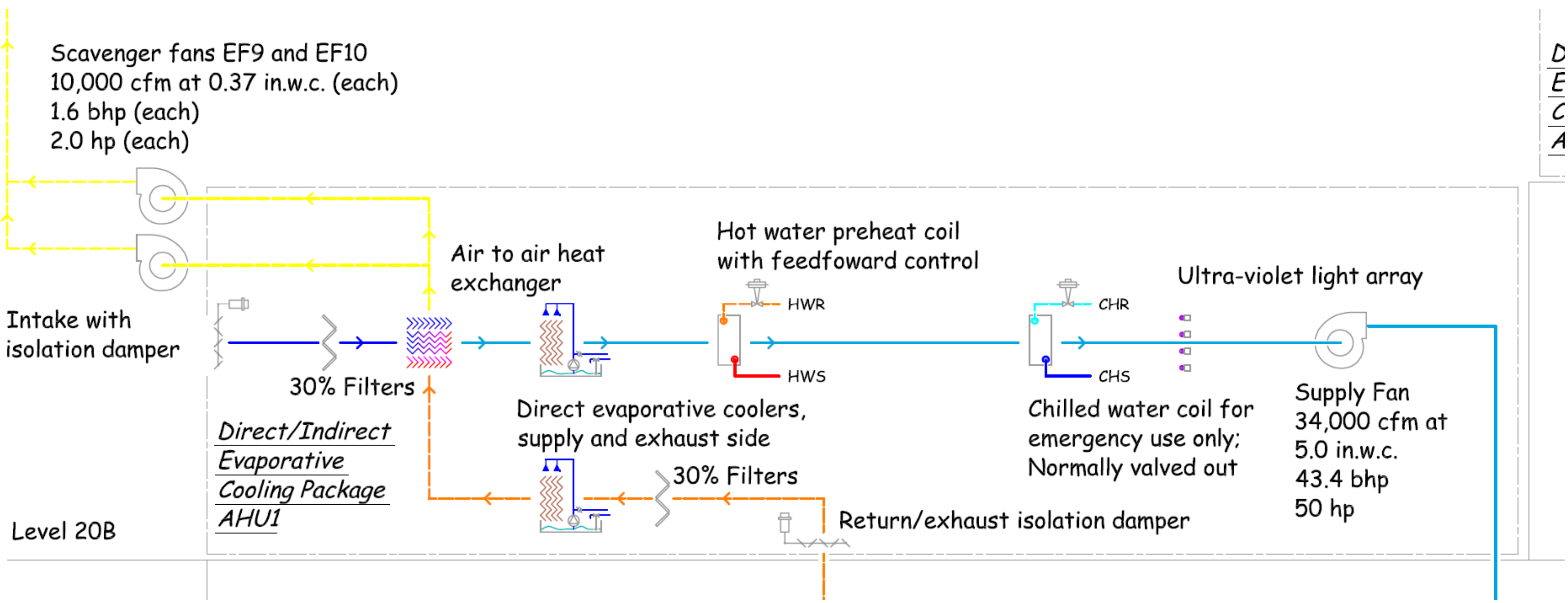
Indirect Evaporative Cooling

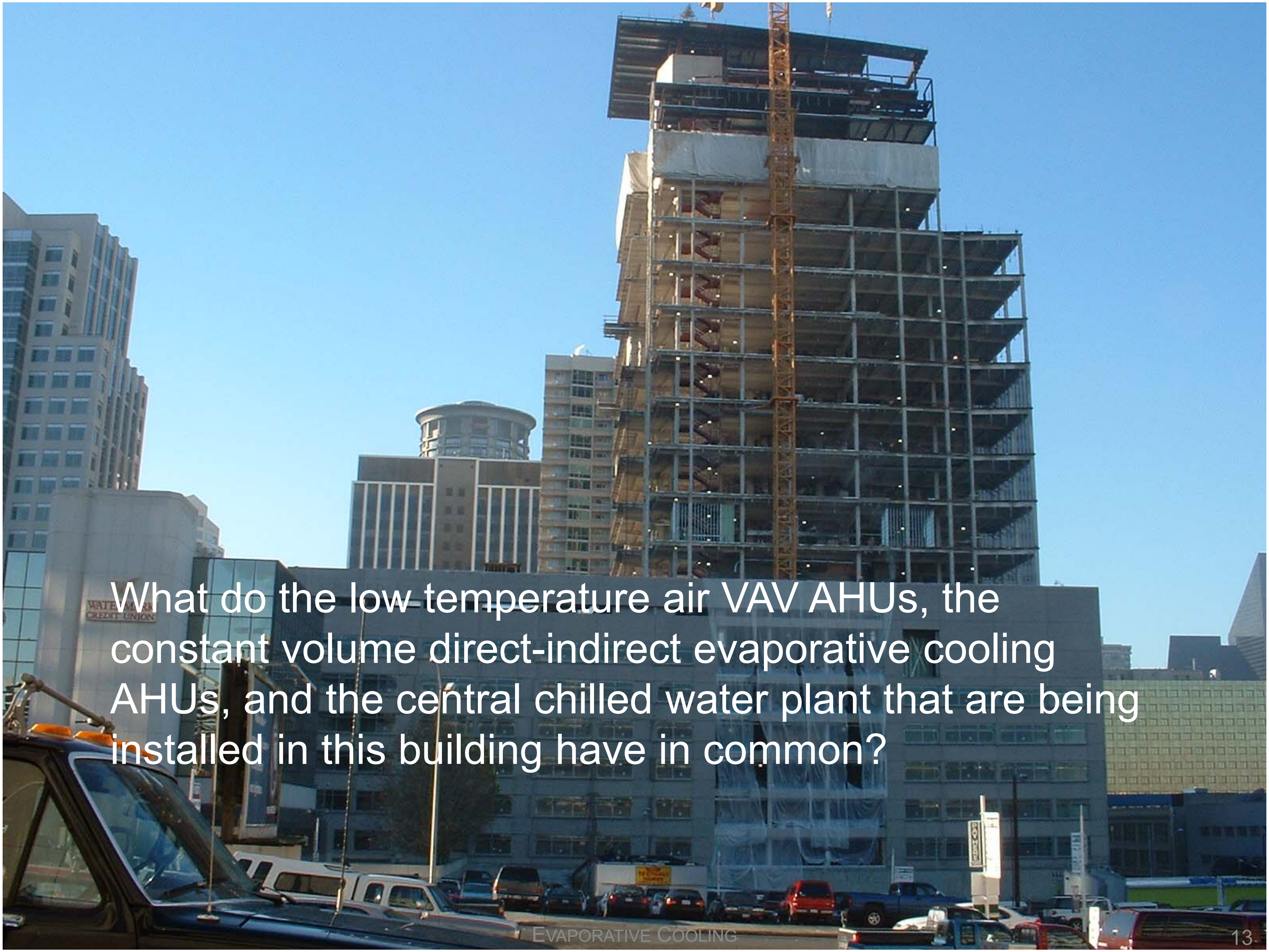
A secondary air stream is cooled by a direct evaporative process and then used to cool the primary air stream

- *Cools with out adding humidity to the primary air stream*



An Evaporatively Cooled AHU





What do the low temperature air VAV AHUs, the constant volume direct-indirect evaporative cooling AHUs, and the central chilled water plant that are being installed in this building have in common?

They all share and interact with the air that is moving in these common return air shafts and plenums

A Bit of Information About the AHUs

Direct/Indirect Evaporative Cooling AHUs

- 120,000 cfm total
- Discharge air at 68.8/67.8 tdb/twb
- Space condition – 75°F/77% RH

Low Temperature Air AHUs

- 380,000 cfm total
- Discharge air at 42.9/42.7 tdb/twb
- Space condition – 72°F/38% RH

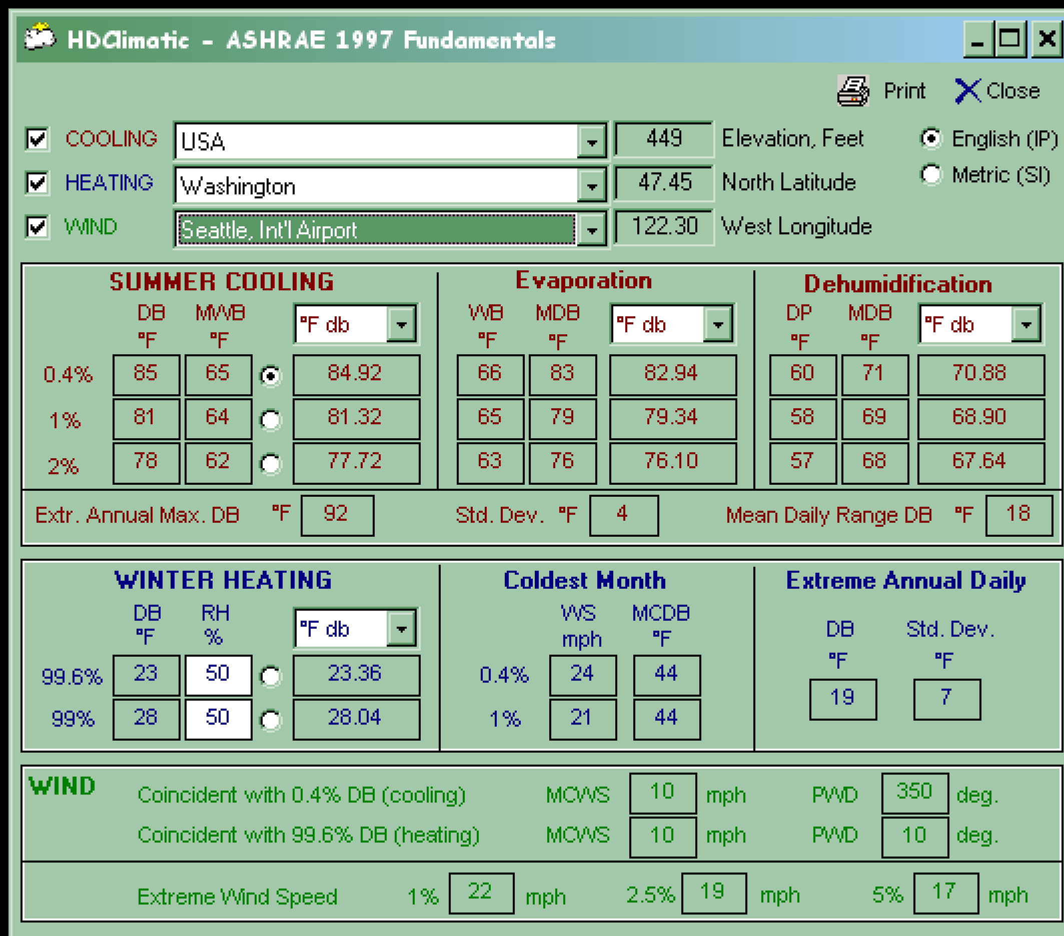
A Couple of Questions

Do you think the shared plenum space and related mixing of the various air streams is a good thing, a bad thing or doesn't matter?

If it does matter:

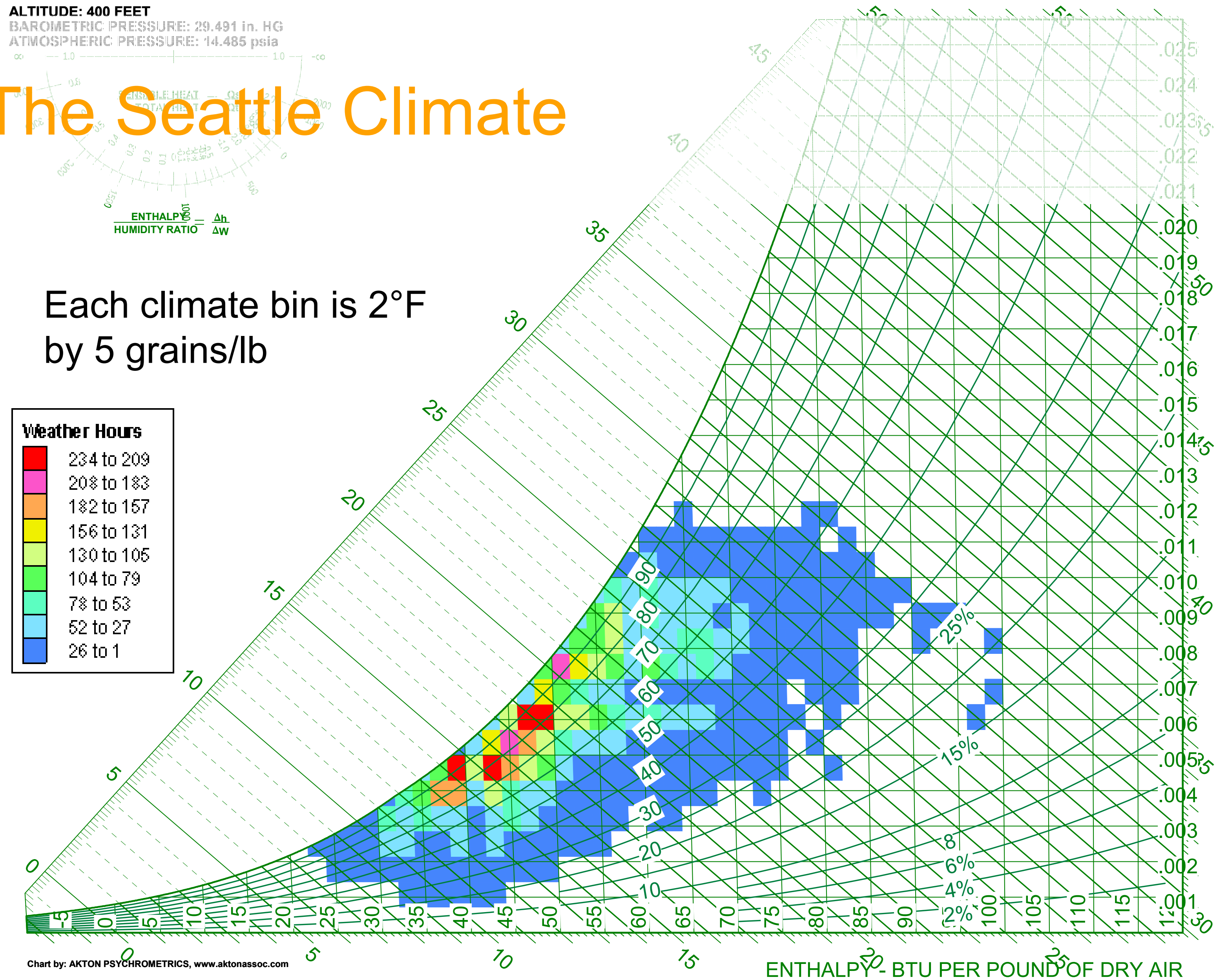
- Why?
- Is there an energy or performance issue?
- How would you assess any energy or performance issues?

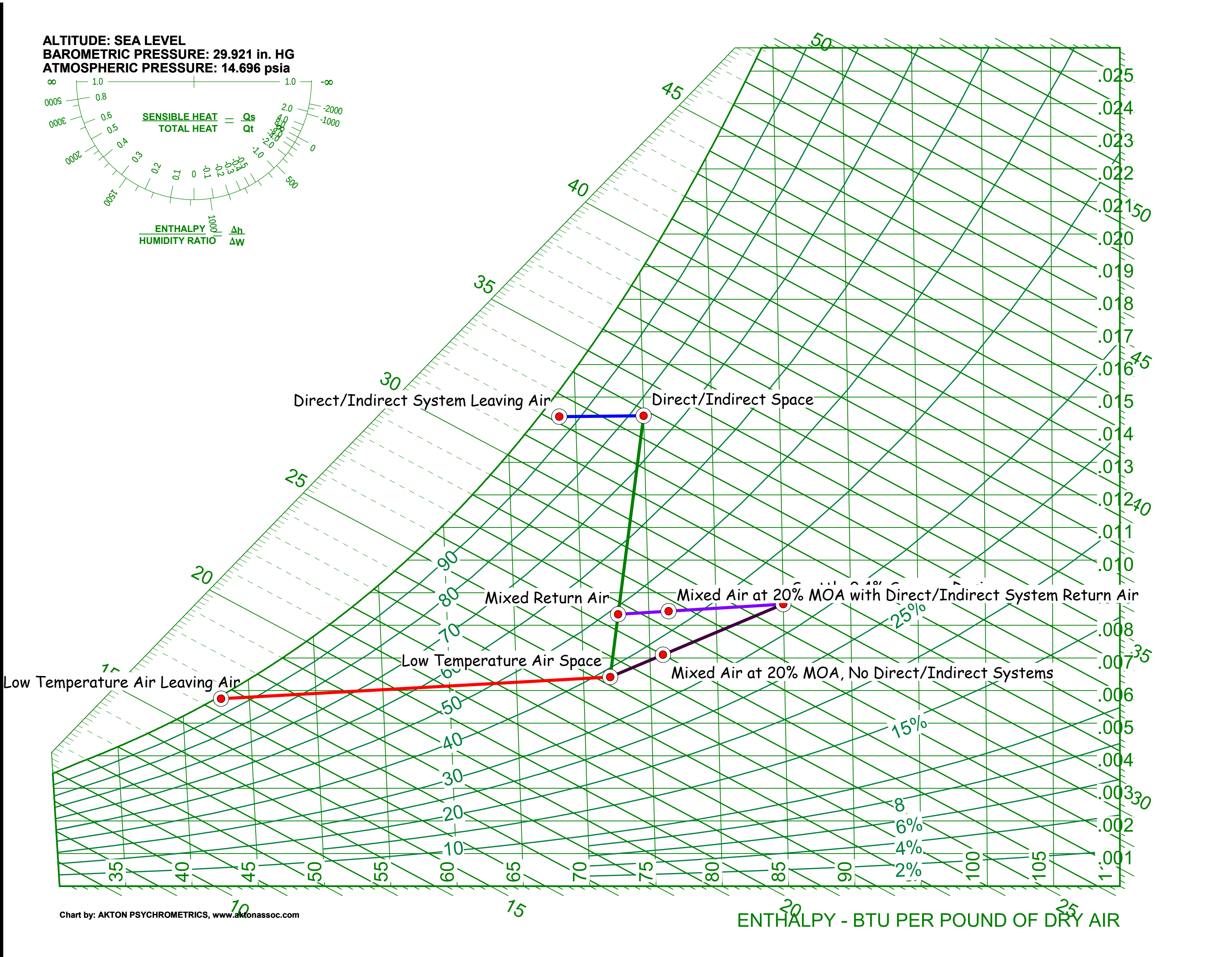
Seattle Design Conditions



The Seattle Climate

Each climate bin is 2°F
by 5 grains/lb





ALTITUDE: SEA LEVEL
BAROMETRIC PRESSURE: 29.921 in. HG
ATMOSPHERIC PRESSURE: 14.696 psia
SENSIBLE HEAT / TOTAL HEAT = Qs / Qt
ENTHALPY / HUMIDITY RATIO = Δh / ΔW
Direct/Indirect System Leaving Air
Direct/Indirect Space
Mixed Return Air
Mixed Air at 20% MOA with Direct/Indirect System Return Air
Low Temperature Air Space
Mixed Air at 20% MOA, No Direct/Indirect Systems
Low Temperature Air Leaving Air
Chart by: AKTON PSYCHROMETRICS, www.aktonassoc.com
ENTHALPY - BTU PER POUND OF DRY AIR

Total Load

$$Q = 4.5 \times cfm \times \Delta h$$

Where :

Q = Load in btu/hr

4.5 = A units conversion constant

cfm = Flow rate in cubic feet per minute

Δh = Enthalpy difference across the element in btu/lb/°F

The Seattle Climate

Each climate bin is 2°F by 5 grains/lb

Given the Seattle Climate, are there any other energy implications associated with the decision to use low temperature air systems?