Control Sequences & Sensors

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OVERVIEW

CONTROLS & SENSORS
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Today's Presenter

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Education
Bachelor of Science, Mechanical Engineering
NC State University
Master of Business Administration
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Biography
Chris Adams, PE is currently the VP of Engineering for Insight Partners, a Manufacturing Representative Firm that represents Aaon, Inc., Marley Cooling Towers, Armstrong Pumps, Samsung VRF, Quantech Chillers, and numerous other air and water treatment lines. Chris' area of expertise is the proper conditioning, treatment, and control for optimal indoor air quality using air or water systems as it relates to Energy Efficiency, Mold/Mildew, Chloramines, and Demand Control Ventilation. Prior experience includes President and Owner of Adams Companies, a Rep Firm covering the Carolinas for air side products. Additional Experience includes a Sales Engineer for servicing Coal, Natural Gas, and Nuclear Power Plants for General Electric. During his employment with General Electric, Chris completed the Six Sigma Training Program achieving the highest level of quality control as a Master Black Belt. Chris' leadership activities include board positions with ASHRAE in Region IV, Charlotte, NC, and Greenville, SC as well as a current member and Jack Stickley Fellow for the Lake Norman Lions Club.

Relative Humidity vs Dew Point
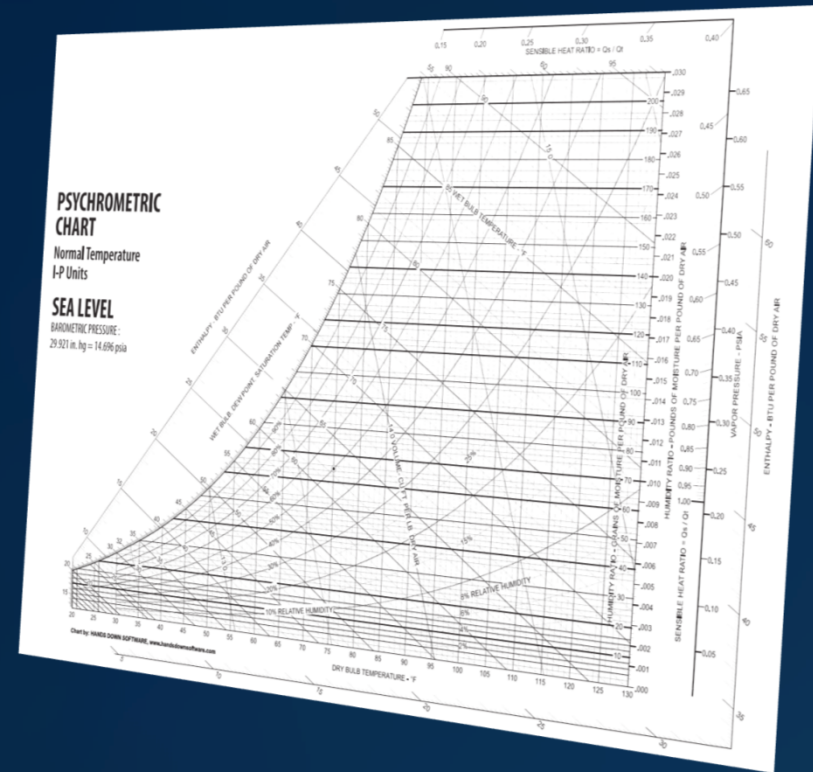
Relative Humidity

NOT a good measure of moisture in the air

Dew Point

Accurate measurement of moisture content in the air

PSYCHROMETRIC CHART

Normal Temperature
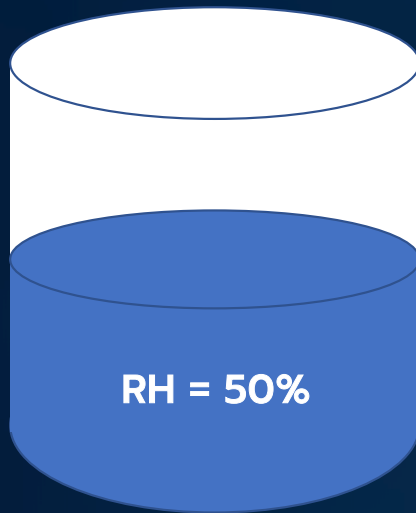I-P Units

SEA LEVEL
BAROMETRIC PRESSURE :
29.921 in. hg = 14.696 psia

RH is % of moisture in the air vs. how much it can hold. It is RELATIVE to Temperature
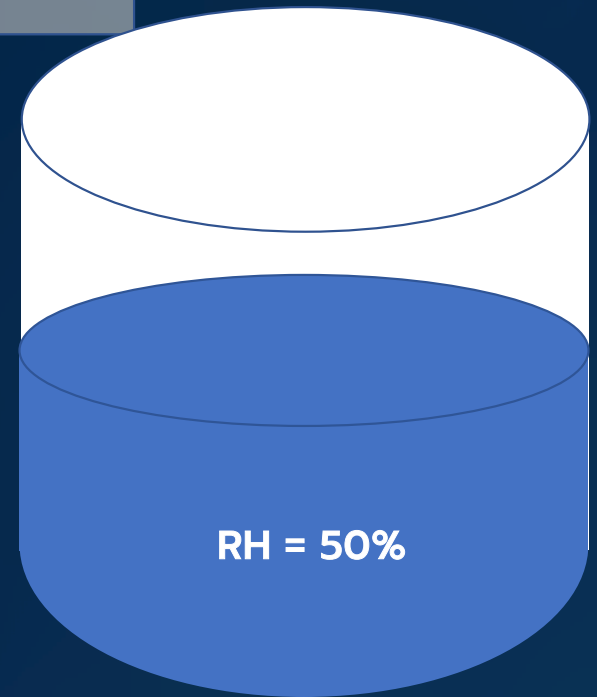
RH = 50%

RH = 50%

RH = 50%

Dry Bulb Temp = 55F

Dry Bulb Temp = 75F

Dry Bulb Temp = 95F

Dew Point measures when moisture will drop out of suspension

RH = 50%
Dry Bulb Temp = 55F
Dew Point = 37F
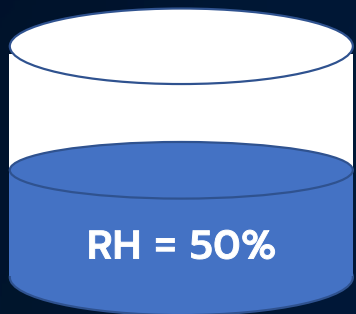
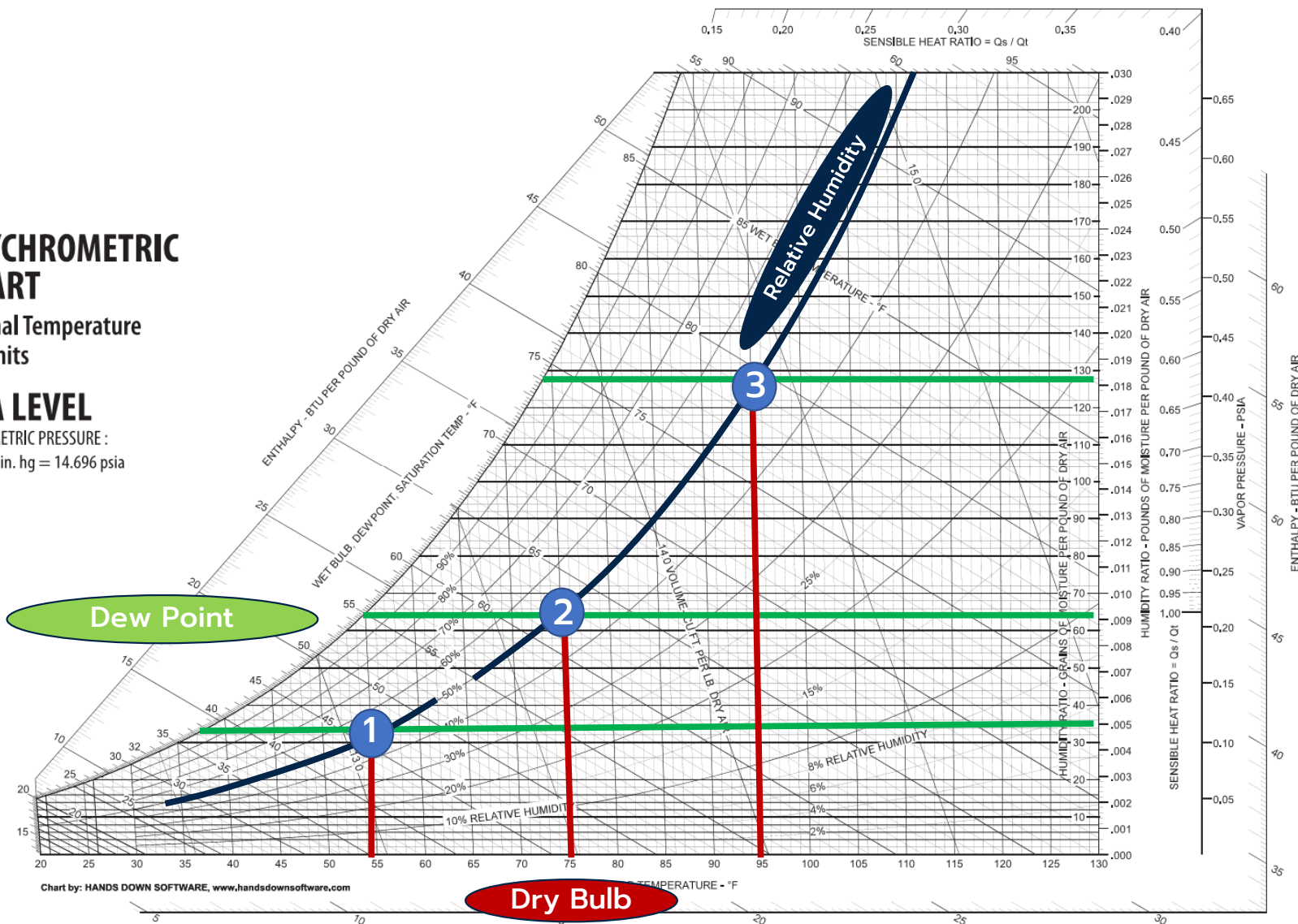RH = 50%
Dry Bulb Temp = 75F
Dew Point = 55F

RH = 50%
Dry Bulb Temp = 95F
Dew Point = 74F

INSIGHT PARTNERS
Controls & Sensors

Controls Basics

No such thing as a bad controller, but lots of bad programmers!

Must Understand Psychrometrics to Optimize

BEING A PROGRAMMER

My mom said "Honey, please go to the market and buy 1 bottle of milk. If they have eggs, bring 6."

I came back with 6 bottles of milk.

She said "Why the hell did you buy 6 bottles of milk?"

I said "Because they had eggs!!"

Controls Basics

Controls Can't Fix A Misapplied System!

Control System Types
1) Basic
2) Configurable
3) Custom

Primary Sequences
1) Variable Air Volume (VAV)
2) Single Zone VAV
3) Make-Up Air

System Types

1) Basic
   a) Thermostat – On/Off
   b) Thermostat – Programmable
2) Configurable
   a) Most Manufacturers
   b) Internal Black Box
   c) Controls Integration with Adjustments ← Most Common in Industry
3) Custom
   a) Tridium
   b) Allerton
   c) Distech
   d) Etc.

AAON Control Options

- AAON TS Mini Controller (T'Stat w/ BACNet/MSTP)

- Custom JACE - Tridium (Vykon, Edge10, FX Explorer, Etc.)

- AAON - WattMaster Control (BACNet/MSTP Standard, Proprietary w/ Translation)

- Terminal Strip

Control Sequences

Primary Sequences
1) Variable Air Volume (VAV)
2) Single Zone VAV
3) Make-Up Air

Are we Missing Any?

- Constant Air Volume (CAV)?
- Dehumidification or Humidification?
- Pressurization

Control Sequences…MODE Sensors

Mode = Off, Venting, Heating, or Cooling

Primary Sequences
1) Variable Air Volume (VAV) ➡ Return Air Temp

2) Single Zone VAV (SZVAV) ➡ Space Temp

3) Make-Up Air (MUA) ➡ Outdoor Air Temperature

4) Dual Mode – Pick 2

Mode Sensors

Control Sequences…Secondary

Secondary Sequence Examples
1) Humidification or Dehumidification
2) Economizing
3) Pressurization
4) Air Flow Monitoring / Control
5) Filter Loading
6) Demand Control Ventilation
7) Safety – Smoke Evacuation

Control Sequences

Secondary Sequence
1) Humidification
2) Dehumidification
3) Economizing
4) Pressurization
5) Air Flow Monitoring / Control
6) Filter Loading
7) Demand Control Ventilation
8) Safety – Smoke Evacuation

Component Sequence
Internal to Unit
    Supply Fan
    Compressors
    Reheat
    Etc.

What are the *Required* Control Sensors?

Control Process Development

Development Steps
1) Application? Classrooms, High Volume O/A
   - Mode Sensor = O/A Temp
2) Humid Climate?
3) Control Moisture?
   - Add O/A Humidity
4) Space Temp Sensing?
   - Add Space Temperature
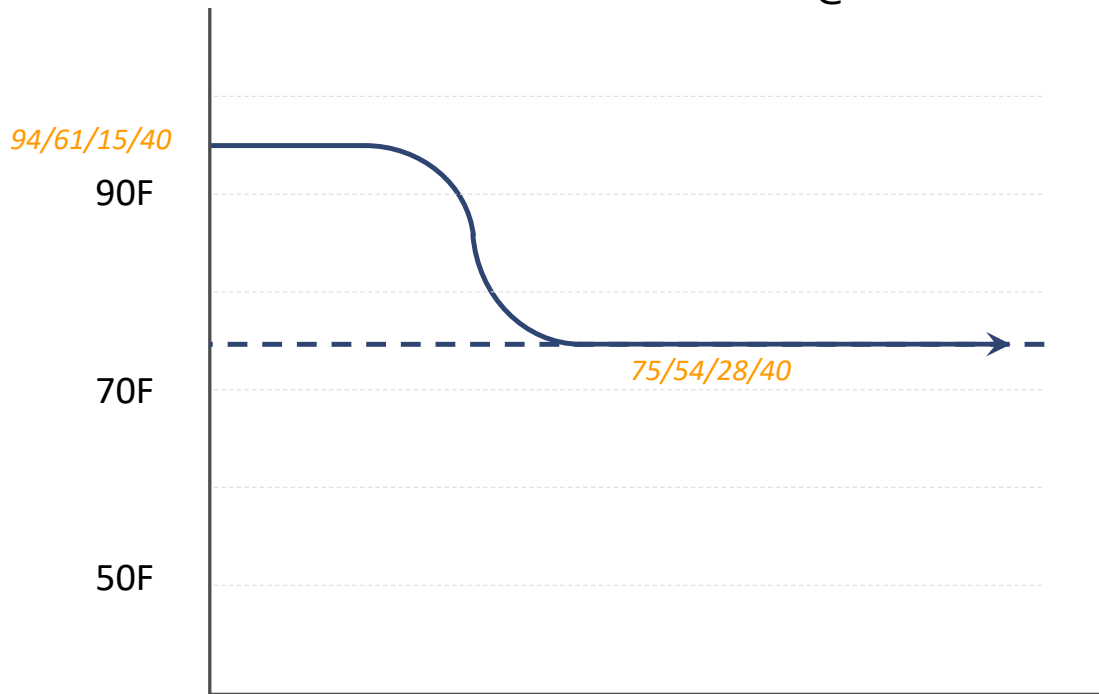5) Economizing?
6) Air Flow Monitoring?

Economizing? Poll Question

1) Application – Classroom with 25% MAU
2) Desired Space 75F, 50% RH
3) Southeast
4) Control Moisture
5) High School FULL Classroom

Room is Warm
Outdoors is Raining and about 55F

Should You Economize?

Psychrometric View – Dry Air

Room Conditions Desired – 75F @ 50% RH   *75/63/50/55*
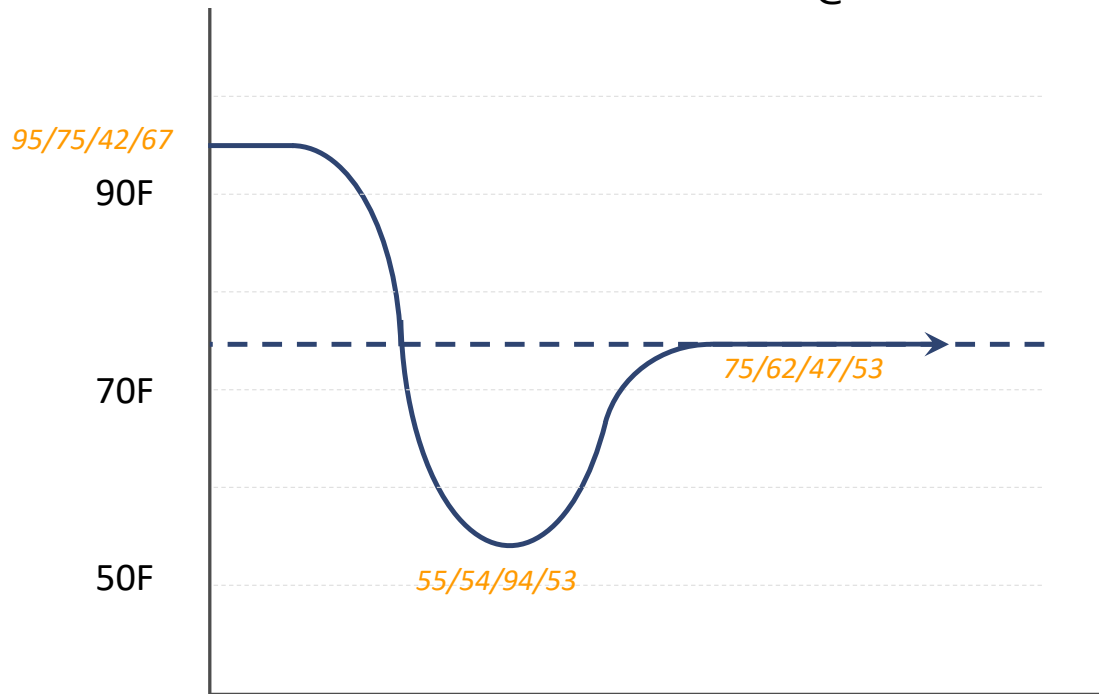
94/61/15/40

90F

75/54/28/40

70F

50F

Hot & Dry Day
1) Outdoor Air = 94F
2) Mode = Cooling
3) Neutral Air Machine
4) Turn on Compressors
5) Supply 75F

Sensible Cooling
Very Dry

(db/wb/rh/dp)

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Psychrometric View – Hot / Humid Air

Room Conditions Desired – 75F @ 50% RH   *75/63/50/55*

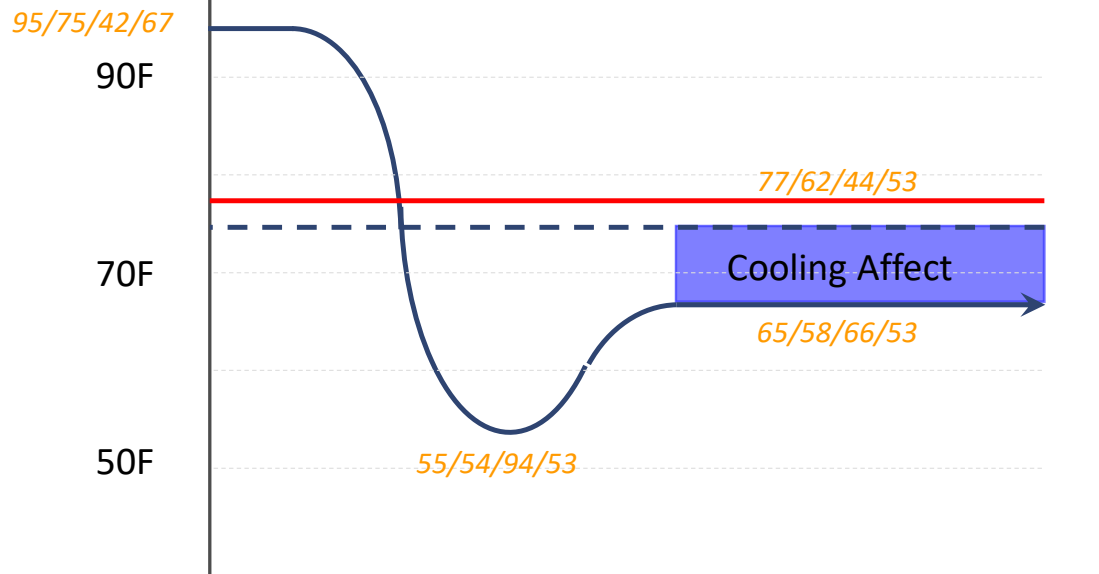*95/75/42/67*

90F

70F

50F

55/54/94/53

75/62/47/53

Hot & Dry Day
1) Outdoor Air = 95db/75wb
2) Dewpoint = 67F
3) Mode = Cooling & Dehum
4) Neutral Air Machine
5) Turn on Compressors
6) Cool to Space Desired DP.
7) Reheat to Supply 75F

Neutral, DRY Air

(db/wb/rh/dp)

Psychrometric View – Hot / Humid Air

Room Conditions Desired – 75F @ 50% RH   *75/63/50/55*

ACTUAL Room Temp = 77F, Supply Cooler

95/75/42/67

90F

77/62/44/53

70F

Cooling Affect

65/58/66/53

50F

55/54/94/53

Hot & Dry Day
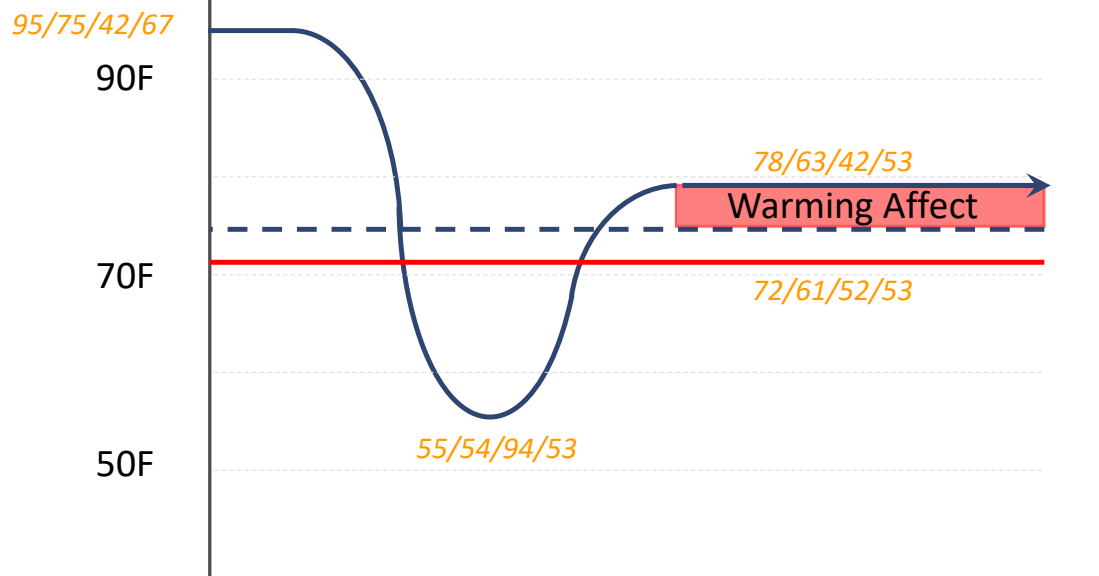1) Outdoor Air = 95db/75wb
2) Dewpoint = 67F
3) Mode = Cooling & Dehum
4) Space Temp Reset
5) Turn on Compressors
6) Cool to Space Desired DP.
7) Reheat to Supply 65-68F

Cooler, DRY Air

Psychrometric View – Hot / Humid Air

Room Conditions Desired – 75F @ 50% RH   *75/63/50/55*

ACTUAL Room Temp = 72F, Supply Warmer

95/75/42/67

90F

78/63/42/53

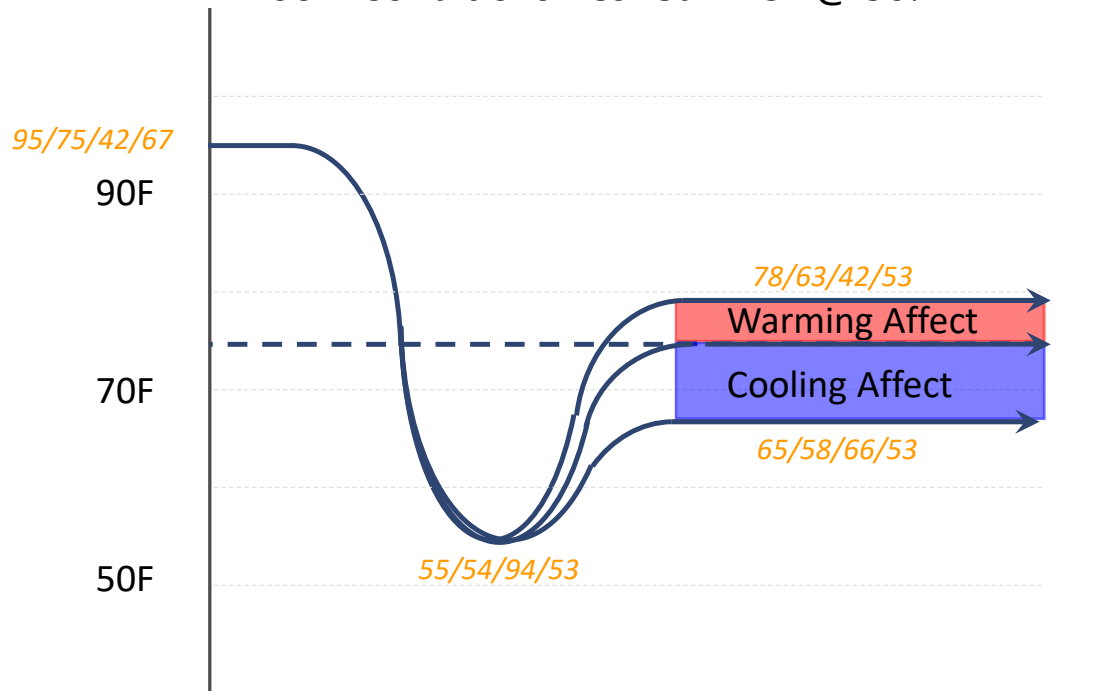**Warming Affect**

70F

72/61/52/53

55/54/94/53

50F

Hot & Dry Day
1) Outdoor Air = 95db/75wb
2) Dewpoint = 67F
3) Mode = Heating & Dehum
4) Space Temp Reset
5) Turn on Compressors
6) Cool to Space Desired DP.
7) Reheat to Supply 78F

Warm, DRY Air

(db/wb/rh/dp)

Psychrometric View – Hot / Humid Air

Room Conditions Desired – 75F @ 50% RH *75/63/50/55*

95/75/42/67

90F

78/63/42/53

Warming Affect

70F

Cooling Affect

65/58/66/53

50F

55/54/94/53

Hot & Dry Day
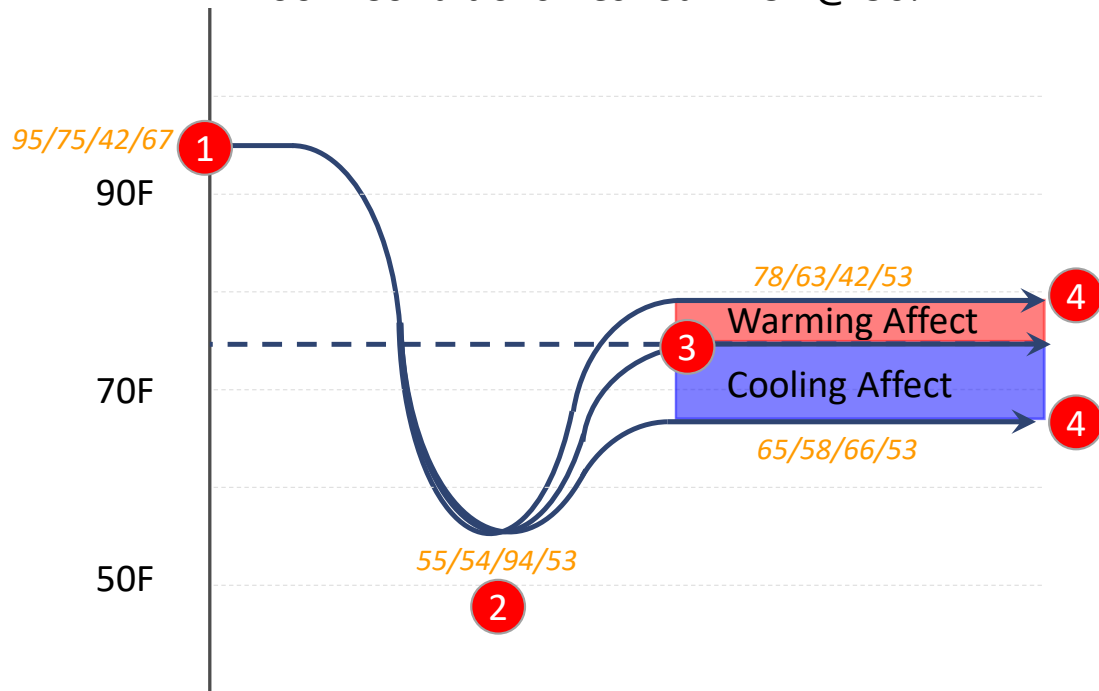1) Outdoor Air = 95db/75wb
2) Dewpoint = 67F
3) Space Temp Reset
4) Turn on Compressors
5) Cool to Space Desired DP.
6) Reheat to Space Temp Reset

Best Energy Solution

(db/wb/rh/dp)

Psychrometric View – Sensors

Room Conditions Desired – 75F @ 50% RH   *75/63/50/55*

95/75/42/67 ①

90F

78/63/42/53

Warming Affect ④

③

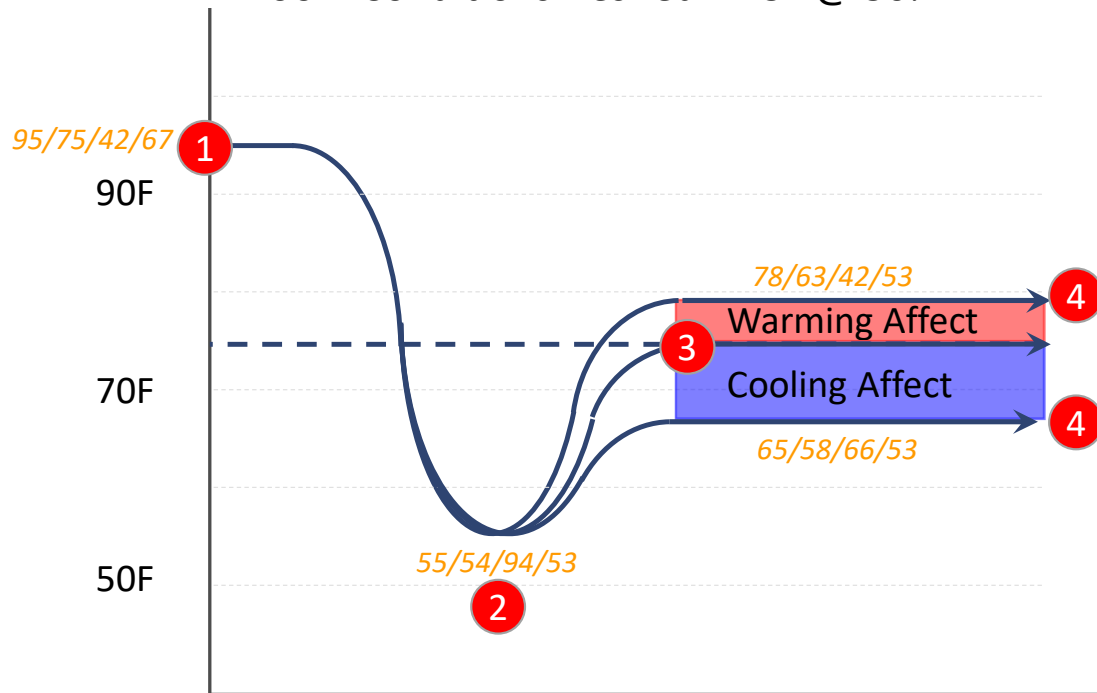Cooling Affect ④

70F

65/58/66/53

55/54/94/53

50F ②

Questions
1) Do you Need Supply Humidity?
2) Do you Need Room Humidity?
3) What is a Proper Coil Suction Temperature?

(db/wb/rh/dp)

Psychrometric View – *Required*

Room Conditions Desired – 75F @ 50% RH   *75/63/50/55*

95/75/42/67
90F

78/63/42/53
Warming Affect
Cooling Affect
65/58/66/53

70F

55/54/94/53

50F

Required Control Sensors
1) Outdoor Temp & RH
2) Coil Temp (Suction Pressure)
3) Supply Air Temp
4) Room Temp

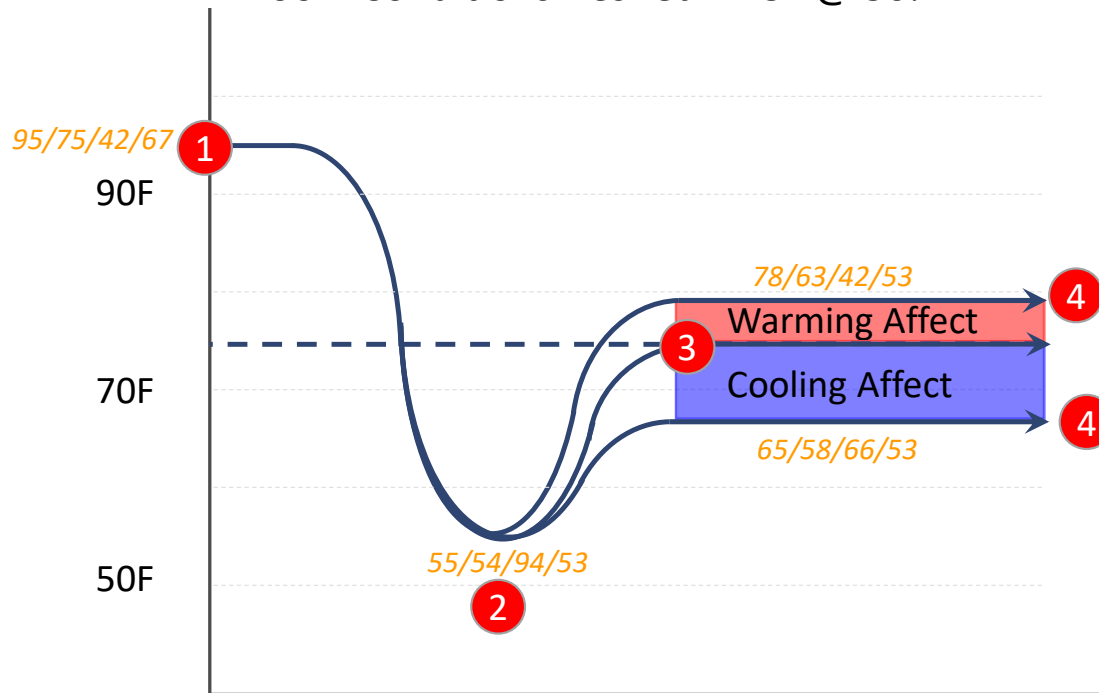**Optional Enhancement**
1) Room Humidity

(db/wb/rh/dp)

Psychrometric View – Sensors

Room Conditions Desired – 75F @ 50% RH   *75/63/50/55*

95/75/42/67 ①

90F

78/63/42/53 ④

70F

③ Warming Affect

Cooling Affect

④

65/58/66/53

50F

55/54/94/53

②

Questions
1) Do you Need Supply Humidity? No
2) Do you Need Room Humidity? No

(db/wb/rh/dp)

Component / Safety Sensors

Component / Internal Sensors
1) Proof of Flow – Pressure
2) Life Safety – Smoke Detector,
   Hi Temp Cut-Out
3) Discharge Pressure –
   Refrigerant Stability

Required Sensors
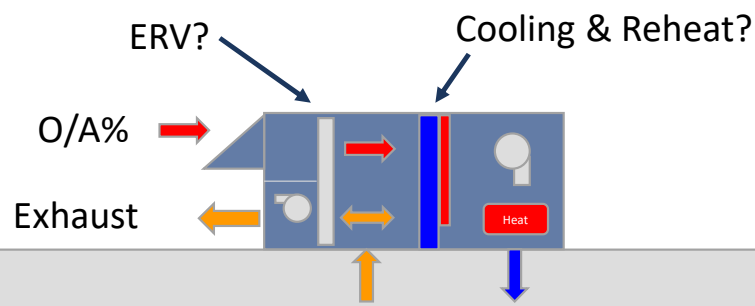1) Outdoor Temp & RH
2) Coil Temp (Suction Pressure)
3) Supply Air Temp
4) Room Temp

Optional Enhancement
1) Room Humidity

What is the Recommend Sequence?

Step 1: Understand the Application!

ERV?   Cooling & Reheat?

O/A%

Exhaust

Heat

Sequence
1) VAV
2) SZVAV
3) MAU

What is Space Application? Is it Latent or Sensible Design?

Track the Heat / Track the Moisture!

1. Permeation / Infiltration: Low Dewpoint Interior Space
2. Perspiration: Workout / Spin Rooms
3. Evaporation: Indoor Pools, Cleaning / Sterilizing
4. Drying: Products
5. Outdoor Air: Make-Up or Ventilation

If ANY of these moisture loads are high, you may be looking at a Latent Design

What is the Recommend Sequence?

Application Examples
1) Church – SZVAV w/ Moisture Control
    a) Low Load Most of the Time – Units are Oversized
    b) Quick Spike in Load Due to Occupants, Need High O/A
        • *High O/A Defined as Greater than 25%*

2) Classroom – SZVAV + MAU *(My Personal Preference)*
    a) Steady Load – Not Generally at Peak HVAC Design Day
    b) Dedicated O/A Unit Feeding Multiple Rooms w/ ERV
    c) Isolate the Sensible vs. Latent
    d) Built in Redundancy

What is the Recommend Sequence?

Application Examples
1) Operating Room / Pharmacy – SZVAV + Pressure Control
   a) Low Temperature, Low Dewpoint
   b) High Air Change Rates
   c) Internal Loads Can Exceed Expectations
   d) Tight Tolerance

2) Indoor Pool – SZVAV + Moisture Control
   a) All Latent
   b) Higher Temperatures with Higher Dewpoints
   c) 24x7 Operation with Fresh Air All the time.

What is the Recommend Sequence?

Application	Typical Conditions
1) Church – SZVAV	72F – 55%, 55dp
2) School Classroom SZVAV + MAU	72F – 55%, 55dp
3) OR/Pharmacy – SZVAV + Pressure Control	60-68F – 50%, 41dp
4) Hotel Hallways – MAU	75F – 55%, 58dp
5) Indoor Pools – SZVAV	84F – 55%, 66dp
6) Grow Houses – SZVAV	50-78F – 50-70%,
7) Fitness Areas – SZVAV + MAU	68-72F – 55%, 51dp
8) Locker Rooms – MAU	72F – 55%, 55dp

Summary

3 Sequences
1) VAV
2) SZVAV
3) MUA

Control Types
1) Basic
2) Configurable
3) Custom

Secondary Sequences
1) Dehum/Humidification
2) Flow Control
3) Etc., Etc., Etc.

Final Thoughts
1) Custom Allows Flexibility / Tuning
2) Only Essential Sensors, Mode & Control
3) 1st Step in Troubleshooting, Listen!
4) 2nd Step: Are your sensors reading "reasonably"? Review the Trends

DISCUSSION

Q&A

THANK YOU!