Welcome to Webinar Wednesday

Varitec Technical Institute - 2023

Presenter: Dan Hahne
(Varitec: Director of High-Performance HVAC Solutions)

Program Coordinator: Kellie Huff
(Varitec: Marketing Manager)

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SHAPING THE FUTURE OF HVAC

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(New Horizons Launch, January 9, 2006)

Mission:

To provide an educational platform for continued learning in the HVAC industry with a focus on high performance buildings and innovative technologies for a better built environment.

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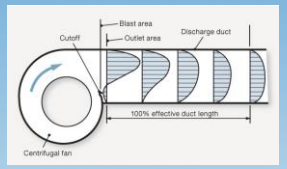
August 9th: Fundamentals of HVAC

- Session #5: Fan System Effect & The Physics of Air Flow



September 13th: 100% Outside Air Systems

- The Importance of Ventilation & Building Design Considerations

October 11th: Thermally Stratified Environments

November 8th: Underfloor Air Systems

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Varitec's Monthly Newsletter: July

- ASHRAE Publishes 241: A Milestone in Controlling Infectious Aerosols
- HOK Makes Strides Towards Carbon-Neutral Portfolio Ahead of AIA 2030 Commitment
- Indoor Air Quality: Unveiling Crucial Research on Exposure and Characterization
- Managing Indoor Air Quality for Health and Efficiency (Dr. Stephanie Taylor)
- Evaluating Building Performance: ANSI / ASHRAE Standard 228 Sets the Bar for Zero Net Energy and Zero Net Carbon


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The Conduit: IEQ & Net Zero Through HVAC | July 2023

TODAY'S DEVELOPMENTS FOR TOMORROW'S WORLD

What you need to read this month

Welcome to our July newsletter! This edition is packed with exciting updates and valuable insights on important topics such as Indoor Air Quality (IAQ), Standard 241, HOK's achievements in net zero energy and decarbonization, water conservation via building controls, and the EPA's latest advancements. We dive into the significance of maintaining healthy IAQ with the release of Standard 241, providing guidelines to control infectious aerosols. We also celebrate HOK's remarkable progress towards achieving carbon neutrality by 2030, setting new standards for sustainability. Additionally, we explore the importance of water conservation and highlight the EPA's groundbreaking research. Stay tuned for informative articles and practical tips to empower you to create healthier and more sustainable environments. Let's embark on this journey together and make a positive impact on our planet.

Varitec; supporting our community for a better tomorrow.

Want to submit an article for next month? Click Here

ASHRAE Publishes Standard 241: A Milestone in Controlling Infectious Aerosols

ASHRAE has announced the release of Standard 241, a significant advancement in the control of infectious aerosols. This groundbreaking publication provides comprehensive guidelines and best practices for effectively mitigating the transmission of airborne pathogens in various settings. Standard 241 covers essential areas such as ventilation strategies, filtration methods, and air cleaning technologies. By adhering to this industry-leading standard, building owners, engineers, and facility managers can enhance the safety and well-being of occupants. ASHRAE's commitment to advancing public health through rigorous research and evidence-based recommendations establishes a vital framework for combating airborne infections. Stay informed and leverage the expertise of Standard 241 to create healthier indoor environments.

Read Press Release

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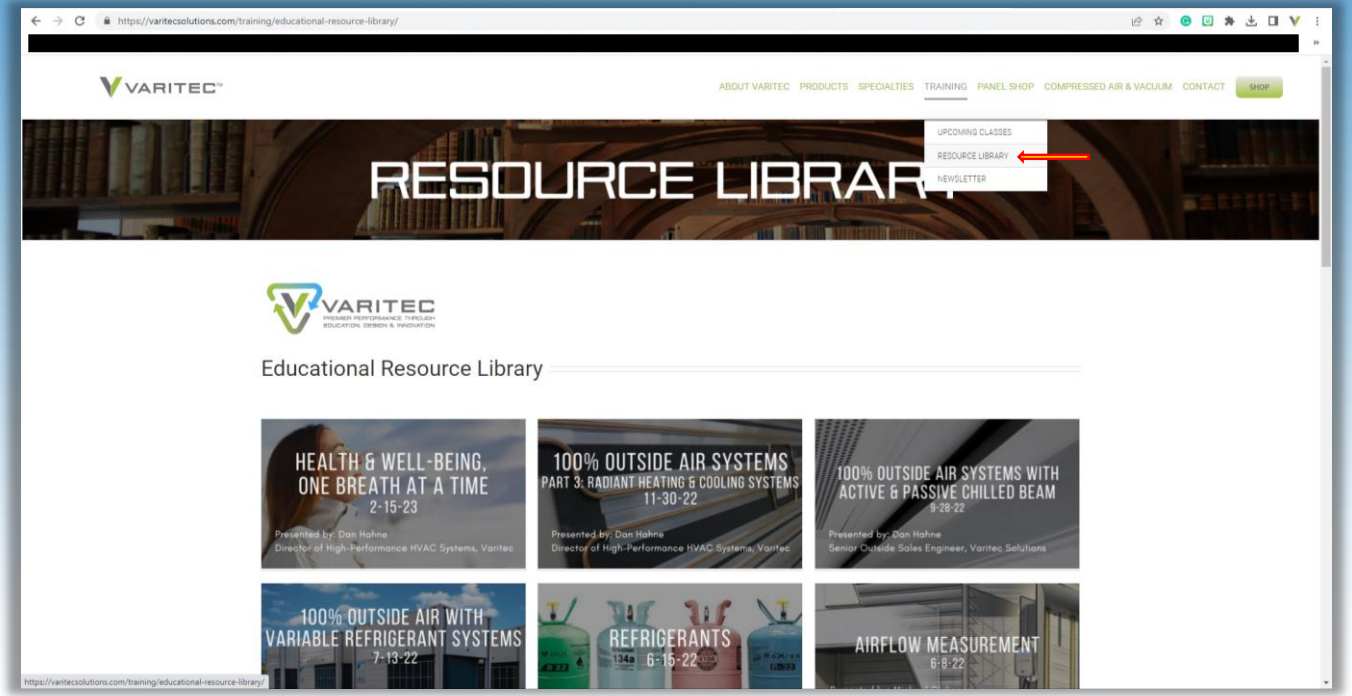

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Housekeeping Items:

- We are recording this session
- Please ask questions in the chat
- If you need PDH or AIA credit, make sure your name is displayed correctly. If you are calling in, send me an email to let me know you attended.

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Psychrometrics Deconstructed Part #2

Presented by: Dan Hahne
Varitec: Director of High-Performance HVAC Solutions

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Introduction

Education:

- University of Arizona – Chemical Engineering
  - 1974 thru 1976
- University College London – BFA Degree (Sculpture)
  - 1978 thru 1983
- Boston University – MFA Degree (Sculpture)
  - 1983 thru 1985

Industry:

- **Norman S. Wright SW:** Estimator/Sales
  - 1985 thru 1999
- **Air Specialty Products/ThermAir Systems:** Outside Sales
  - 2000 thru 2008
- **Air Specialty Products/ThermAir Systems:** Engineering Sales
  - 2009 thru 2016
- **Varitec Solutions:**
  - Senior Sales Engineer
    - 2016 - 2022
  - Director of High-Performance HVAC Solutions/Educator
    - 2022 thru present

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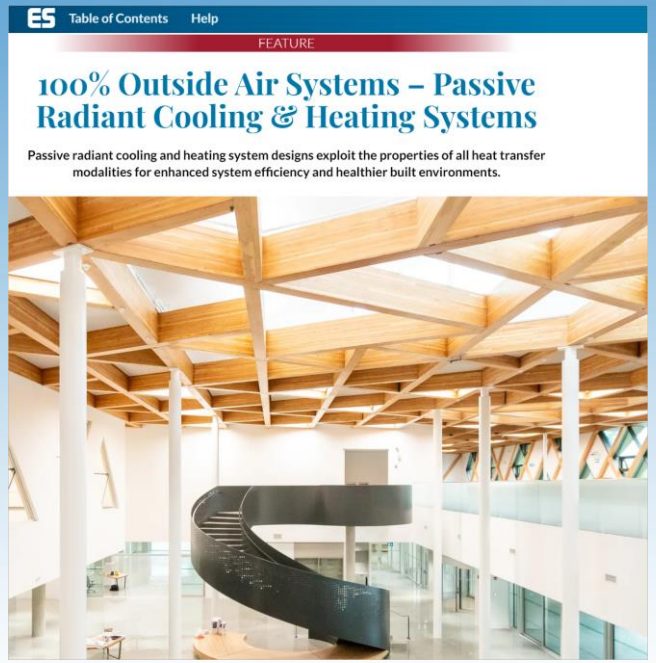
Latest Publication

Engineered Systems Magazine: December 2022 Edition

- *100% Outside Air Systems – Passive Radiant Cooling and Heating Systems*



- **(Co-Author: Darren Alexander, P.E. (Twa Panel Systems, Inc.)**

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HVAC Fundamentals

Agenda:

- Psychrometric Terminology Review
- Medium Pressure VAV Systems: Psychrometric Process
  - VAV with Terminal Reheat
- Controlling Building Humidity Supplying 55F DB / 54F WB Supply Air
- Sensible and Enthalpy Heat Recovery: Psychrometric Process
- 100% Outside Air Units (DOAS): Psychrometric Process
- Displacement Ventilation Air Handlers: Psychrometric Process
- Custom DX DOAS Units for Building Humidity Control: Psychrometric Process

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Psychrometrics Terminology: Review

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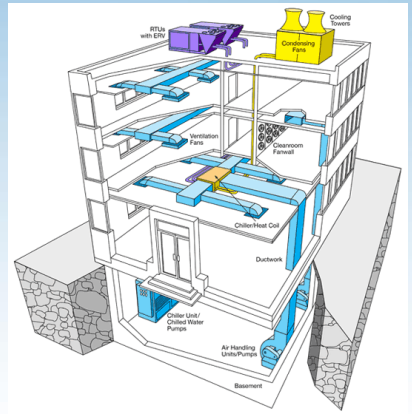
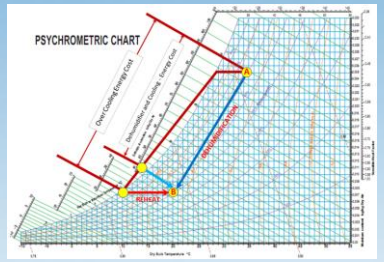
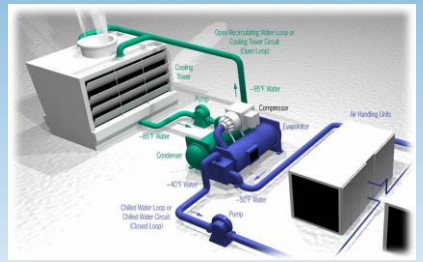
Psychrometrics Terminology Review

HVAC Systems: Energy (Heat) Transfer, Moving Energy

- Determine amount of energy to be moved to maintain building **temperature** and **humidity** set points







Cooling:

- **Sensible energy:** measured at a building thermostat
- **Latent energy:** energy removed to cause a water phase change from vapor to a liquid
- Calculate **total load (sensible energy + latent energy)**
- **How? Apply the Psychrometric Chart**

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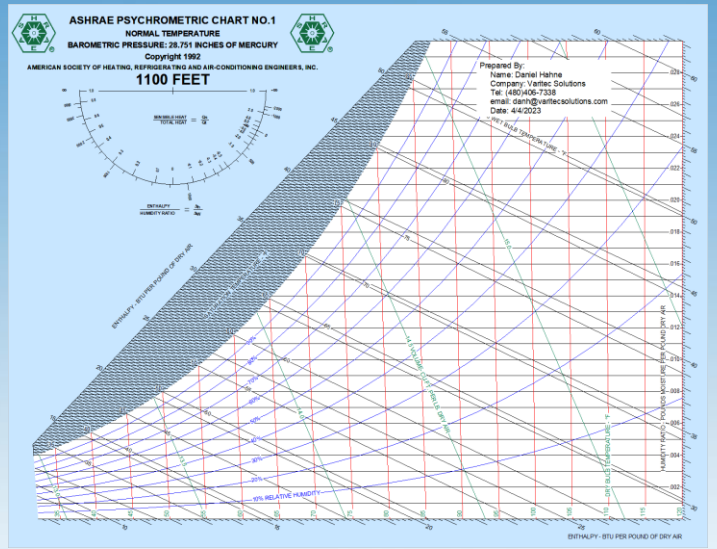
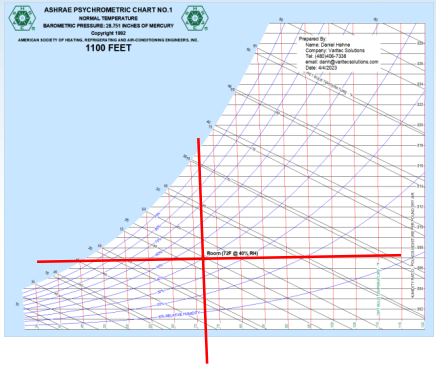
Psychrometrics Terminology Review

Psychrometric Chart: Purpose

- **The Psychrometric Chart is HVAC:**
  - The Psychrometric Chart was created by **Louis Carrier in 1902** to make HVAC system design less time consuming.
  - The chart is a **REFERENCE CHART** illustrates essential characteristics of the properties of air
  - Provides graphic representation of performance lines generated from each **"state point"**; i.e. dry bulb and wet bulb temperature, relative humidity, specific humidity, dew point, enthalpy…etc.





- Knowing any two points on the chart will reveal any other air property state point represented on the chart
- Illustrate the energy differential between state points

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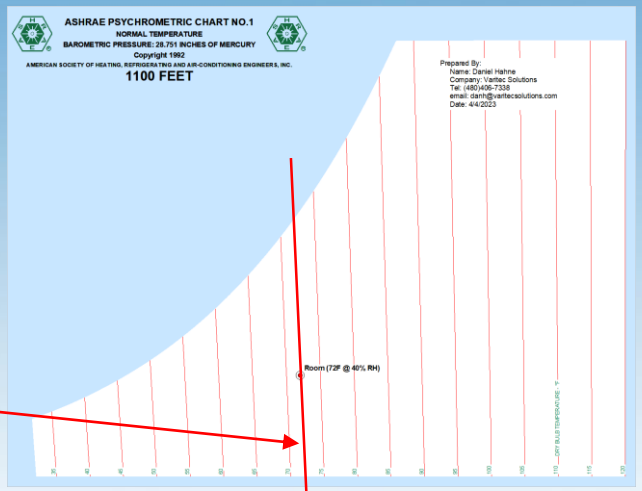
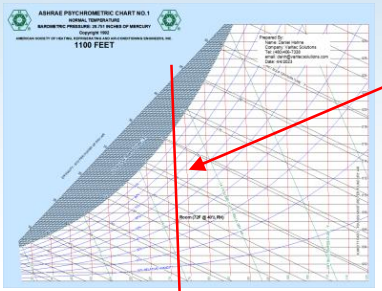
Psychrometrics Terminology Review

Properties of Air: Terms and Definitions

- **Dry-Bulb Temperature (DB)**: A value of energy present in a space as **measured by a room thermostat** or “dry” thermometer.
  - Referred to as **“sensible (heat) energy”**, the heat read and displayed by a **dry thermometer**.





Room Temperature: 72F DB

Room Design Condition:

- **Dry Bulb (DB) Temperature:**
  - 72F Dry Bulb (DB) @ 40% RH

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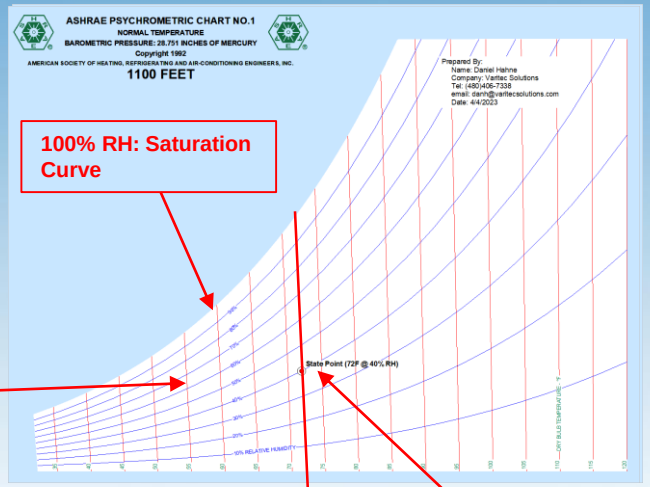
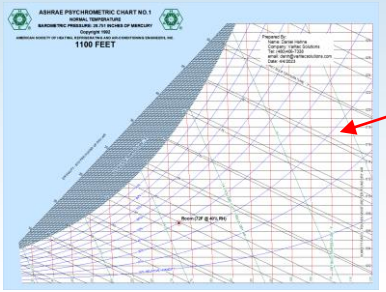
Psychrometrics Terminology Review

Properties of Air: Terms and Definitions

- **Relative Humidity (RH):** moisture content in a sample air as a **percent** of the total amount of moisture air can hold when fully saturated **(100% RH)** at a given dry bulb temperature.
- **Relative** to what? **Temperature** **(RH varies per dry bulb temperature)**





Relative Humidity (RH):

Room: Design Condition:

- **Dry Bulb (DB) Temperature:**
  - 72F Dry Bulb (DB) @ 40% RH

State Point: 72F DB @ 50% RH

Dry Bulb & RH line intersection is the State Point

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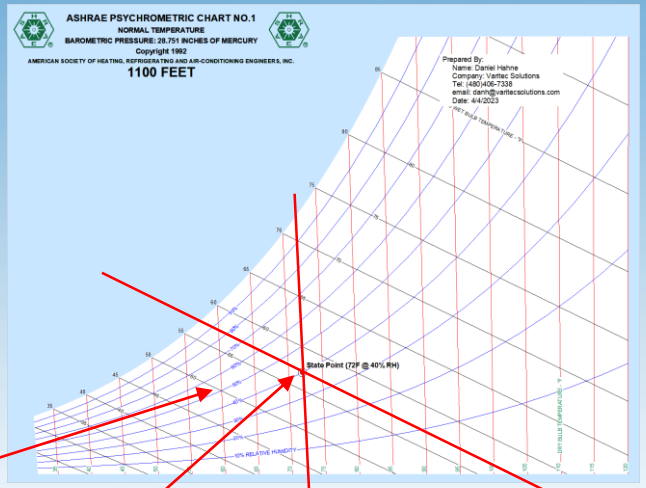
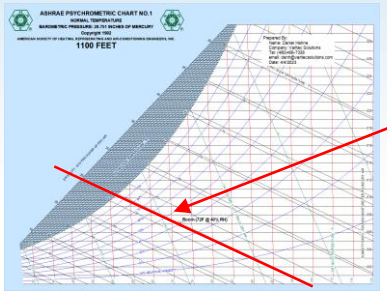
Psychrometrics Terminology Review

Properties of Air: Terms and Definitions

- **Wet-Bulb Temperature (WB)**: Lowest **temperature** air is cooled to by water evaporating into a vapor on a **sling psychrometer** at a constant pressure.

- Measured by wrapping a **wet wick around a thermometer bulb.** The **measured temperature** is the **wet bulb temperature. (Latent Energy)**





57F WB Wet Bulb Line

State Point: 72F DB @ 40% RH

Room Design Condition:

- 72F Dry Bulb (DB) @ 40% RH = **57F WB**

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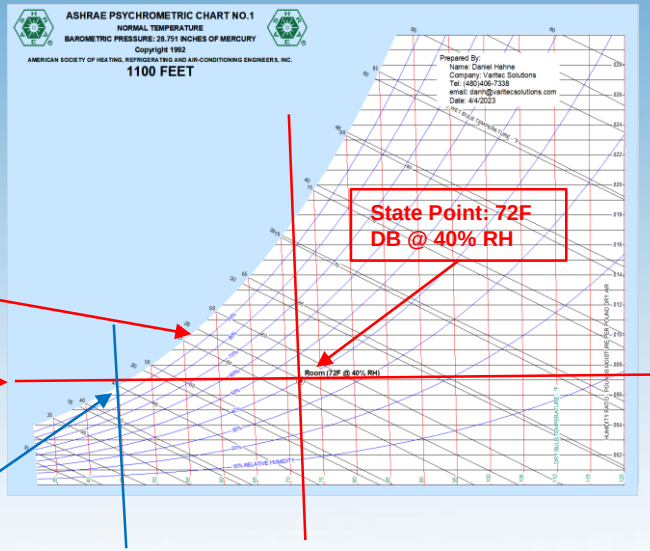
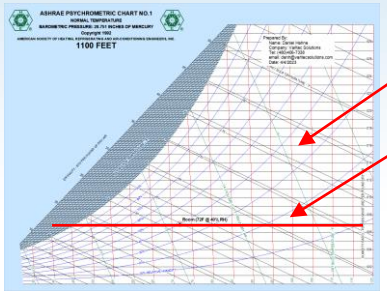
Psychrometrics Terminology Review

Properties of Air: Terms and Definitions

- **Dew Point (DP):** The temperature (°F) at which water vapor condenses to a liquid as dew; e.g. cold surfaces (at a temperature below dew point).
- **Absolute measure of air moisture content.** Not related to temperature





Room Design Condition:

- **Dry Bulb (DB) Temperature:**
  - 72F Dry Bulb (DB) @ 40% RH = **46.4F DP**

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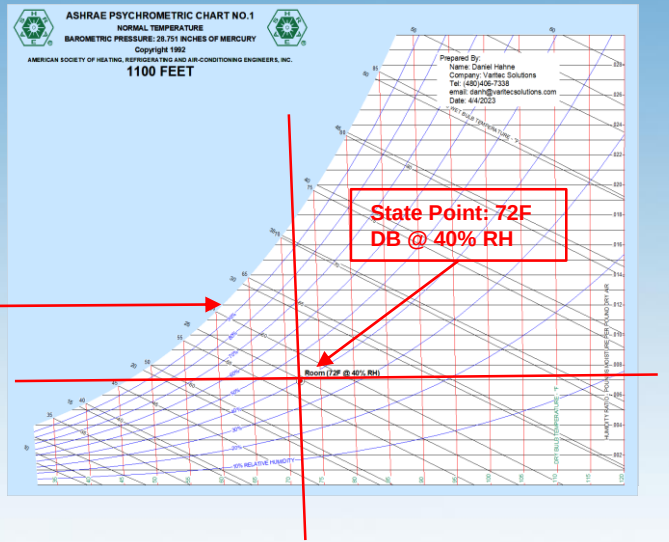
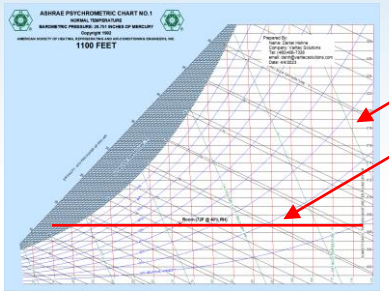
Psychrometrics Terminology Review

Properties of Air: Terms and Definitions

- **Specific Humidity:**
  - The mass of water vapor in dry air measured in grains of moisture per pound of dry air (gr/lb).
  - **7,000 grains = 1 LB of water vapor**





Room Design Conditions:

- 72F Dry Bulb (DB) @ 40% RH = **48.7 gr/lb** (air)

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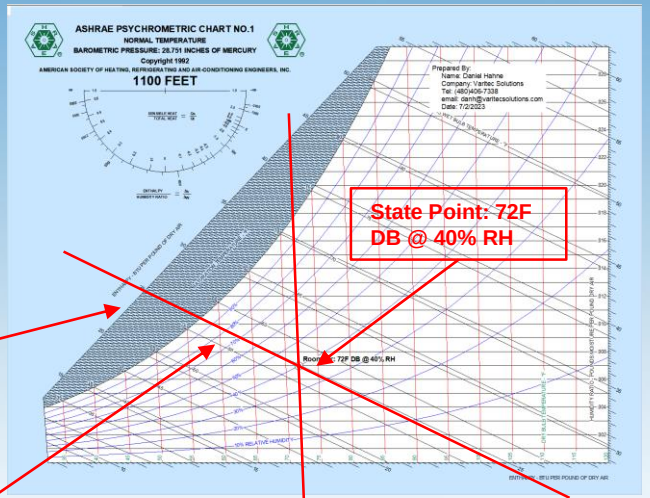
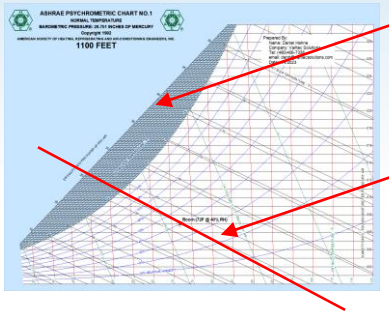
Psychrometrics Terminology Review

Properties of Air: Terms and Definitions

- **Enthalpy:**
  - **Total Energy = (Sensible Btus + Latent Btus)** in an air sample and the product of the pressure and volume of a thermodynamic system





Room Design Conditions:

- 72F Dry Bulb (DB) @ 40% RH = **24.9 Btus / LB** (Air)

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Medium Pressure VAV Systems: Psychrometric Process

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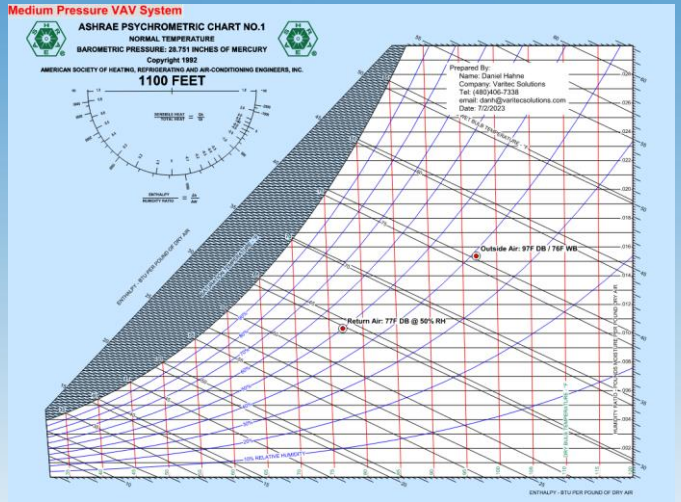
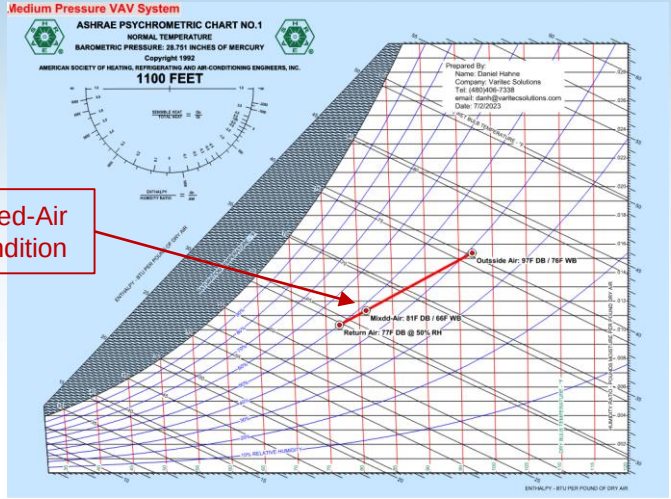
Medium Pressure VAV Systems: Psychrometrics

Air Handler Design Conditions:

- **VAV AHU Airflow:**
  - Supply 20,000 CFM @ 2.5” w.c esp
  - Outside Air: 20% or 4,000 CFM (Assuming Minimum)
    - **Monsoon Conditions: 97F DB / 76F WB (70.1F DP)**
    - Winter: 32F
  - Return Air: 80% or 16,000 CFM
    - **Monsoon: 77F DB @ 50% RH (57F DP)**
    - Winter: 72F DB @ 30% RH





Mixed-Air Conditions:

- **Chilled Water Cooling Coil:**
  - **Monsoon: Mixed Entering Air: 81F DB / 66F WB**
    - Chilled Water: 44F EWT
    - Cooling Coil LAT: 55F DB/54F WB

Mixed-Air Condition is the air condition at the inlet of a cooling coil

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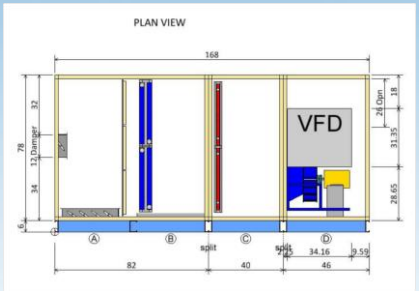
Medium Pressure VAV Systems: Psychrometrics

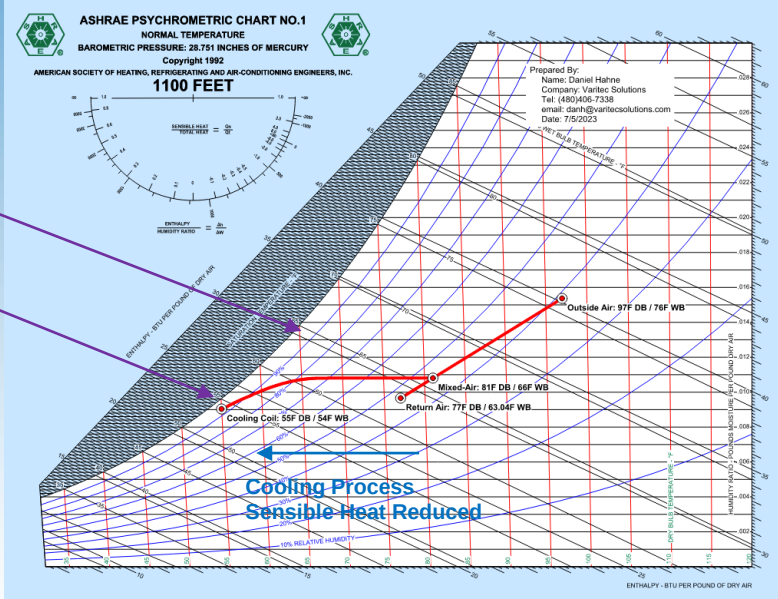
Air Handler Design Conditions:

- **VAV AHU Psychrometric Process:**
  - Mixed-Air Condition: 81F DB / 66F WB
  - Cooling Coil: Chilled Water Temperature 44F
  - Cooling Coil Leaving Air Temp (LAT):
    55F DB / 54F WB



Saturation Curve = 100% RH

Point of Saturation = 55F DB / 55FWB



Process Notes:

- LAT is **not at 55F DB / 55F WB** or 100% RH (Saturation)
- Psychrometric process from Mixed-Air condition to LAT is **not a straight line**

Condensation begins to occur when dry bulb temperature approaches Saturation Curve

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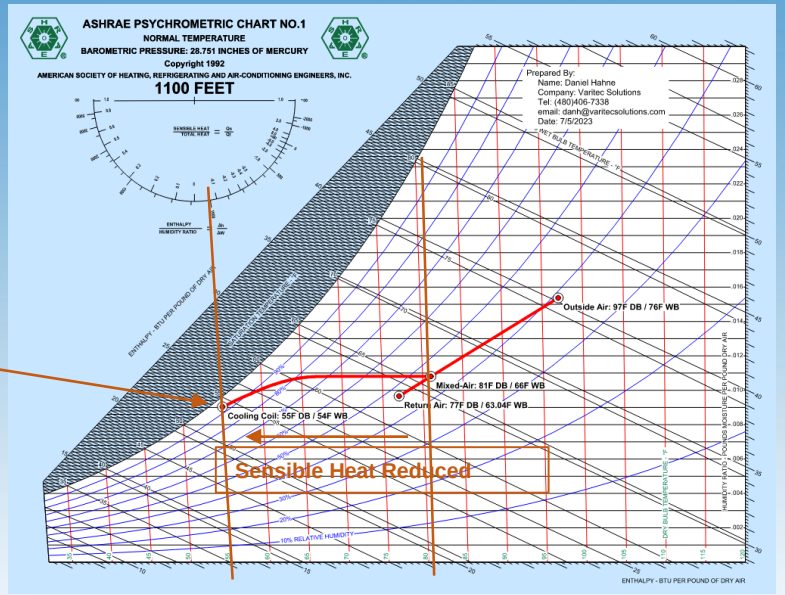
Medium Pressure VAV Systems: Psychrometrics

Air Handler Design Conditions:

- **VAV AHU Psychrometric Process:**
  - Mixed-Air Condition: 81F DB / 66F WB
  - Cooling Coil: Chilled Water Temperature 44F
  - Cooling Coil Leaving Air Temp (LAT): 55F DB / 54F WB

Sensible Heat Depression = 26F degrees



- **Sensible Heat Removal: Cooling Coil**
  - **81F DB EAT – 55F LAT = ∆26F degrees**

- **Total Sensible Energy (*Ts*) Calculation:**
  - ***Ts = 1.08 X CFM x ∆T (T1 – T2)***
  - **Process: *TS = 1.08 x 20,000 CFM x 26F degrees = 561,600 Btus***

- *Ts is total sensible heat energy*
- *1.08 is a constant value*
- *CFM is the total system airflow*
- *T1 – First state point dry bulb temperature*
- *T2 – Second state point dry bulb temperature*

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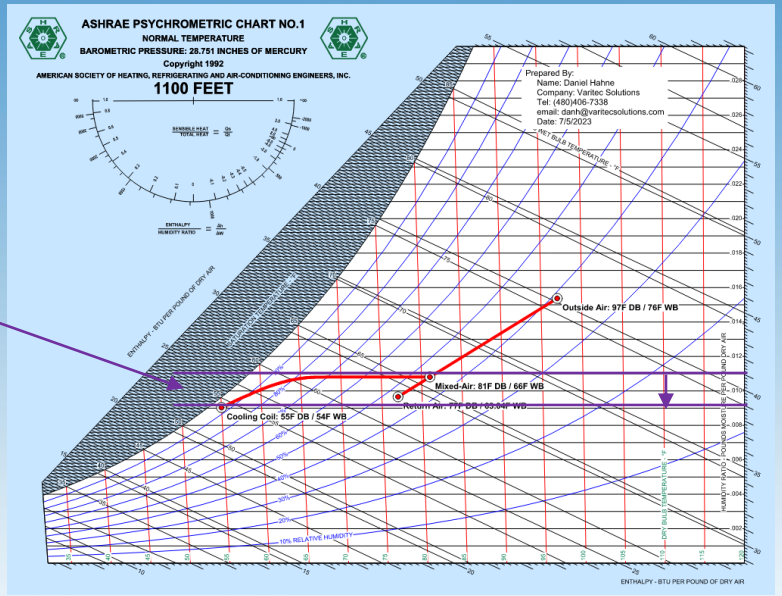
Medium Pressure VAV Systems: Psychrometrics

Air Handler Design Conditions:

- **AHU Psychrometric Process:**
  - Mixed-Air Condition: 81F DB / 66F WB
  - Cooling Coil: Chilled Water Temperature 44F
  - Cooling Coil Leaving Air Temp (LAT): 55F DB / 54F WB



Dew Point / Specific Humidity Depression:
Moisture Removed

- **Dehumidification: Cooling Coil**
  - **Mixed-Air 58.3F DP – Leaving Air 53.3F DP = ∆5F (dew point) Depression**
  - **75.9 grains/lb – 63.2 grains/lb = ∆12.7 grains/lb**
  - **Moisture Removed = 150 LBs/ Hour**

- **Total Latent Energy (T_L) Calculation:**
  - ***T_L = 0.68 X CFM x ∆W gr. (W_1 – W_2)***
  - **Process: *T_L = 0.68 x 20,000 CFM x 12.7 gr/lb = 172,720 Btus (Latent)***

- *TL is total sensible heat energy*
- *0.68 is a constant value*
- *CFM is the total system airflow*
- *W_1 – First state point grains/lb*
- *W_2 – Second state point grains/lb*

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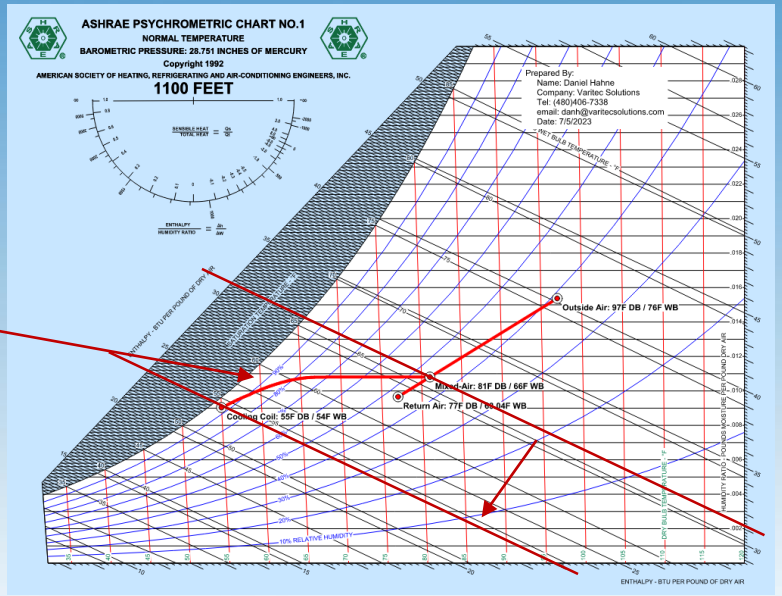
Medium Pressure VAV Systems: Psychrometrics

Air Handler Design Conditions:

- **AHU Psychrometric Process:**
  - Mixed-Air Condition: 81F DB / 66F WB
  - Cooling Coil: Chilled Water Temperature 44F
  - Cooling Coil Leaving Air Temp (LAT): 55F DB / 54F WB



Total Energy (Enthalpy) Removed:

- **Total Enthalpy (h_T) Calculation:**
  - $h_t = h_s + h_l$
  - **Process: *h_t = 561,600 Btus + 172,720 Btus = 734,320 Btus (Total)***

- **Total Energy Enthalpy: Removed**
  - **Total: 734,320 Btus**
    - **Sensible Heat: 561,600 Btus**
    - **Latent Heat: 172,720 Btus**

- *h_t is total sensible heat energy*
- *h_s – First state point grains/lb*
- *h_l – Second state point grains/lb*

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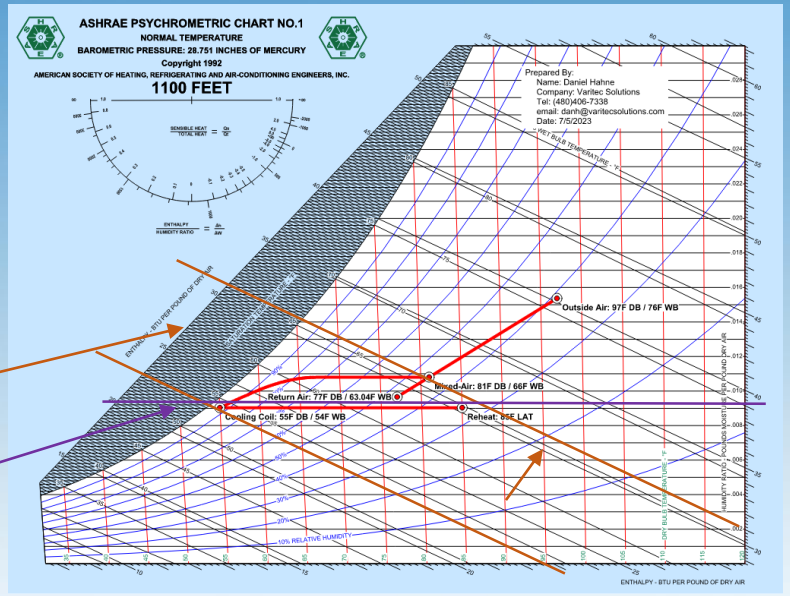
Medium Pressure VAV Systems: Psychrometrics

Air Handler Design Conditions:

- **VAV Reheat Psychrometric Process:**
  - Common AHU Serving Interior & Perimeter Zones
    - Interior: Cooling Only
    - Perimeter: VAV Boxes with Reheat Coils
      - Size 12 Box = 1600 Max CFM
      - Reheat Airflow @ 50% flow = 800 CFM
      - Entering Air = 55F, Leaving Air = 85F



Total Energy Added:

Relative Humidity Decreases, Dew Point remains the same

- **Reheat: Total Energy Added per Perimeter Zone (800 CFM VAV Box)**
  - $T_S = 1.08 \times CFM \times \Delta T\ (T_1 - T_2)$
  - **Heat Added: 25,900Btus Added Heat Energy**

- **Reheat & Humidity:**
  - **Relative Humidity decreases** from 94% to 33.8%
  - **Dew Point, remains the same:** 53.35F degrees

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Controlling Building Humidity: Supplying 55F DB / 54F WB Supply Air?

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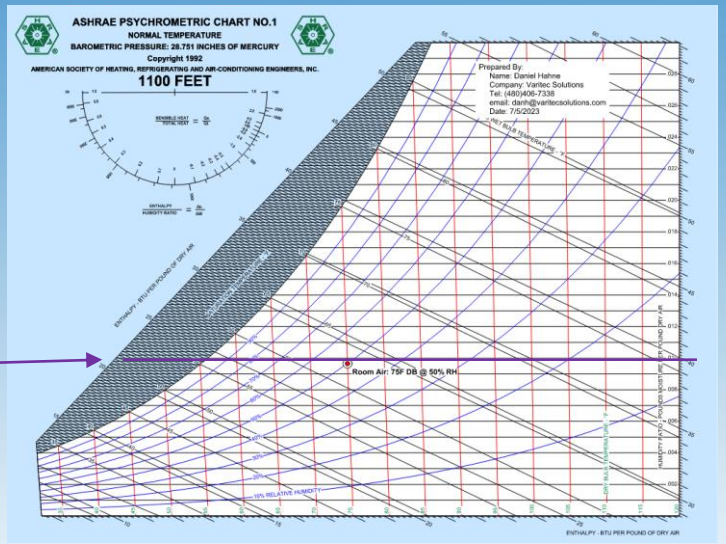
Controlling Building Humidity

Air Handler Design Conditions:

- **Applying Psychrometrics:**
  - Space Design Set Point: **75F @ 50% RH**
  - Zone Dew Point: **55.13F degrees**



Zone Dew Point Condition: 55.13F

The Humidity Challenge:

- A space dew point of **55.13F degrees is the challenge.**
- **To control humidity is to control dew point**

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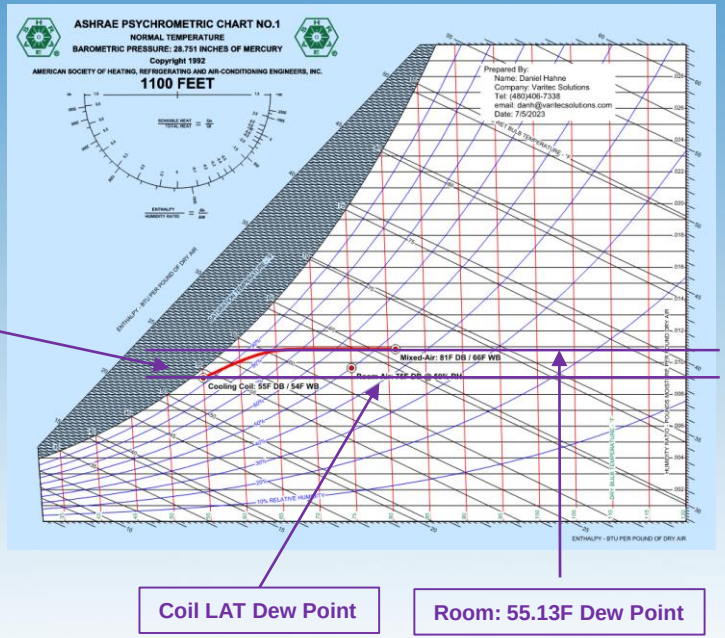
Controlling Building Humidity

Air Handler Design Conditions:

- **Applying the Psychrometric Process:**
  - Space Design Set Point: 75F @ 50% RH
  - Cooling Coil: Chilled Water Temperature 44F
  - Air Handler Cooling Coil Leaving Air Temp (LAT):
    55F DB / 54F WB



Dew Point Depression: 1.8F degrees

Coil LAT Dew Point

Room: 55.13F Dew Point

The Humidity Challenge:

- Space Design Condition: 75F @ 50% RH = 55.13F Dew Point
- **Supply Air Condition: 55F DB / 54F WB = 53.35F Dew Point**

Total Space Dew Point Depression:

55.13F – 53.35F = 1.8F Dew Point Depression

Outside air dehumidified, but what about the latent gain in the zone; occupants, humidity infiltration…etc.

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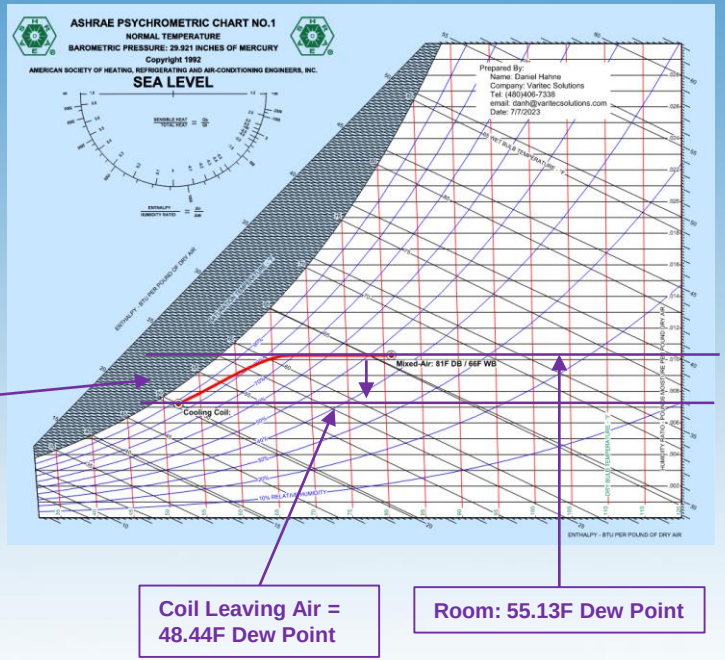
Controlling Building Humidity

Air Handler Design Conditions:

- **Applying the Psychrometric Process:**
  - Space Design Set Point: 75F @ 50% RH
  - Cooling Coil: Chilled Water Temperature 44F or lower
  - Cooling Coil Leaving Air Temp (LAT):
    52F DB / 50F WB = 48.44F Dew Point



Dew Point Depression: 6.7F degrees

Coil Leaving Air = 48.44F Dew Point

Room: 55.13F Dew Point

- **The Humidity Challenge:**
  - Space Design Condition: 75F @ 50% RH = 55.13F Dew Point
  - **Supply Air Condition: 52F DB / 50F WB = 48.4F Dew Point**
  - **Total Space Dew Point Depression:**
    - **55.13F – 48.4F = 6.7F Dew Point Depression**

Space Humidity Control Maintained

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Sensible and Enthalpy Heat Recovery: Psychrometric Process

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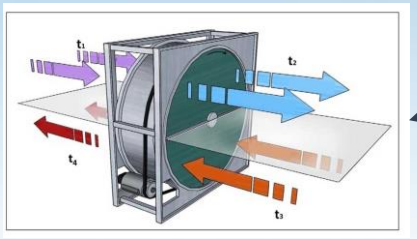
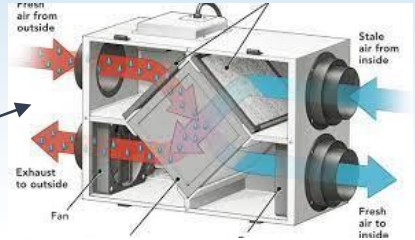
Sensible and Enthalpy Heat Recovery:

Energy Recovery: Purpose

- **Pre-Condition Outside Air for Increase Energy Efficiency:**
  - Summer: Reduce outside air temperature during hot months
  - Winter: Increase outside air temperature during cold months
  - How?: Energy exchange between exhaust and supply airstreams
  - Calculate total exhaust airflow in relation to minimum outside air requirements to maintain building pressure at 0.10” w.c. positive



Enthalpy Heat Recovery Wheels:



Sensible Plate & Frame Heat Exchangers:

Total Heat Recovery = Sensible (T_S) + Latent Heat (T_L) Transfer

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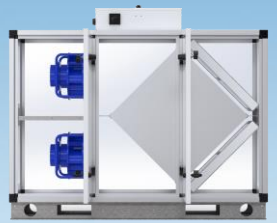
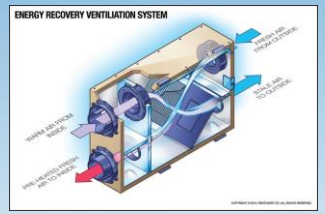
Sensible and Enthalpy Heat Recovery:

Energy Recovery Design Conditions:

- **Sensible Heat Exchanger Psychrometric Process:**
  - Sensible Heat Exchanger:
    - **Precondition Outside Air Temperature with Exhaust Air Energy Exchange**





OXYGEN 8 V40 SELECTION ONLY
Not for Submittal Use

Heat Exchanger

Design Condtions	Outdoor Air	Return Air
SCFM:	4000	3400
Summer DB (F) / WB (F) / RH (%):	97 / 76 / 39.1	77 / 62.4 / 44.7
Winter DB (F) / WB (F) / RH (%):	32 / 30 / 79.9	72 / 54.1 / 30.1

Performance Leaving Air	Supply Air	Exhaust Air
Summer SCFM:	4000	3400
Winter SCFM:	4000	3400
Summer DB (F) / WB (F) / RH (%):	81.9 / 72 / 62.8	94.8 / 68.1 / 25.4
Winter DB (F) / WB (F) / RH (%):	62.5 / 46.1 / 25.2	37.9 / 37.6 / 97

- **Airflow:**
  - Supply 20,000 CFM @ 2.5” w.c esp
  - Outside Air: 20% or **4,000 CFM (Assuming Minimum)**
    - **Monsoon Conditions: 97F DB / 76F WB (70.1F DP)**
    - Winter: 32F
  - Return Air: 80% or 16,000 CFM
    - **Monsoon: 77F DB @ 50% RH (57F DP)**
    - Winter: 72F DB @ 30% RH
  - **Enthalpy Heat Exchanger:**
    - Outside Air: **4,000 CFM** @ 97F DB / 76F WB
    - Exhaust Air: **3,400 CFM** @ 77F DB 46.8F WB

- **Leaving Air Conditions:**
  - **Summer: 81.9F DB / 72F WB (Effectiveness: 88.9%)**
  - **Winter: 62.5F DB / 46.1F WB (Effectiveness: 89.8%)**

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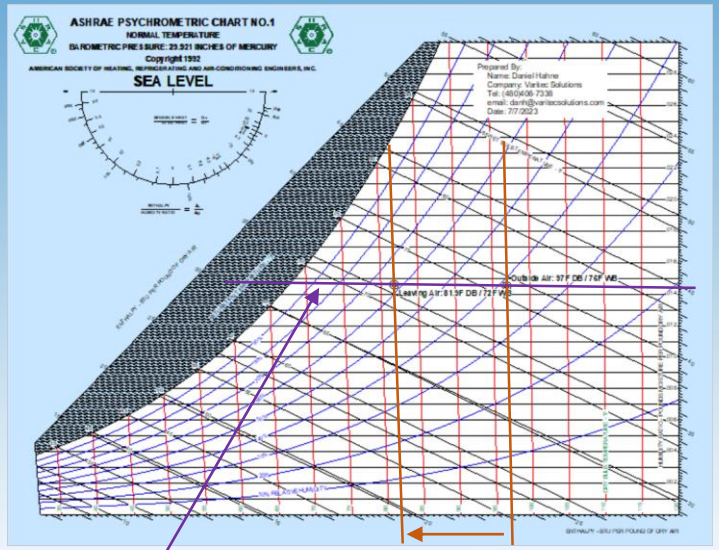
Sensible and Enthalpy Heat Recovery:

Energy Recovery Design Conditions:

- **Sensible Outside Air Heat Exchanger Psychrometric Process:**
  - Entering Air Condition: 97F DB / 76F WB = **68.0F Dew Point**
  - Exhaust Air Condition: 77F DB / 63F WB
  - Outside Air Leaving Air Condition: 81.9F DB / 72.0F WB = **68F Dew Point**

- **Sensible Energy Depression:**
  - 97F DB (OSA) – 81.9F DB (LAT) = 15.1F Degrees
  - ***Ts = 1.08 X CFM x ∆T (T1 – T2)***
  - *Ts = 1.08 X 4,000 CFM x 15.1F =* ***65,232 Btus***

- **Latent Energy Depression: Dehumidification**
  - 97F DB (OSA) – 81.9F DB (LAT) = 15.1F Degrees
  - ***Ts = 0.68 X CFM x ∆W grains/lb (W1 – W2)***
  - *Ts = 0.68 X 4,000 CFM x 0.0W grains/lb =* ***0 Btus***



No Latent Energy Reduction

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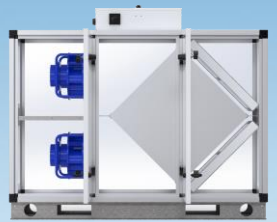
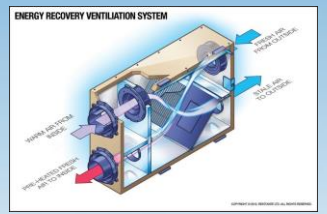
Sensible and Enthalpy Heat Recovery:

Energy Recovery Design Conditions:

- **Enthalpy Heat Exchanger Psychrometric Process:**
  - Enthalpy Heat Exchanger:
    - **Precondition Outside Air Temperature & Humidity with Exhaust Air Energy Exchange**





OXYGEN 8 V40 SELECTION ONLY
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Heat Exchanger

Design Condtions	Outdoor Air	Return Air
SCFM:	4000	3400
Summer DB (F) / WB (F) / RH (%):	97 / 76 / 39.1	77 / 62.4 / 44.7
Winter DB (F) / WB (F) / RH (%):	32 / 30 / 79.9	72 / 54.1 / 30.1

Performance Leaving Air	Supply Air	Exhaust Air
Summer SCFM:	4000	3400
Winter SCFM:	4000	3400
Summer DB (F) / WB (F) / RH (%):	83.1 / 67.9 / 46.4	93.3 / 72.9 / 38.5
Winter DB (F) / WB (F) / RH (%):	59.5 / 47.2 / 38.8	39.6 / 35.9 / 71.1

- **Airflow:**
  - Supply 20,000 CFM @ 2.5” w.c esp
  - Outside Air: 20% or 4,000 CFM (Assuming Minimum)
    - **Monsoon Conditions: 97F DB / 76F WB (70.1F DP)**
    - Winter: 32F
  - Return Air: 80% or 16,000 CFM
    - **Monsoon: 77F DB @ 50% RH (57F DP)**
    - Winter: 72F DB @ 30% RH
  - **Enthalpy Heat Exchanger:**
    - Outside Air: 4,000 CFM @ 97F DB / 76F WB
    - Exhaust Air: 3,400 CFM @ 77F DB 46.8F WB

- **Leaving Air Conditions:**
  - **Summer: 83.1F DB / 67.9F WB (Effectiveness: 74.7%)**
  - **Winter: 59.5F DB / 57.2F WB (Effectiveness: 78.8%)**

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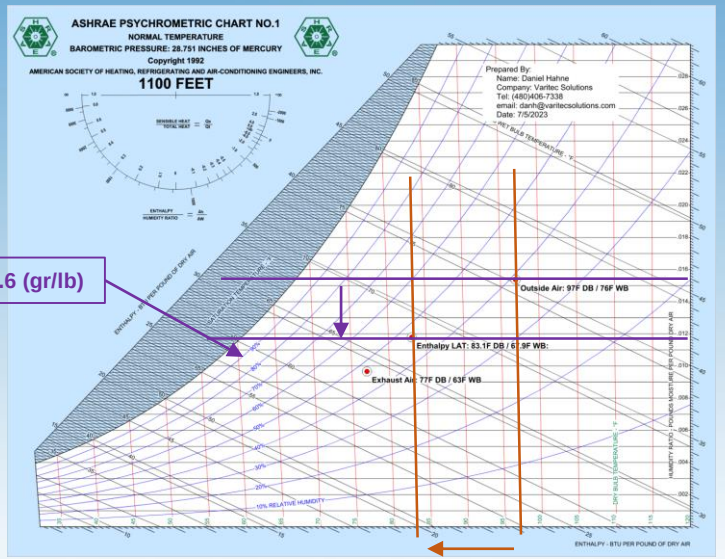
Sensible and Enthalpy Heat Recovery:

Energy Recovery Design Conditions:

- **Enthalpy Outside Air Heat Exchanger Psychrometric Process:**
  - Entering Air Condition: 97F DB / 76F WB
  - Exhaust Air Condition: 77F DB / 63F WB
  - Outside Air Leaving Air Condition: 83.1F DB / 63.9F WB

- **Sensible Energy Depression:**
  - 97F DB (OSA) – 83.1F DB (LAT) = 13.9F Degrees
  - *$T_S = 1.08 \times CFM \times \Delta T\ (T_1 - T_2)$*
  - *$T_S = 1.08 \times 4{,}000\ CFM \times 13.9F =$* ***58,752 Btus***

- **Latent Energy Depression: Dehumidification**
  - 107.6 gr/lb (OSA) – 62.0 gr/lb (ERV LAT) = 45.6
  - *$T_S = 0.68 \times CFM \times \Delta W$ grains/lb $(W_1 - W_2)$*
  - *$T_S = 0.68 \times 4{,}000\ CFM \times 45.6W$ grains/lb =* ***124,032 Btus***



Specific Humidity Reduction = 45.6 (gr/lb)

Sensible Heat Reduction = 13.9F

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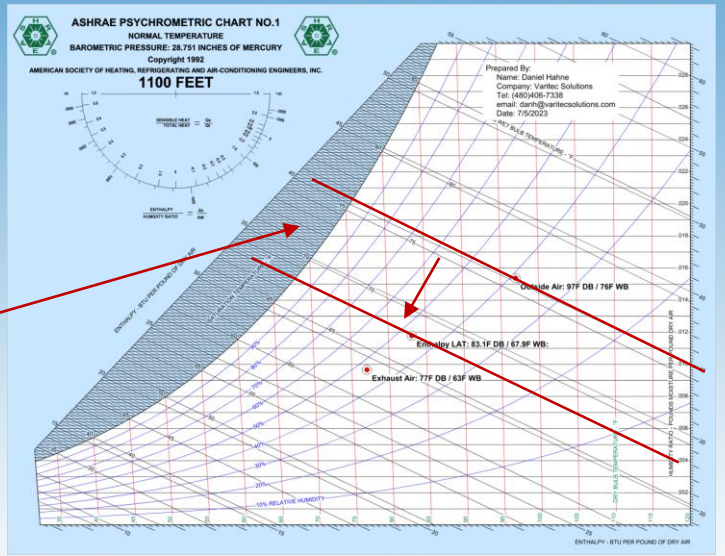
Sensible and Enthalpy Heat Recovery:

Energy Recovery Design Conditions:

- **Enthalpy Outside Air Heat Exchanger Psychrometric Process:**
  - Entering Air Condition: 97F DB / 76F WB
  - Exhaust Air Condition: 77F DB / 63F WB
  - Outside Air Leaving Air Condition: 83.1F DB / 63.9F WB



Total Peak Enthalpy Savings = 182,794 Btus

- **Total Peak Summer Enthalpy (h_T) Savings:**
  - $h_t = h_s + h_l$
  - ***h_t = 58,762 Btus + 124,032 Btus = 182,794 Btus (Total)***

Tons Cooling Net Reduction = 15.23 Tons

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Displacement Ventilation Air Handlers: Psychrometric Process

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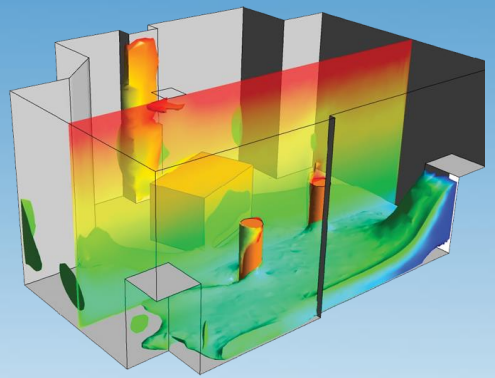
Displacement Ventilation Air Handlers

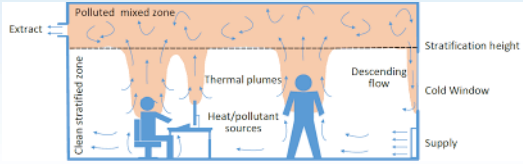
Thermally Stratified Building Space: How?

- **Displacement Ventilation:**
  - Supply air at low velocity: **~40 FPM**
  - Supply air temperature: **62-68°F**
  - Upper level room air temp: **80-85°F**
  - High level return/exhaust grilles



(Thermally Stratified Space)

- Stratified: Non-uniform space temperature
- Room thermal profile
  - Floor: **~ 70F**
  - Thermostat: **~75F (set point)**
  - Ceiling: **~78F to 82F (9ft AFF)**



Space Air Movement: Applied buoyancy forces (convection)

- Space heat sources: people, lighting, computers…
- Chilled Surfaces: Panels and Sails

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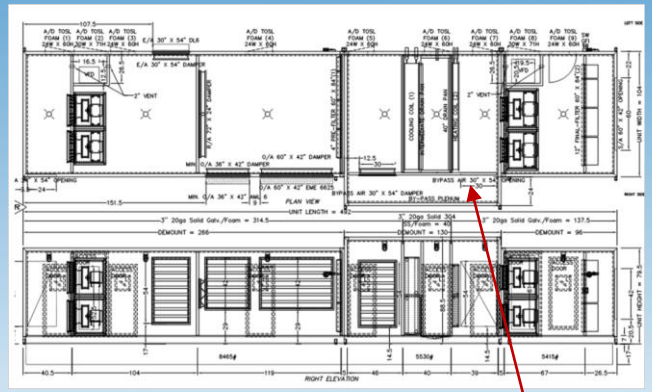
Medium Pressure VAV Systems: Psychrometrics

Displacement AHU Design Conditions:

- **Airflow:**
  - Supply 20,000 CFM @ 2.0” w.c esp
  - Outside Air: 20% or 4,000 CFM (Assuming Minimum)
    - **Monsoon Conditions: 97F DB / 76F WB (70.1F DP)**
    - Winter: 32F
  - Return Air: 80% or 16,000 CFM
    - **Monsoon: 80F DB @ 46.6% RH (57.8F DP)**
    - Winter: 77F DB @ 30% RH



Side-Stream Bypass Plenum

Chilled Water Coil		Component: 4		Length: 28 in			Shipping Section: 3	
Coil Model	Total Capacity	Sensible Capacity	Number of Coils	Number of Rows	Fins per Inch		Tube Diameter	Tube Spacing (Face x Row)
5WM12068	726335 Btu/hr	555700 Btu/hr	1	6	12		0.625 in	1.50 in x 1.299 in
Air Volume	Air Temperature				Coil Air Pressure Drop	Finned Height	Finned Length	Face Area	Face Velocity
	Entering		Leaving						
	Dry Bulb	Wet Bulb	Dry Bulb	Wet Bulb					
20000 cfm	81.0 °F	66.0 °F	54.5 °F	53.9 °F	1.20 inWc	48 in	91 in	30.33 ft²	659 ft/min
Water		Flow Rate	Pressure Drop	Velocity		Volume		Weight	Piping Vestibule
Entering	Leaving								
44.0 °F	54.1 °F	143.80 gpm	9.00 ftHd	3.20 ft/s		24.0 gal		265.00 lb	- in

Mixed-Air Conditions:

- **Chilled Water Cooling Coil:**
  - **Monsoon: Mixed Entering Air: 81F DB / 66F WB**
    - Chilled Water: 44F EWT
    - Cooling Coil LAT: 54.5F DB/53.9F WB
    - Bleed mix-air into the supply airstream after cooling coil to reheat supply air temperature to 65F

Air Handler Leaving Air Condition: 65F DB / 53.5F Dew Point

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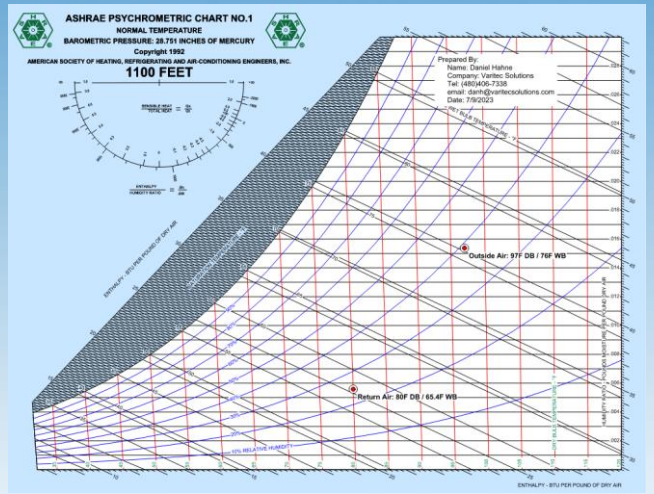
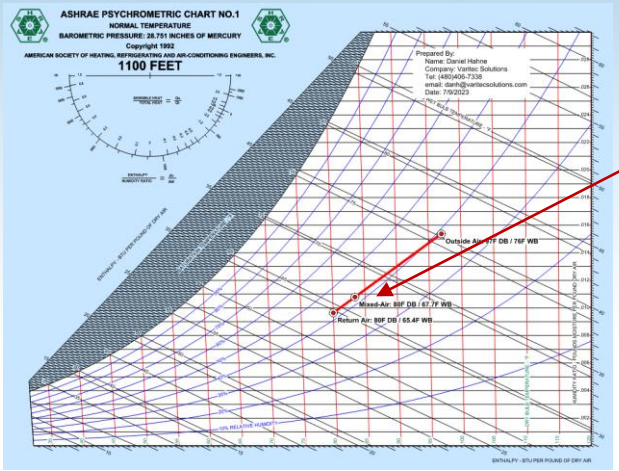
Medium Pressure VAV Systems: Psychrometrics

Displacement AHU Design Conditions:

- **Airflow:**
  - Supply 20,000 CFM @ 2.5” w.c esp
  - Outside Air: 20% or 4,000 CFM (Assuming Minimum)
    - **Monsoon Conditions: 97F DB / 76F WB (70.1F DP)**
    - Winter: 32F
  - **Return Air:** 80% or 16,000 CFM
    - **Monsoon: 80F DB @ 46.7% RH (57.8F DP)**
    - Winter: 77 DB @ 30% RH





Mixed-Air: 83.3F DB / 67.7F WB

Mixed-Air Conditions:

- **Chilled Water Cooling Coil:**
  - **Monsoon: Mixed Entering Air: 83.3F DB / 67.7F WB**
    - Chilled Water: 44F EWT
    - Cooling Coil LAT: 55F DB/54F WB

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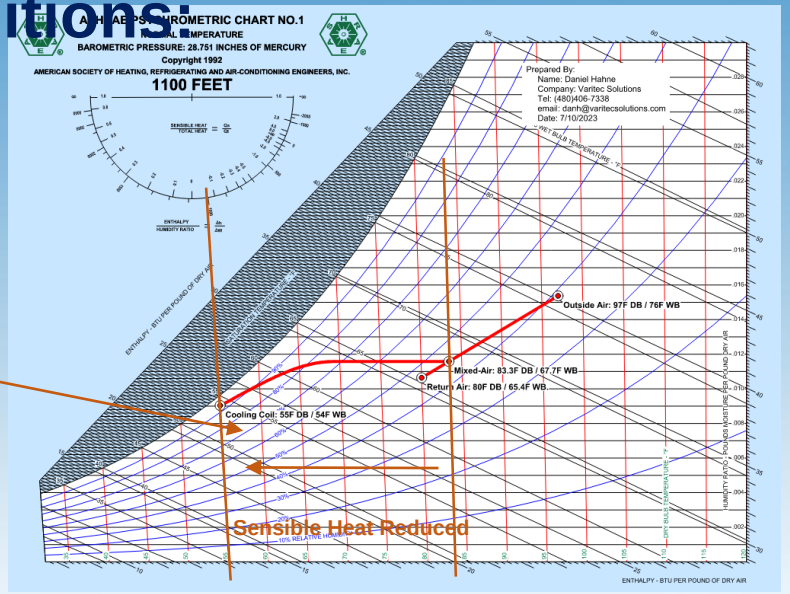
Medium Pressure VAV Systems: Psychrometrics

Displacement AHU Design Conditions:

- **AHU Psychrometric Process:**
  - Mixed-Air Condition: 81F DB / 66F WB
  - Cooling Coil: Chilled Water Temperature 44F
  - Cooling Coil Leaving Air Temp (LAT): 55F DB / 54F WB

Sensible Heat Depression = 26F degrees



- **Sensible Heat Removal: Cooling Process**
  - **81F DB EAT – 55F LAT = ∆26F degrees**

- **Total Sensible Energy (*Ts*) Calculation:**
  - ***Ts = 1.08 X CFM x ∆T (T1 – T2)***
  - **Process: *TS = 1.08 x 20,000 CFM x 26F degrees = 561,600 Btus***

- *Ts is total sensible heat energy*
- *1.08 is a constant value*
- *CFM is the total system airflow*
- *T1 – First state point dry bulb temperature*
- *T2 – Second state point dry bulb temperature*

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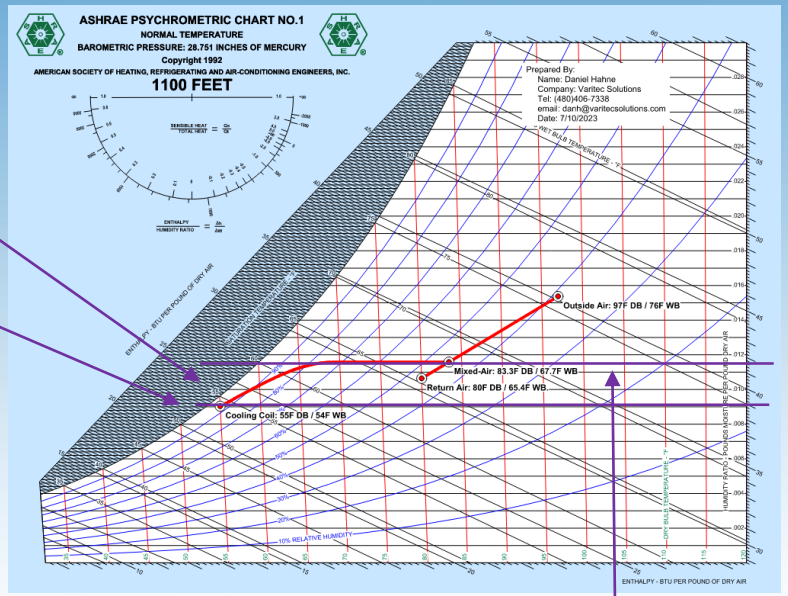
Controlling Building Humidity

Displacement AHU Design Conditions:

- **Displacement Psychrometric Process:**
  - **Mixed-Air Condition: 81F DB / 66F WB**
  - **Cooling Coil: Chilled Water Temperature 44F**
  - **Cooling Coil Leaving Air Temp (LAT): 55F DB / 54F WB**
  - **AHU Leaving Air Condition: 65F DB / 57F WB**



Dew Point Depression: 1.8F

Coil LAT Dew Point

Room: 55.13F Dew Point

The Humidity Challenge:

- Space Design Condition: 75F @ 50% RH = 55.13F Dew Point
- **Supply Air Condition: 65F DB / 57F WB = 53.35F Dew Point**

Total Space Dew Point Depression:

55.13F – 53.35F = 1.8F Dew Point Depression

Outside air dehumidified, but what about the latent gain in the zone; occupants, humidity infiltration

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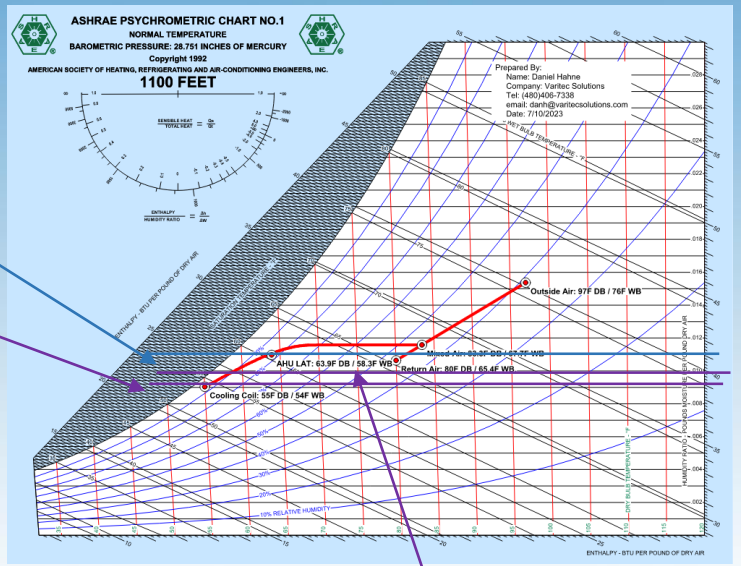
Controlling Building Humidity

Displacement AHU Design Conditions:

- **Displacement Psychrometric Process:**
  - **Mixed-Air Condition: 81F DB / 66F WB**
  - **Cooling Coil: Chilled Water Temperature 44F**
  - **Cooling Coil LAT @ 13,500 CFM: 55F DB / 54F WB**
  - **Mixed-Air @ 6,500 CFM: 83.3F DB / 67.7F WB**
  - **AHU Leaving Air Condition: 65F DB / 57F WB**



LAT Dew Point Increase: +3.5F

Coil LAT Dew Point

The Humidity Challenge:

- Space Design Condition: 75F @ 50% RH = 55.13F Dew Point
- **Supply Air Condition: 65F DB / 57F WB = 58.6F Dew Point**

Total Space Dew Point Increase:

58.6F – 53.35F (Coil) = +3.5F Dew Point Increase

Room: 75F @ 50% RH = 55.13F Dew Point

No Humidity Control

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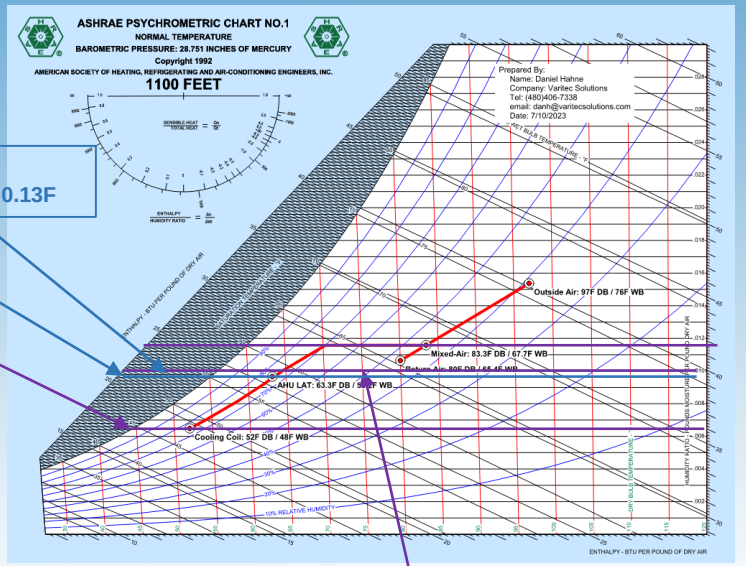
Controlling Building Humidity

Displacement AHU Design Conditions:

- **Displacement Psychrometric Process:**
  - Mixed-Air Condition: 83.3F DB / 67.7F WB
  - Cooling Coil: Chilled Water Temperature 42F (?)
  - Cooling Coil LAT @ 12,500 CFM: 52F DB / 48F WB
  - Mixed-Air @ 7,500 CFM: 83.3F DB / 67.7F WB
  - AHU Leaving Air Condition: 65F DB / 58.2F WB



Dew Point Depression = 0.13F

AHU LAT = 55F Dew Point

Coil LAT Dew Point = 44.6F

Room: 75F @ 50% RH = 55.13F Dew Point

The Humidity Challenge:

- Space Design Condition: 75F @ 50% RH = 55.13F Dew Point

Supply Air Condition: 65F DB / 58.2F WB = 55.0F Dew Point

Total Space Dew Point Depression:

55.13F – 55.0F (AHU) = 0.13F Dew Point

Space dehumidification occurs, but is it enough?

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Custom DX DOAS Units for Building Humidity Control: Psychrometric Process

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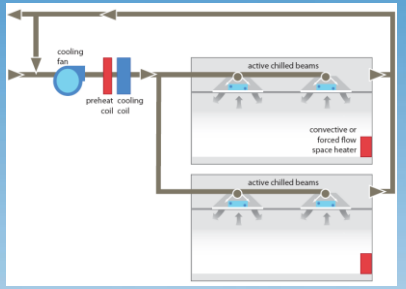
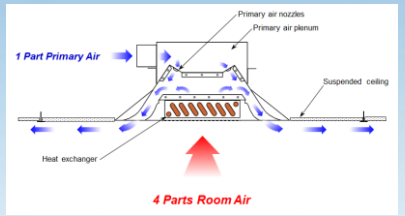
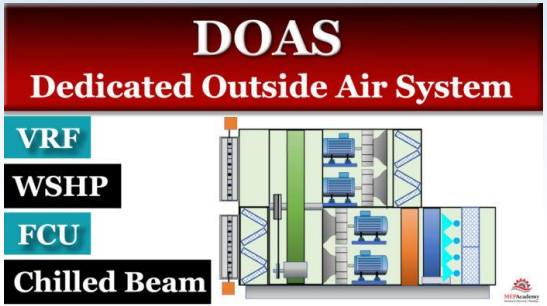
Custom DX DOAS Units For Humidity Control

DOAS Unit Design Conditions:

- **100% OSA Unit (DOAS) for Decoupled Hydronic Systems:**
  - **System Types:** Chilled Beams, Passive Radiant Cooling & Heating…
  - **Design Intent:** Decouple the Total Load into Latent and Sensible Components
  - **Sensible Load:** Controlled mostly at the zone level
  - **Latent Load:** Controlled by DOAS primary air condition







Dedicated OSA Unit (DOAS):

- Sample Building Size: 20,000 SQFT
- Total Supply Airflow: 7,000 CFM (0.35 CFM / SQFT)
- DOAS unit to use enthalpy heat recovery.
- Total Exhaust: 6,300 CFM (90% of supply for building pressure)

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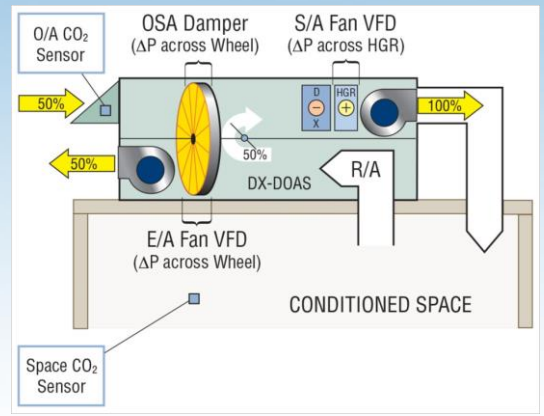
Custom DX DOAS Units For Humidity Control

DOAS Unit Design Conditions:

- **Design Conditions: Summer Monsoon**
  - Outside Air: Peak Summer @ 97F DB / 76F WB
  - Room Condition: 75F DB / 62.4F WB or 50% RH
  - Exhaust Air: 77F DB / 63.0F WB or 46% RH



DX-DOAS Unit Design Parameters:

- Dual tunnel configuration: Supply / Exhaust
- Total Supply Airflow: 7,000 CFM
- Supply Air: 52F DB / 50F WB or 48F (48.4F Dew Point)
- Total Exhaust Airflow: 6,400 CFM
- Exhaust Air: 77F DB / 63.0F WB or 46% RH

Hot Gas Reheat Coil: Leaving Air Condition 60F DB @ 48.4F DP for Humidity Control

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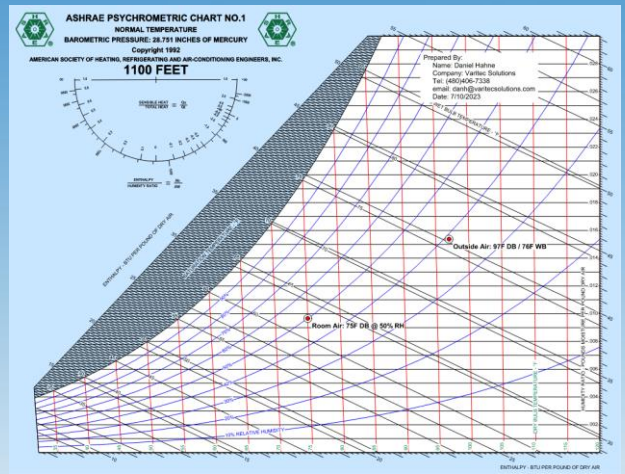
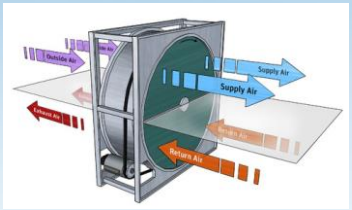
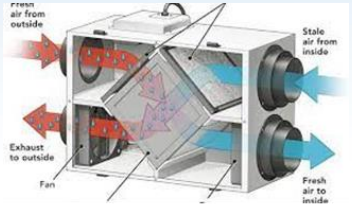
Custom DX DOAS Units For Humidity Control

DOAS Unit Design Conditions:

- **100% OSA Unit (DOAS) Unit**
  - **Design Conditions: Summer Monsoon**
    - Outside Air Summer @ 97F DB / 76F WB
    - Room Condition: 75F DB / 62.4F WB or 50% RH
    - Exhaust Air: 77F DB / 63.0F WB or 46% RH







New Technology

Energy Recovery (Enthalpy) Wheel Performance:

- **Entering Air Conditions:**
  - Outside Air (7,000 CFM): 97F DB / 76F WB
  - Exhaust Air (6,400 CFM: 77F DB / 63F WB
- **Leaving Outside Air Conditions:**
  - Summer: 83.1F DB / 67.9F WB (Effectiveness: 74.7%)
  - Winter: 59.5F DB / 57.2F WB (Effectiveness: 78.8%)

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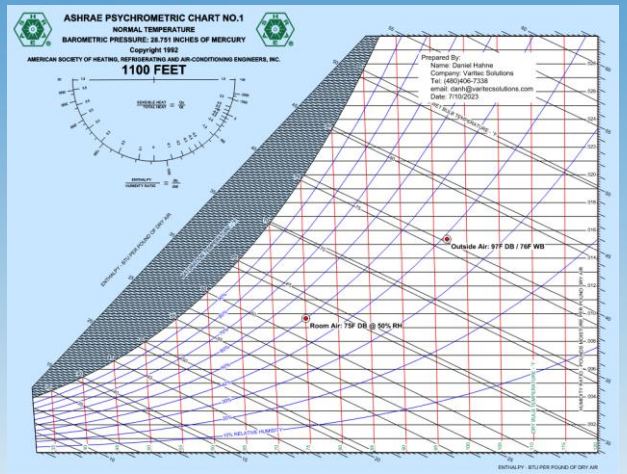
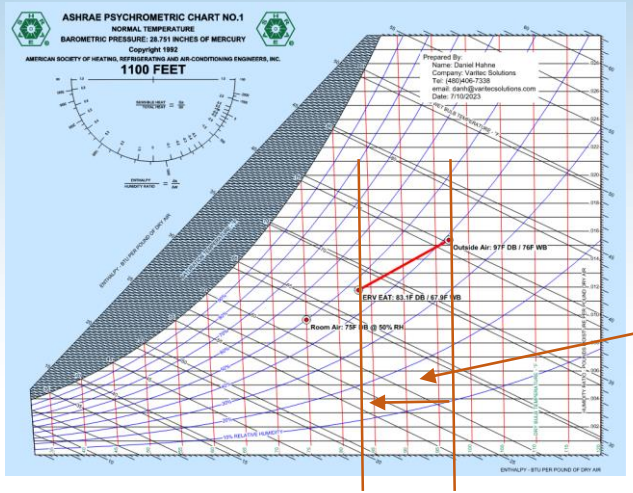
Custom DX DOAS Units For Humidity Control

DOAS Unit Design Conditions:

- **100% OSA Unit (DOAS) Unit**
  - **Design Conditions: Summer Monsoon**
    - Outside Air Summer @ 97F DB / 76F WB
    - Room Condition: 75F DB / 62.4F WB or 50% RH
    - Exhaust Air: 77F DB / 63.0F WB or 46% RH





Energy Recovery Cooling LAT:

- Outside Air Dry Bulb = 97F
- Leaving Air Dry Bulb = 83.1F
- **Cooling Sensible Depression: 13.9F DB**
- $T_S = 1.08 \times CFM \times \Delta T\ (T_1 - T_2)$ = ***105,084 Btus Sensible Heat Recovery***

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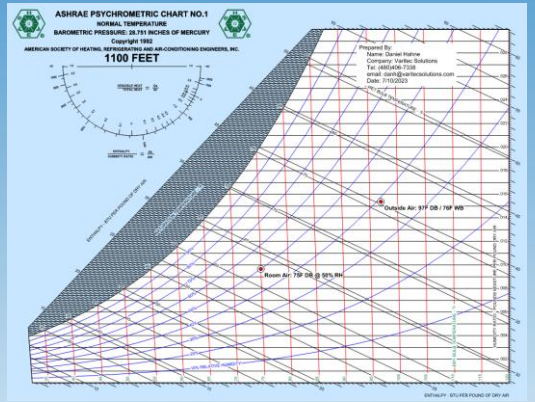
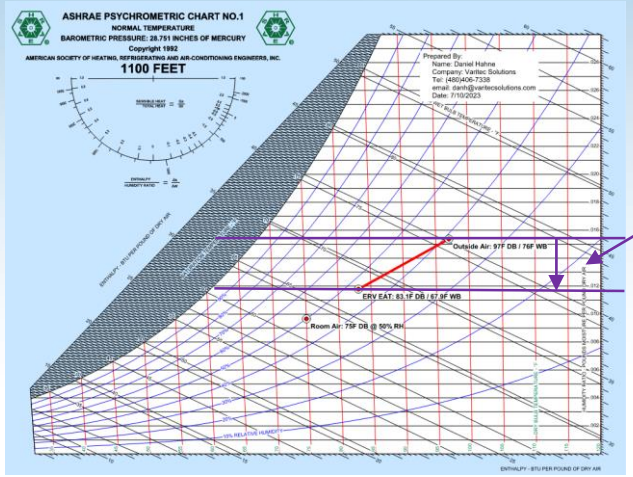
Custom DX DOAS Units For Humidity Control

DOAS Unit Design Conditions:

- **100% OSA Unit (DOAS) Unit**
  - **Design Conditions: Summer Monsoon**
    - Outside Air Summer @ 97F DB / 76F WB
    - Room Condition: 75F DB / 62.4F WB or 50% RH
    - Exhaust Air: 77F DB / 63.0F WB or 46% RH





Energy Recovery Dehumidification LAT:

- Outside Air Dew Point = 68F = 107.6 gr/lb
- Leaving Air Condition: 83.1F DB / 67.9F WB = 60.6F DP = 82.5 gr/lb
- **Cooling Dew Point Depression: 7.4F DP**
- ***T_L = 0.68 X CFM x ΔW gr. ($W_1 - W_2$) = 119,476 Btus Latent***

Heat Recovery Total Energy Savings
= 224,560 Btus

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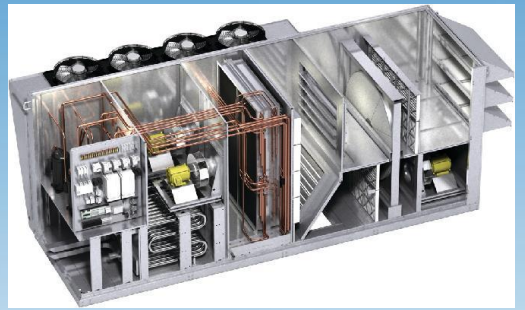
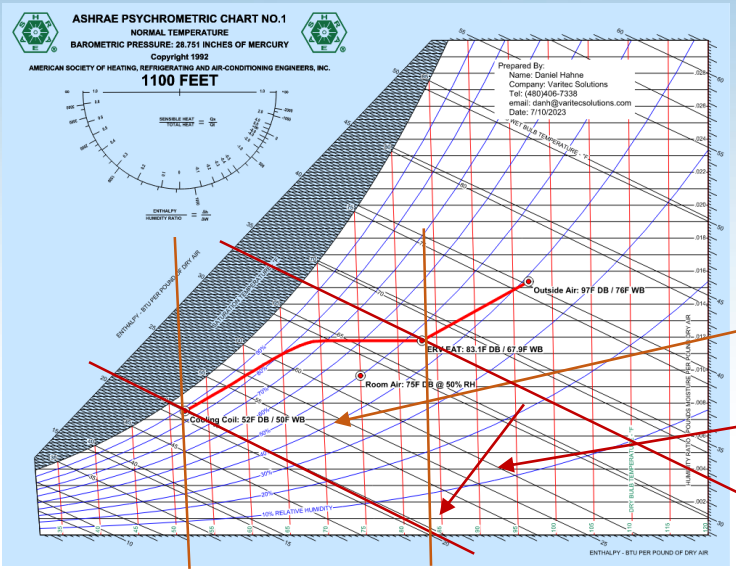
Custom DX DOAS Units For Humidity Control

DOAS Unit Design Conditions:

- **DOAS Unit Psychrometric Process:**
  - **Design Conditions: Summer Monsoon**
    - Outside Air Summer @ 97F DB / 76F WB
    - Cooling Coil LAT: 52F DB / 50F WB or 48.4F DP
    - Exhaust Air: 77F DB / 63.0F WB or 46% RH





Cooling Coil LAT: Enthalpy Heat Recovery

- Cooling Coil Dry Bulb EAT = 83.1F
- Cooling Coil Dry Bulb LAT = 52F
- **Cooling Sensible Dry Bulb Depression = 31.1F Total**
- $T_S = 1.08 \times CFM \times \Delta T\ (T_1 - T_2)$ = ***235,116 Btus Sensible Heat Recovery***

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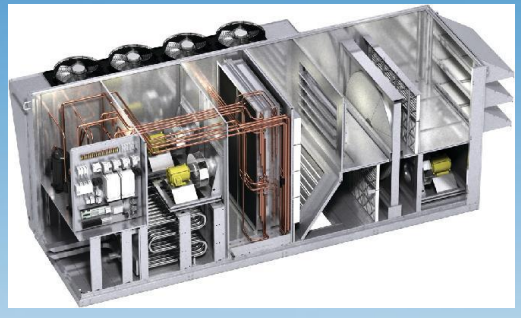
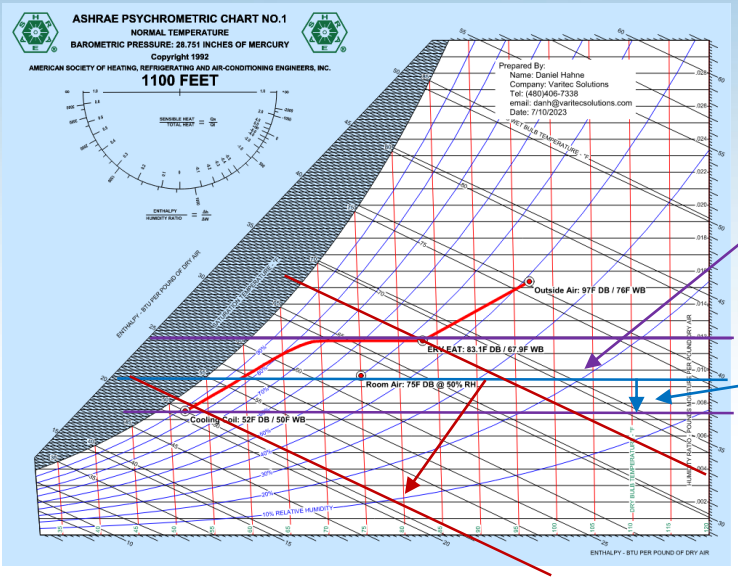
Custom DX DOAS Units For Humidity Control

DOAS Unit Design Conditions:

- **DOAS Unit Psychrometric Process:**
  - **Design Conditions: Summer Monsoon**
    - Outside Air Summer @ 97F DB / 76F WB
    - Cooling Coil LAT: 52F DB / 50F WB or 48.4F DP
    - Exhaust Air: 77F DB / 63.0F WB or 46% RH





Cooling Coil LAT:

- Outside Air DP = 68.0F = 82.5 gr/lb
- Cooling Coil LAT DP = 48.4F = 52.6 gr/lb
- **Cooling Dew Point Depression**
- ***T_L = 0.68 X CFM x ΔW gr. (W_1 – W_2) = 142,324 Btus Latent***
- **Space Dew Point Depression = 6.7F**
- **Total Load: $h_t = h_s + h_l =$ *377,440 Btus***

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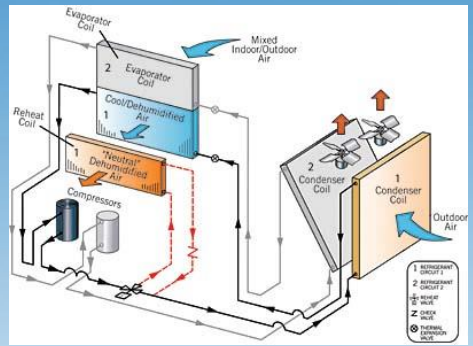
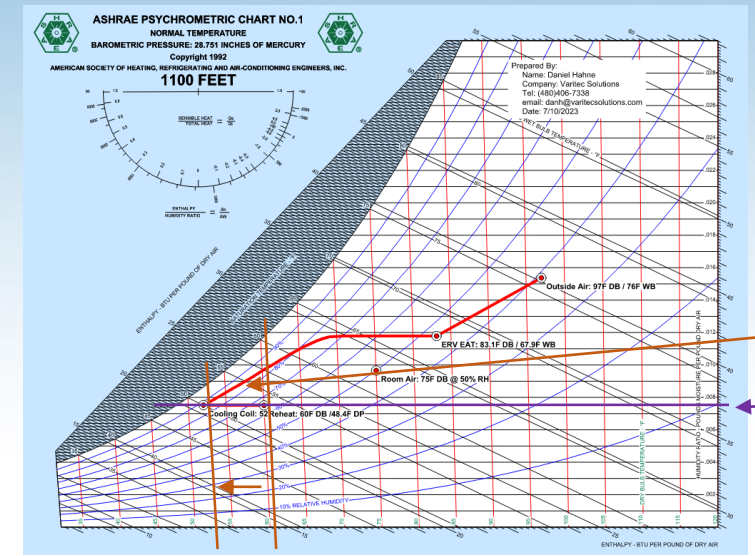
Custom DX DOAS Units For Humidity Control

DOAS Unit Design Conditions:

- **DOAS Unit Psychrometric Process: Hot Gas Reheat**
  - **Design Conditions: Summer Monsoon**
    - Cooling Coil LAT: 52F DB / 50F WB or 48.4F DP
    - Hot Gas Reheat LAT: 60F DB / 53.3F WB or 48.4F DP





- **Hot Gas Reheat Coil: Load Neutral Air**
  - Compressor Heat Energy Capture to post-condition supply air off the cooling coil

- **Sensible Heat Gain: 18F DB**
- **Dew Point remains the same: 48.4F**

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Presentation Review

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Presentation Review

- Psychrometric Terminology Review
- Medium Pressure VAV Systems: Psychrometric Process
  - VAV with Terminal Reheat
- Controlling Building Humidity Supplying 55F DB / 54F WB Supply Air
- Sensible and Enthalpy Heat Recovery: Psychrometric Process
- Displacement Ventilation Air Handlers: Psychrometric Process
- Custom DX DOAS Units for Building Humidity Control: Psychrometric Process

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Questions?

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Thank you.

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