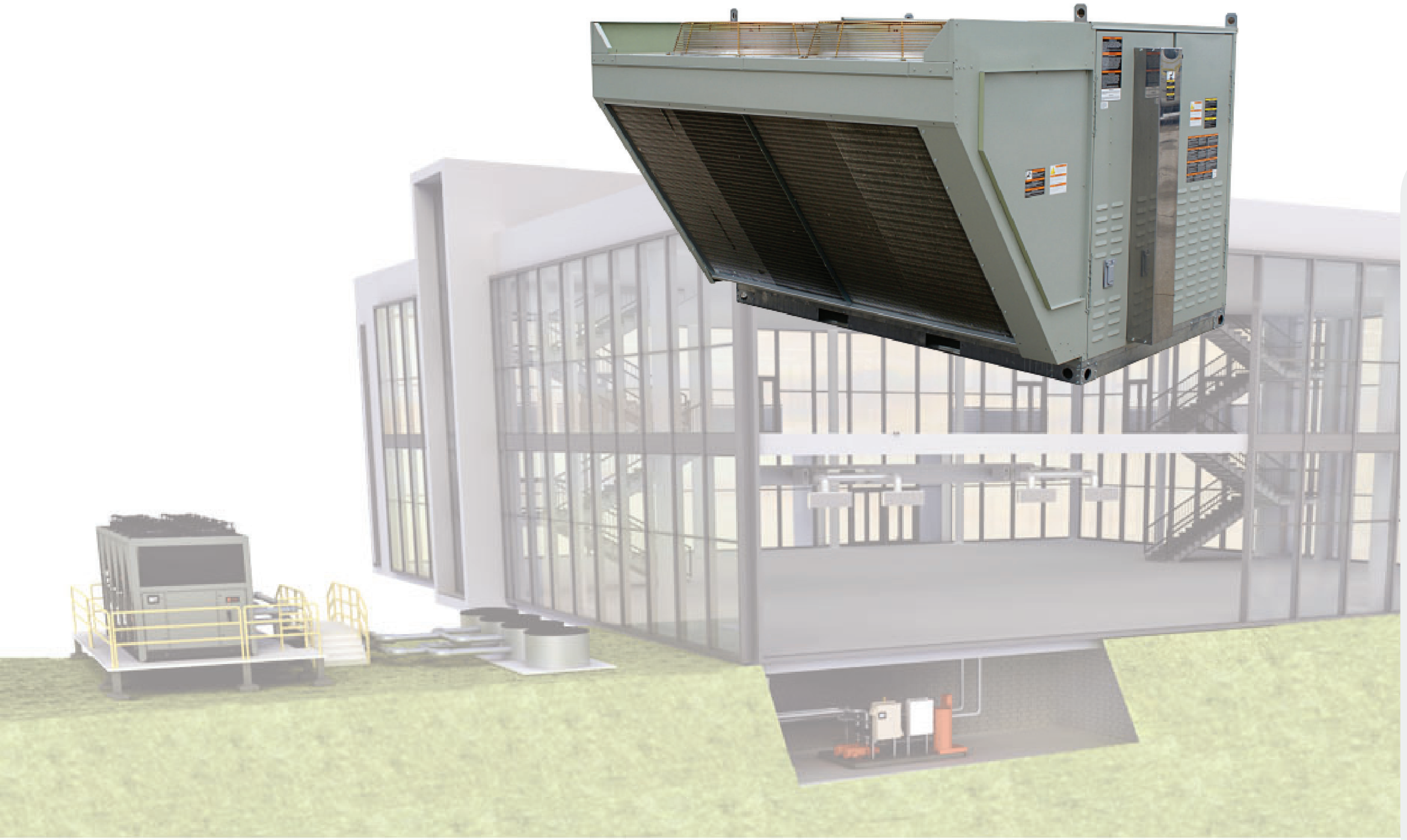
Trane Engineers Newsletter Live

Impact of DOAS Dew Point on Space Humidity

with Trane Application Engineers Ronnie Moffitt, John Murphy and Eric Sturm



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Agenda

Trane *Engineers Newsletter Live* Series

Impact of DOAS Dew Point on Space Humidity

Abstract
Dedicated outdoor-air systems (DOAS) are used in a variety of building types to provide ventilation.
A DOAS can help prevent high space humidity levels when it dehumidifies the outdoor air drier than the space. But many systems designed and installed today are not dehumidifying adequately. This ENL will demonstrate the impact of the DOAS supply-air dew point on space humidity levels, at both full load and part load.

Presenters: Trane application engineers Ronnie Moffitt, John Murphy and Eric Sturm

After viewing attendees will be able to:

1. Explain the definition of DOAS
2. Understand the impact of DOAS supply-air dew point on space humidity levels
3. Complete the steps for determining the "right" DOAS supply-air dew point for a given application
4. Identify the factors that influence the required DOAS supply-air dew point
5. Understand common DOAS control strategies

Agenda

- Definition of DOAS
- Impact of DOAS supply-air dew point
- What's the "right" dew point?
- DOAS air delivery configurations and control

Presenter biographies

Impact of DOAS Dew Point on Space Humidity

JOHN MURPHY | APPLICATIONS ENGINEER | TRANE

John has been with Trane since 1993. His primary responsibility as an applications engineer is to aid design engineers and Trane sales personnel in the proper design and application of HVAC systems. His main areas of expertise include energy efficiency, dehumidification, dedicated outdoor-air systems, air-to-air energy recovery, psychrometry, airside system control and ventilation. He is also a LEED Accredited Professional.

John is the author of numerous Trane application manuals and Engineers Newsletters, and is a frequent presenter on Trane's Engineers Newsletter Live series. He has authored several articles for the ASHRAE Journal, and was twice awarded "Article of the Year" award. He is an ASHRAE Fellow and has served on the "Moisture Management in Buildings" and "Mechanical Dehumidifiers" technical committees. He was a contributing author of the Advanced Energy Design Guide for K-12 Schools and the Advanced Energy Design Guide for Small Hospitals and Health Care Facilities, a technical reviewer for the ASHRAE Guide for Buildings in Hot and Humid Climates, and a presenter on the 2012 ASHRAE "Dedicated Outdoor Air Systems" webcast.

RONNIE MOFFITT | SYSTEMS ENGINEER | TRANE

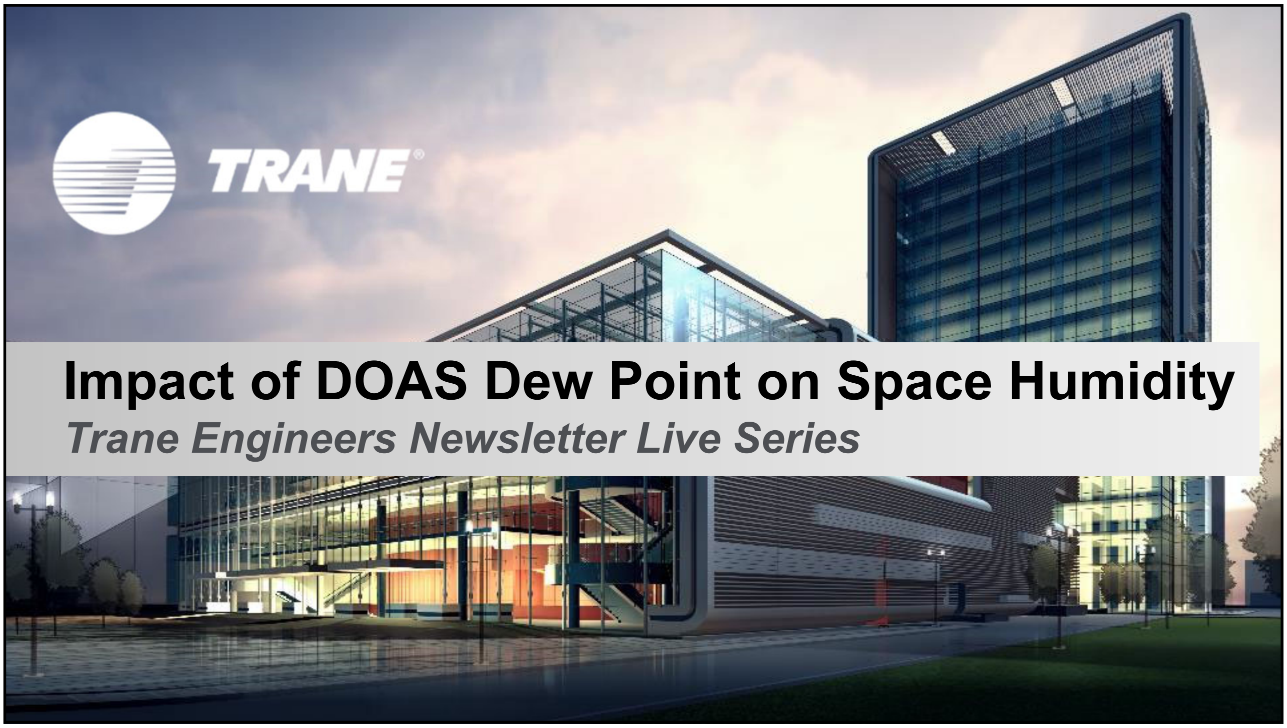
Ronnie joined Trane in 1996 and currently is a systems engineer focused on developing and optimizing commercial HVAC systems and control strategies. His primary focus has been dehumidification, air-to-air energy recovery and DOAS design. He has several patents related to these subjects and serves on related AHRI and ASHRAE engineering committees.

Ronnie is the past chairman of the AHRI dehumidification engineering section and past chairman of ASHRAE's "Energy Recovery" technical committee. He led the development of the Trane CDQ™ system, a winner of the R&D 100 Award for The Most Technologically Significant New Products of 2005. He received his B.S. in Aerospace Engineering from Syracuse University and is a licensed professional engineer and a certified Energy Manager (CEM) by Association of Energy Engineers.

ERIC STURM | APPLICATIONS ENGINEER | TRANE

Eric joined Trane in 2006 after graduating from the University of Wisconsin – Platteville with a Bachelor of Science degree i n mechanical engineering. Prior to joining the applications engineering team, he worked in the Customer Direct Services (C.D.S.) department as a marketing engineer and product manager for the TRACE™ 700 load design and energy simulation application. As a C.D.S. marketing engineer he supported and trained customers globally.

In his current role as an applications engineer, Eric's areas of expertise include acoustics, airside systems, and standards and codes. He is currently involved with ASHRAE as a representative on Members Council and member of the "indoor agriculture" and "Sound and Vibration" technical committees. Eric is the recipient of a Young Engineers in ASHRAE Award of Individual Excellence for service to the La Crosse Area Chapter and nationally recognized with an ASHRAE Distinguished Service Award.



Impact of DOAS Dew Point on Space Humidity

Trane Engineers Newsletter Live Series

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Learning Objectives

- Explain the definition of DOAS
- Understand the impact of DOAS supply-air dew point on space humidity levels
- Complete the steps for determining the "right" DOAS supply-air dew point for a given application
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- Understand common DOAS control strategies

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- Definition of DOAS
- Impact of DOAS supply-air dew point
- What's the "right" dew point?
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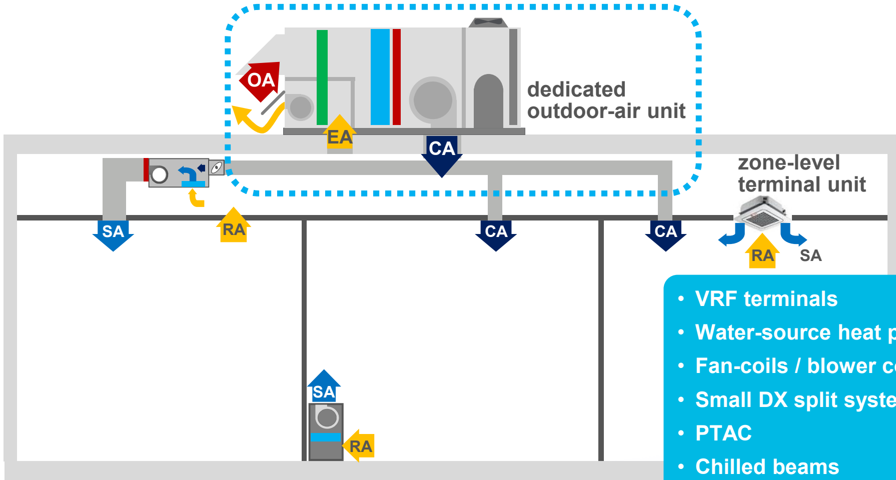
Today's Presenters

John Murphy
Applications Engineer

Eric Sturm
Applications Engineer

Ronnie Moffitt
Applications Engineer

Dedicated Outdoor-Air System (DOAS)



- VRF terminals
- Water-source heat pumps
- Fan-coils / blower coils
- Small DX split systems
- PTAC
- Chilled beams
- Sensible-cooling terminal units

AHRI Standard 920
What is a Dedicated Outdoor-Air Unit?

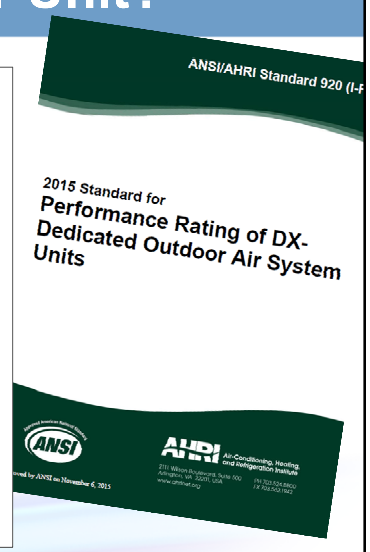
A dedicated outdoor-air unit …

"operate[s] in combination with a separate sensible cooling system to satisfy the entire building humidity load.

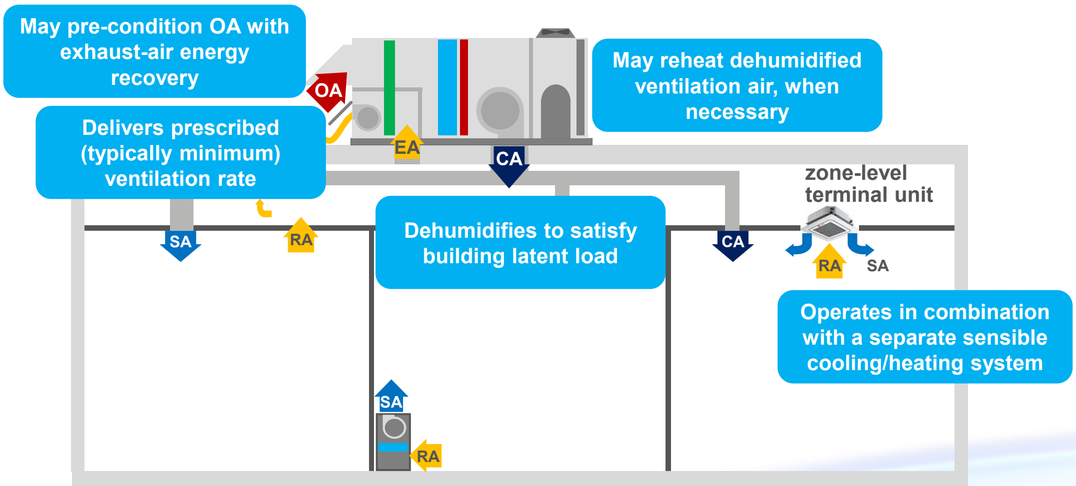
The system is sized to maintain a prescribed ventilation rate under any load condition. The ventilation rate can be constant or varied based on the building operation or occupancy schedule or in response to the actual occupancy.

It may pre-condition outdoor air by incorporating an enthalpy wheel, sensible wheel, desiccant wheel, plate heat exchanger, heat pipes or other heat or mass transfer apparatus.

It shall reheat the ventilation air by containing a reheat refrigerant circuit, sensible wheel, heat pipe, or other heat or mass transfer apparatus."



AHRI Standard 920
What is a Dedicated Outdoor-Air Unit?



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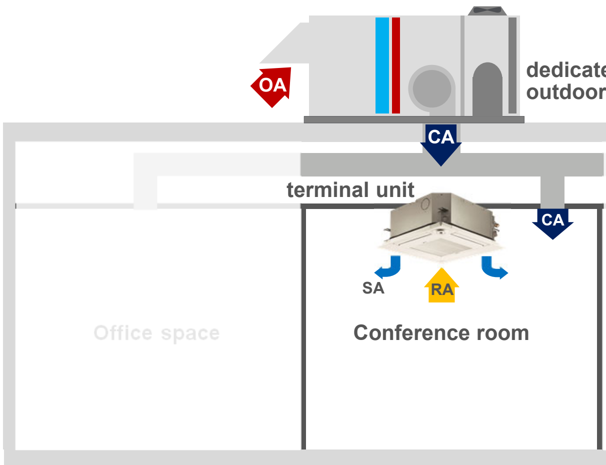
- **Impact of DOAS supply-air dew point**
- What's the "right" dew point?
- DOAS air delivery configurations and control

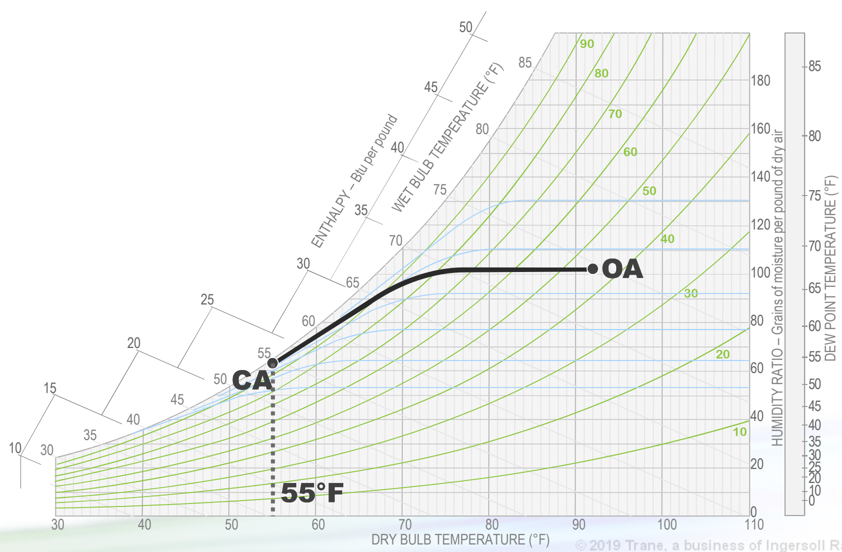
Psychrometric analysis



Conference room	
Area:	1000 ft^2
Design occupancy:	25 people
Required ventilation:	185 cfm
Design sensible load:	11,800 Btu/hr
Design latent load:	3,900 Btu/hr
Sensible heat ratio (SHR):	0.75
Temperature and humidity setpoints:	75°F, 50% rh (~55.1°F DPT)

DOAS Supply of 55°F

Psychrometric analysis – design conditions



DOAS Supply of 55°F
Psychrometric analysis – design conditions

	Sensible load Btu/hr	Latent load Btu/hr
Design loads	11,800	3,900
Space load offset by ventilation system, Btu/hr	-4,015	-204
Subtotal	7,785	3,696

DOAS Supply of 55°F
Psychrometric analysis – design conditions

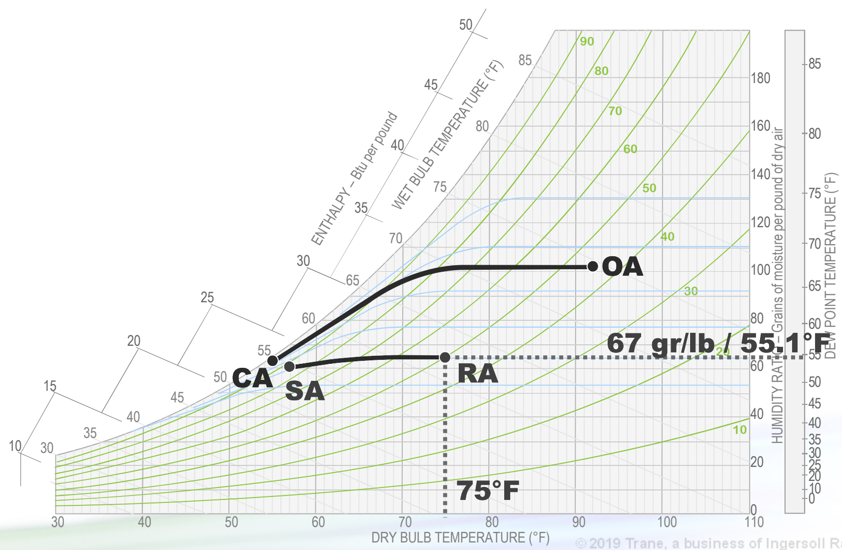
$Q_{space,\ sensible} = 1.085 \times cfm \times \Delta T$

7,785 Btu/hr = 1.085 × **SA** cfm × (75°F – 57°F) ∴ **SA = 400 cfm**

$Q_{space,\ latent} = 0.69 \times cfm \times \Delta W$

$\mathbf{Q_{space,\ latent}} = 0.69 \times 400\ cfm \times (67.5\ gr/lb - 62.3\ gr/lb)$ ∴ $\mathbf{Q_{space,\ latent} = 1{,}431\ Btu/hr}$

Psychrometric analysis – design conditions

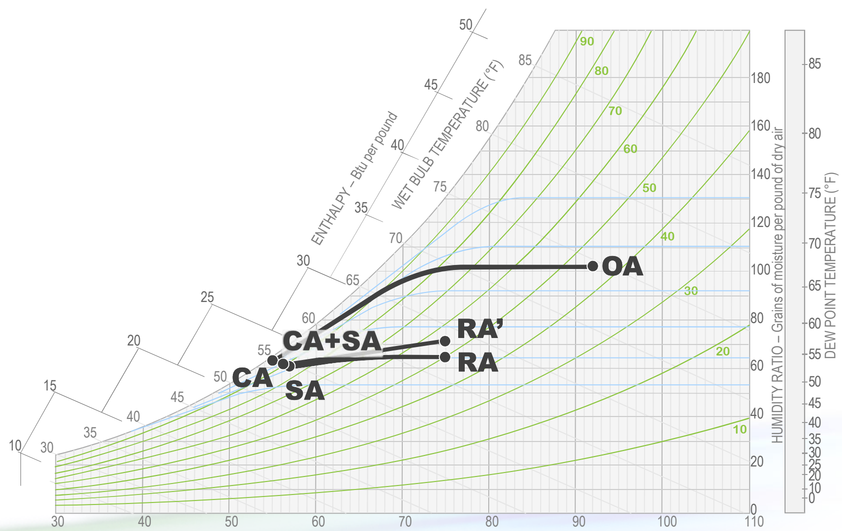


DOAS Supply of 55°F

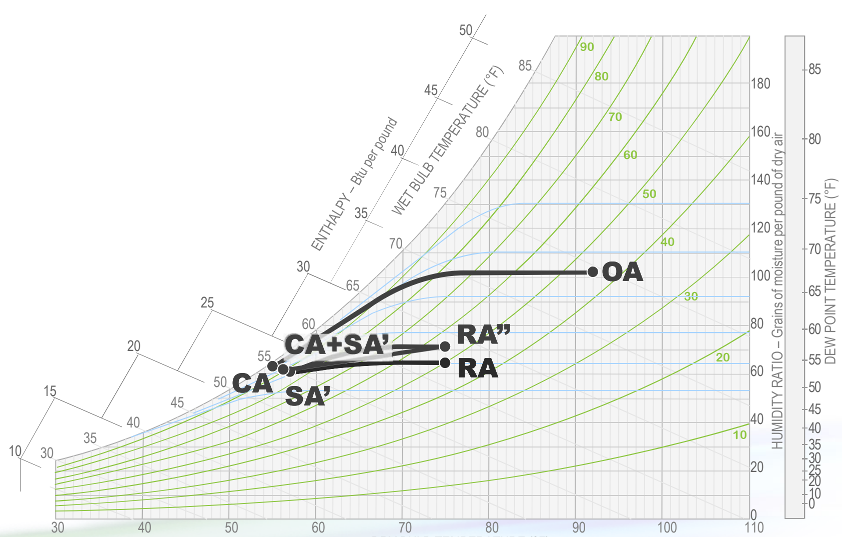
Psychrometric analysis – design conditions

	Sensible load Btu/hr	Latent load Btu/hr
Design loads	11,800	3,900
Space load offset by ventilation system, Btu/hr	-4,015	-204
Subtotal	7,785	3,696
Terminal Unit	-7,785	-1,431
Total	**0**	**2,265**

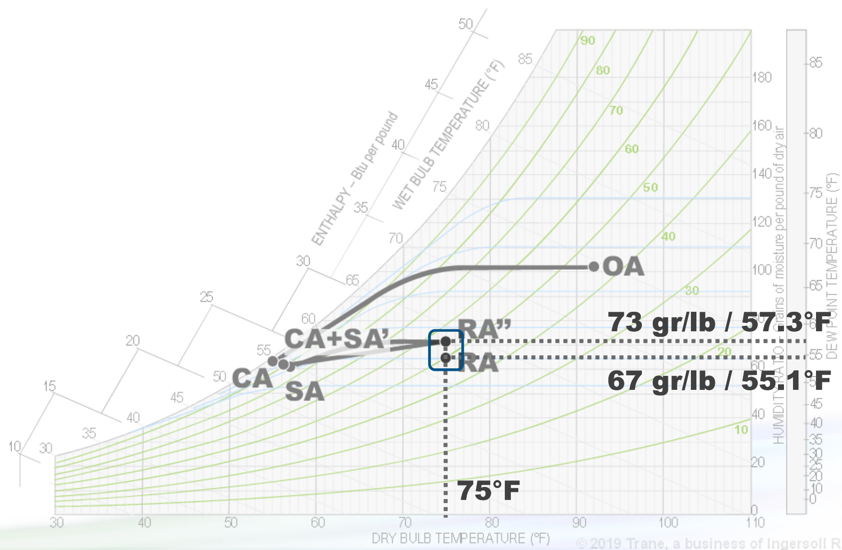
DOAS Supply of 55°F
Psychrometric analysis – design conditions



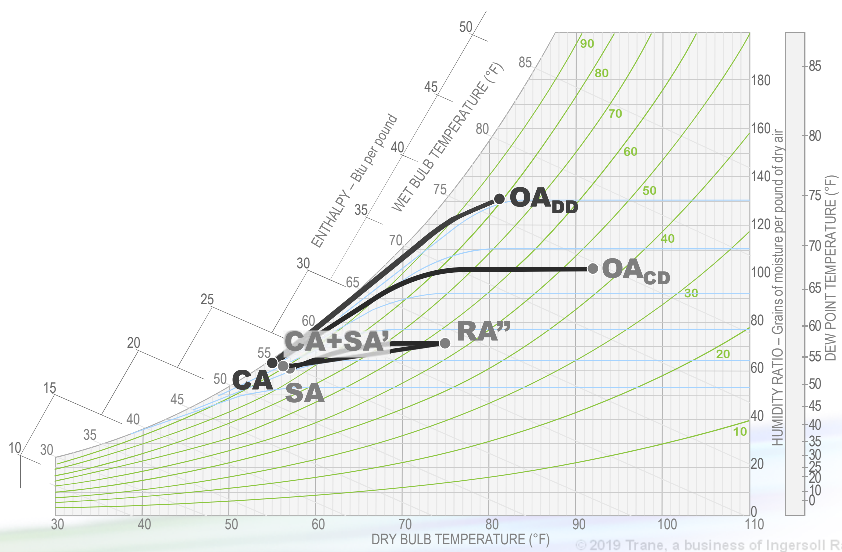
DOAS Supply of 55°F
Psychrometric analysis – design conditions



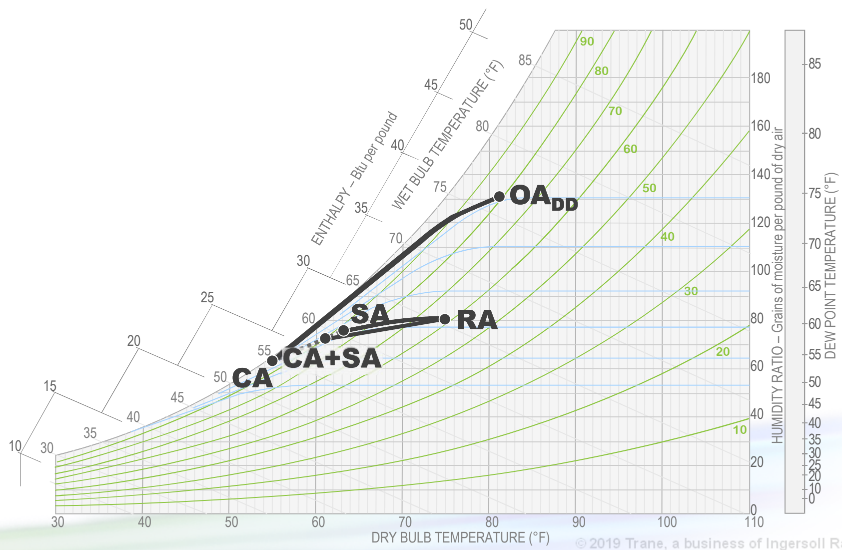
DOAS Supply of 55°F
Psychrometric analysis – design conditions



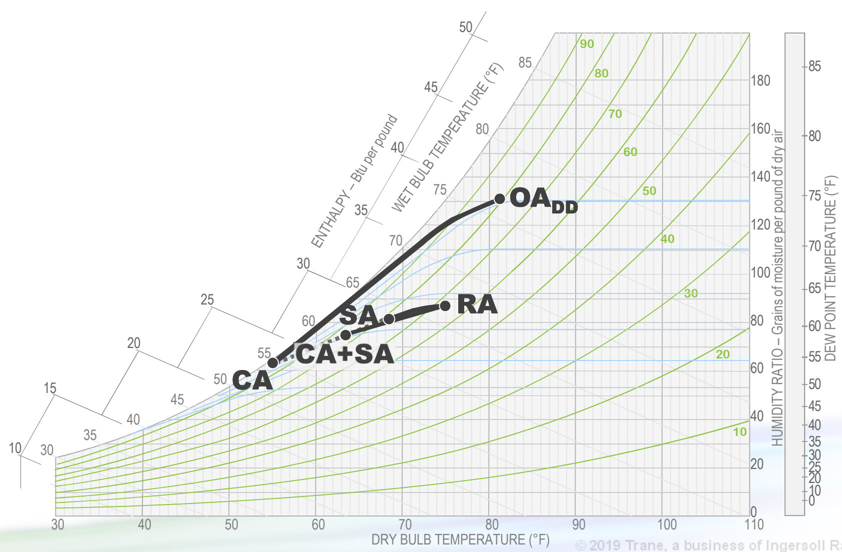
DOAS Supply of 55°F
Psychrometric analysis – part-load conditions



DOAS Supply of 55°F
Psychrometric analysis – part-load conditions



Psychrometric analysis – part-load conditions



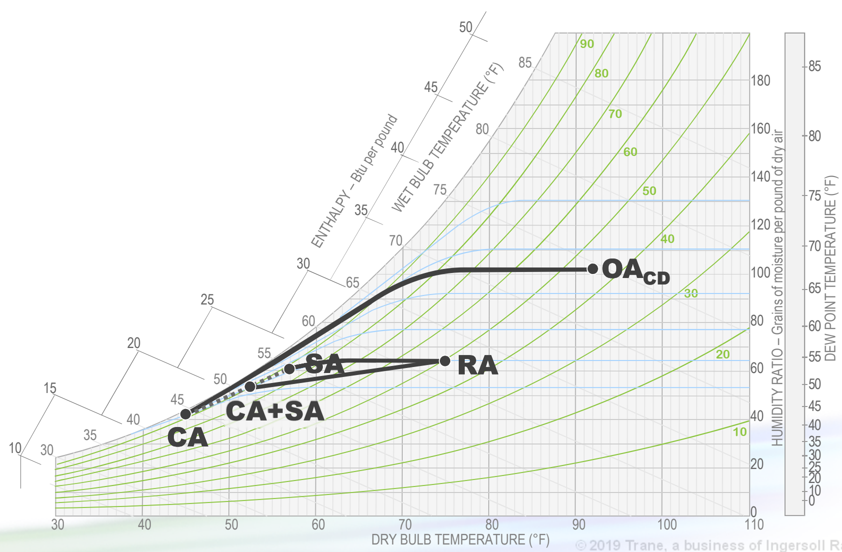
DOAS Supply of 55°F

Psychrometric analysis – results

	Full load (SHR: 0.75)	Part-load (SHR: 0.67)	Part-load (SHR: 0.61)
DOAS Supply	185 cfm 55.0°F dry-bulb 54.4°F dew-point	185 cfm 55.0°F dry-bulb 54.4°F dew-point	185 cfm 55.0°F dry-bulb 54.4°F dew-point
Load offset by DOAS	4,015 Btu/hr sensible (0.88 lb/hr)	4,015 Btu/hr sensible (2.16 lb/hr)	4,015 Btu/hr sensible (2.85 lb/hr)
Terminal unit airflow	400 cfm (design)	300 cfm	300 cfm
Load offset by terminal unit	7,785 Btu/hr sensible	3,785 Btu/hr sensible	2,110 Btu/hr sensible
Resulting space relative humidity	54%	62%	66%

DOAS Supply of 45°F

Psychrometric analysis – design conditions



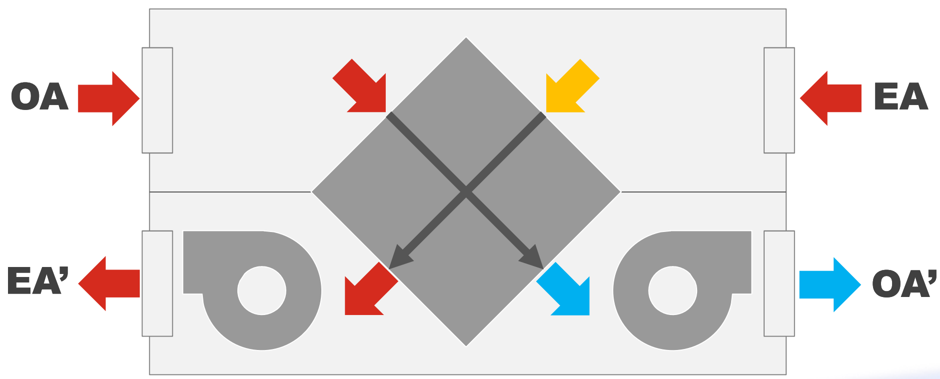
DOAS Supply of 45°F
Psychrometric analysis – results

	Full load (SHR: 0.75)	**Part-load** (SHR: 0.67)	**Part-load** (SHR: 0.61)
DOAS Supply	185 cfm 45.0°F dry-bulb 44.5°F dew-point	185 cfm 45.0°F dry-bulb 44.5°F dew-point	185 cfm 45.0°F dry-bulb 44.5°F dew-point
Load offset by DOAS	6,022 Btu/hr sensible (2.63 lb/hr)	6,022 Btu/hr sensible (3.42 lb/hr)	6,022 Btu/hr sensible (3.42 lb/hr)
Terminal unit airflow	296 cfm (design)	222 cfm	222 cfm
Load offset by terminal unit	5,778 Btu/hr sensible	1,778 Btu/hr sensible	103 Btu/hr sensible
Resulting space relative humidity	49.8%	54.8%	54.8%

Comparing the two options: 55°F vs 45°F

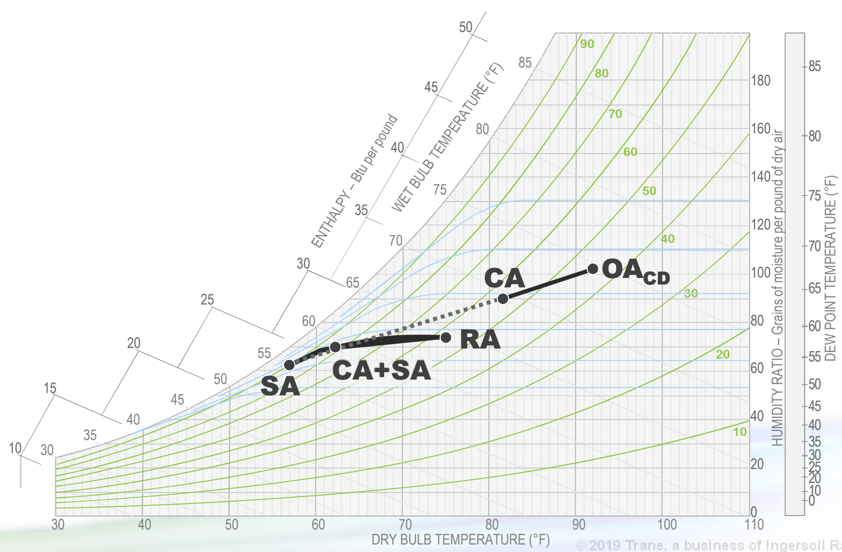
	55-degree DOAS		**45-degree DOAS**	
Supply (DBT/DPT)	55.0°F / 54.4°F		45.0°F / 44.5°F	
Space Sensible Heat Ratio (SHR)	0.75	0.61	0.75	0.61
Load offset by DOAS (Sensible)	4,015 Btu/hr	4,015 Btu/hr	6,022 Btu/hr	6,022 Btu/hr
Terminal unit airflow	400 cfm	300 cfm	296 cfm	222 cfm
Load offset by terminal (Sensible)	7,785 Btu/hr	2,110 Btu/hr	5,778 Btu/hr	103 Btu/hr
Space relative humidity	54%	66%	49%	54%

Energy Recovery Ventilation (ERV)

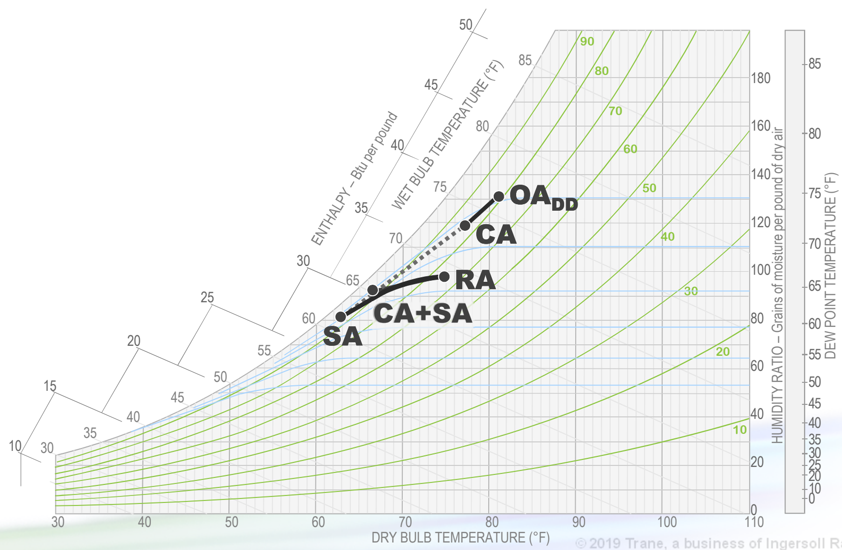


Energy recovery ventilator

Psychrometric analysis – design conditions



Energy recovery ventilator
Psychrometric analysis – part-load conditions



Using an energy recovery ventilator

	55-degree DOAS		45-degree DOAS		ERV	
Supply (DBT/DPT)	55.0°F / 54.4°F		45.0°F / 44.5°F		81.7°F / 62.3°F	77.2°F / 68.1°F
Space Sensible Heat Ratio (SHR)	0.75	0.61	0.75	0.61	0.75	0.61
Load offset by DOAS (Sensible)	4,015 Btu/hr	4,015 Btu/hr	6,022 Btu/hr	6,022 Btu/hr	-1,345 Btu/hr	-442 Btu/hr
Terminal unit airflow	400 cfm	300 cfm	296 cfm	222 cfm	673 cfm	505 cfm
Load offset by terminal (Sensible)	7,785 Btu/hr	2,110 Btu/hr	5,778 Btu/hr	103 Btu/hr	13,145 Btu/hr	6,567 Btu/hr
Space relative humidity	54%	66%	49%	54%	56%	73%

Impact on terminal unit sizing

	ERV	55-degree DOAS	45-degree DOAS
Supply (DBT/DPT)	81.7°F / 62.3°F	55.0°F / 54.4°F	45.0°F / 44.5°F
Space Sensible Heat Ratio (SHR)	0.75	0.75	0.75
Load offset by DOAS (Sensible)	-1,345 Btu/hr	4,015 Btu/hr	6,022 Btu/hr
Terminal unit airflow	673 cfm	400 cfm	296 cfm
Terminal unit size (tons)	1.6 tons	0.9 tons	0.6 tons
Space relative Humidity (0.75 SHR/0.61 SHR)	56% / 73%	54% / 66%	49% / 54%

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- Definition of DOAS
- Impact of DOAS supply-air dew point
- **What's the "right" dew point?**
- DOAS air delivery configurations and control

example: K-12 classroom
What DOAS Supply-Air DPT is Required?

$$Q_{space,latent} = 0.69 \times V_{oz} \times (W_{space} - W_{ca})$$

example K-12 classroom:

$Q_{space,latent}$ = **4030 Btu/hr**
V_{oz} = **350 cfm**
W_{space} = **60.6 gr/lb** (73°F DBT and 50% RH)

$$4030 \text{ Btu/hr} = 0.69 \times 350 \text{ cfm} \times (60.6 \text{ gr/lb} - W_{ca})$$

W_{ca} = **43.9 gr/lb** (~45°F DPT)

example: conference room
What DOAS Supply-Air DPT is Required?

$$Q_{space,latent} = 0.69 \times V_{oz} \times (W_{space} - W_{ca})$$

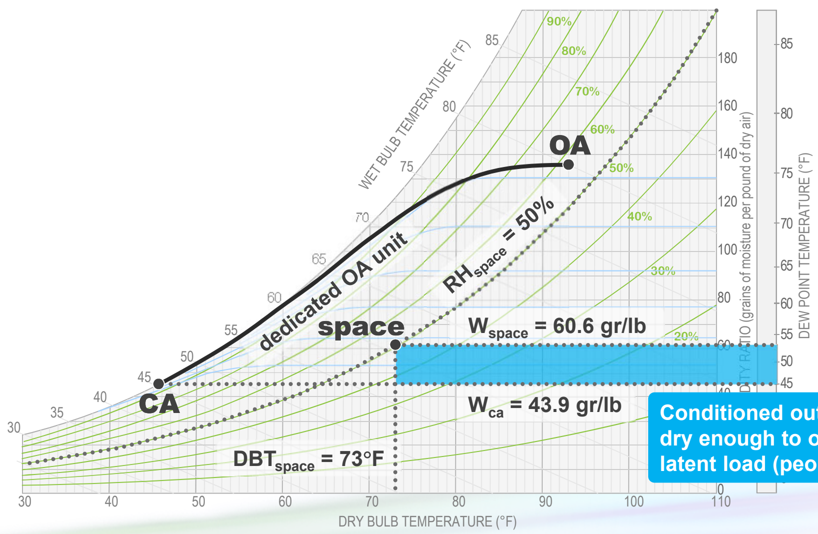
example conference room:

$Q_{space,latent}$ = **3900 Btu/hr**
V_{oz} = **185 cfm**
W_{space} = **64.9 gr/lb** (75°F DBT and 50% RH)

$$3900 \text{ Btu/hr} = 0.69 \times 185 \text{ cfm} \times (64.9 \text{ gr/lb} - W_{ca})$$

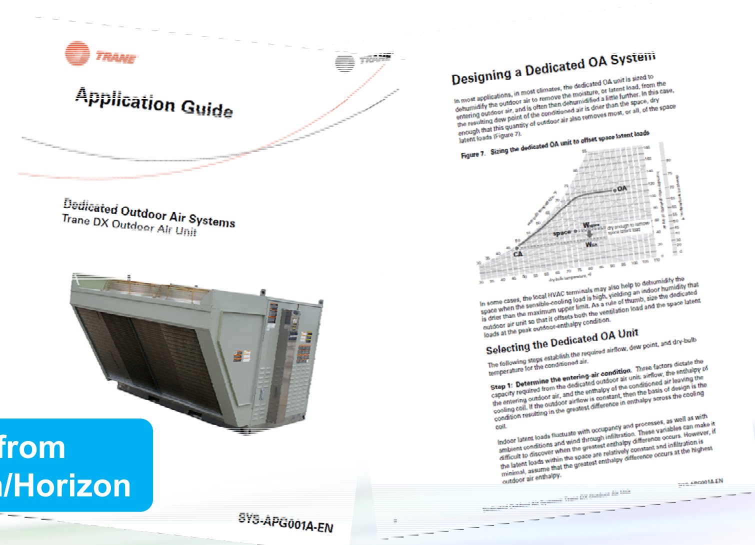
W_{ca} = **34.3 gr/lb** (~38°F DPT)

What DOAS Supply-Air DPT is Required?



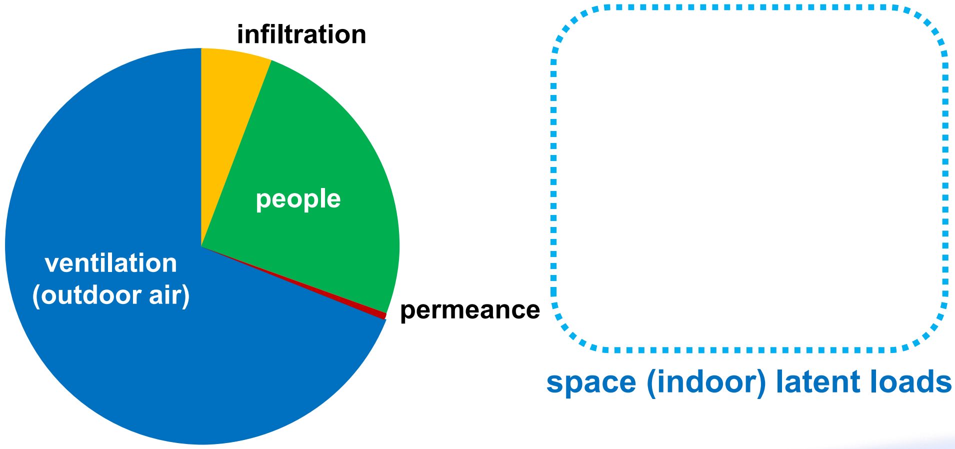
Conditioned outdoor air (CA) is dry enough to offset space latent load (people, infiltration)

What DOAS Supply-Air DPT is Required?



Download from www.trane.com/Horizon

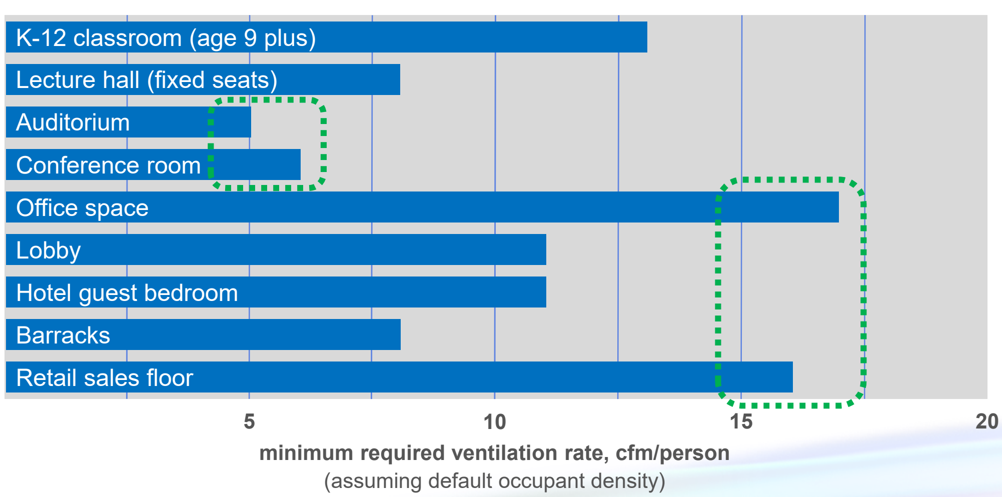
Impact of Space Latent Load, $Q_{space,latent}$



typical latent loads
for a K-12 classroom

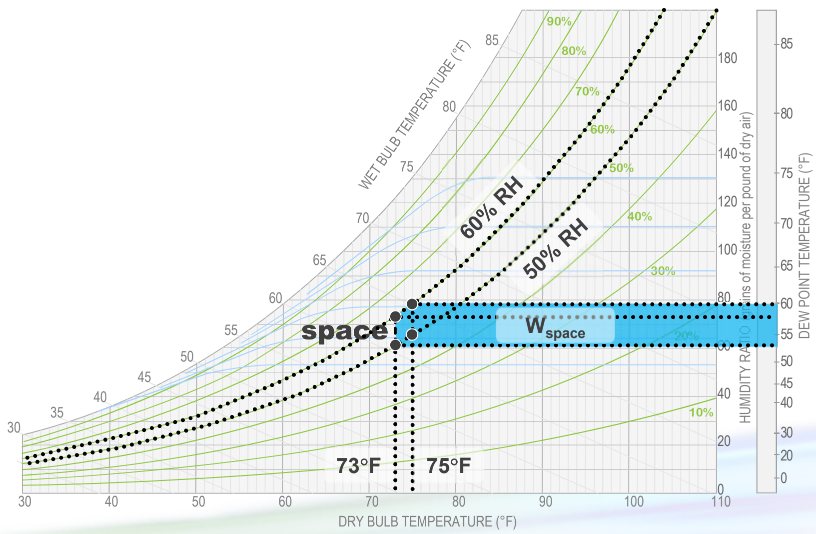
source: *Humidity Control Design Guide*, ASHRAE © 2001, p. 278

Impact of Required Ventilation Rate, V_{oz}

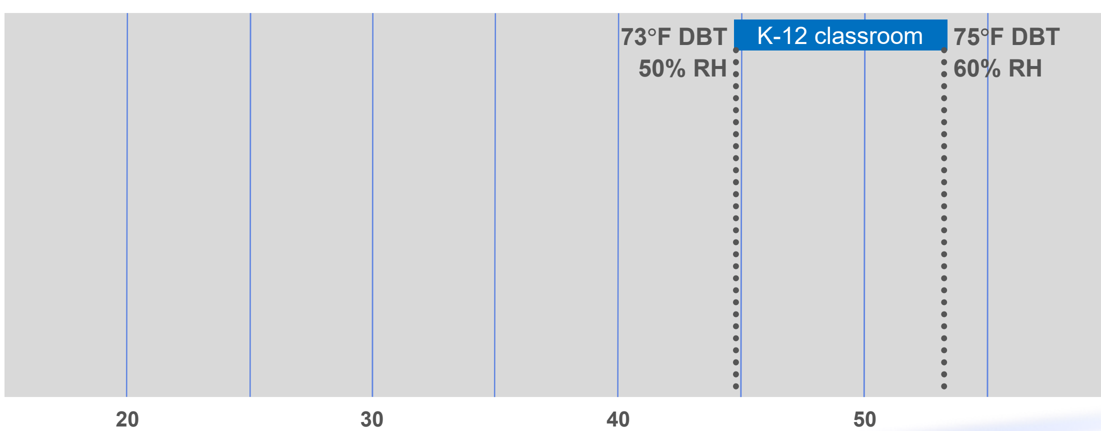


source: ASHRAE Standard 62.1-2016, Table 6.2.2.1 ("Combined Outdoor Air Rate")

Impact of Desired Space Humidity, W_{space}



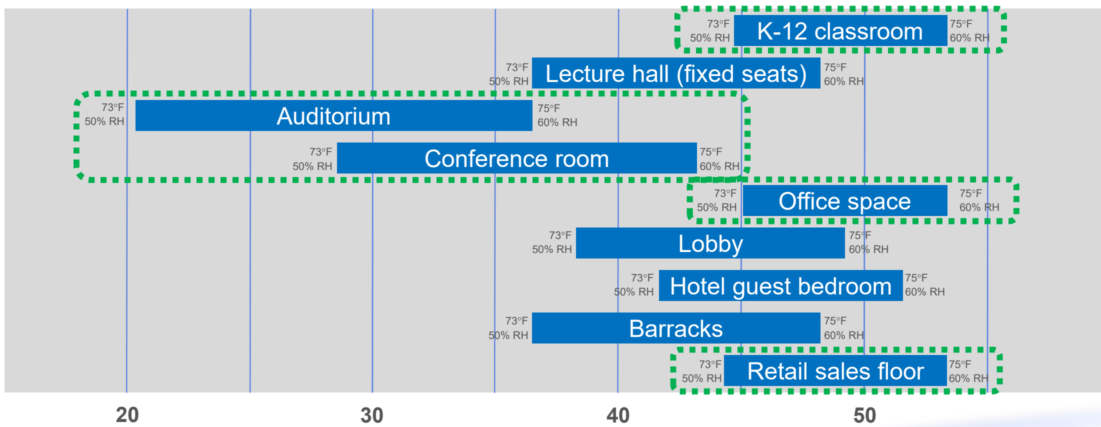
Required DOAS Supply-Air Dew Point



required DPT of conditioned OA to maintain desired space humidity level, °F

(assuming default occupant density, 155 or 200 Btu/h/person space latent load, and sea level elevation)

Required DOAS Supply-Air Dew Point



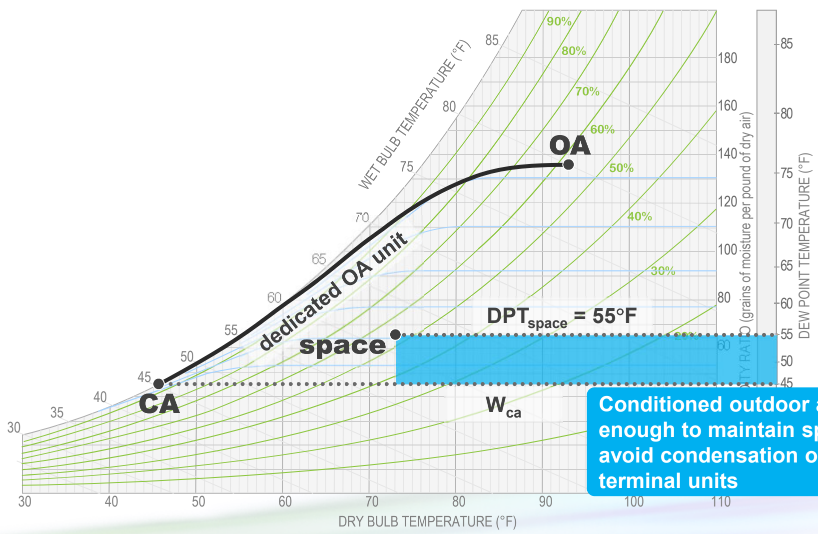
required DPT of conditioned OA to maintain desired space humidity level, °F

(assuming default occupant density, 155 or 200 Btu/h/person space latent load, and sea level elevation)

Limiting Space DPT to Avoid Condensation

- Chilled beams
- Radiant cooling panels
- Sensible-cooling terminal units

Limiting Space DPT to Avoid Condensation



Conditioned outdoor air (CA) is dry enough to maintain space DPT ≤ 55°F to avoid condensation on sensible-only terminal units

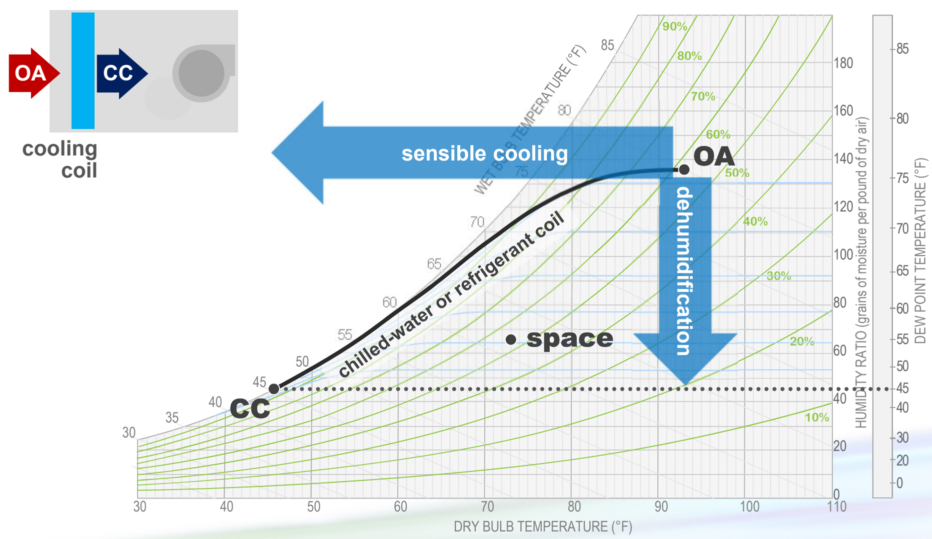
"Neutral" vs. Cold Dry-Bulb Temperature

6.5.2.6 Ventilation Air Heating Control

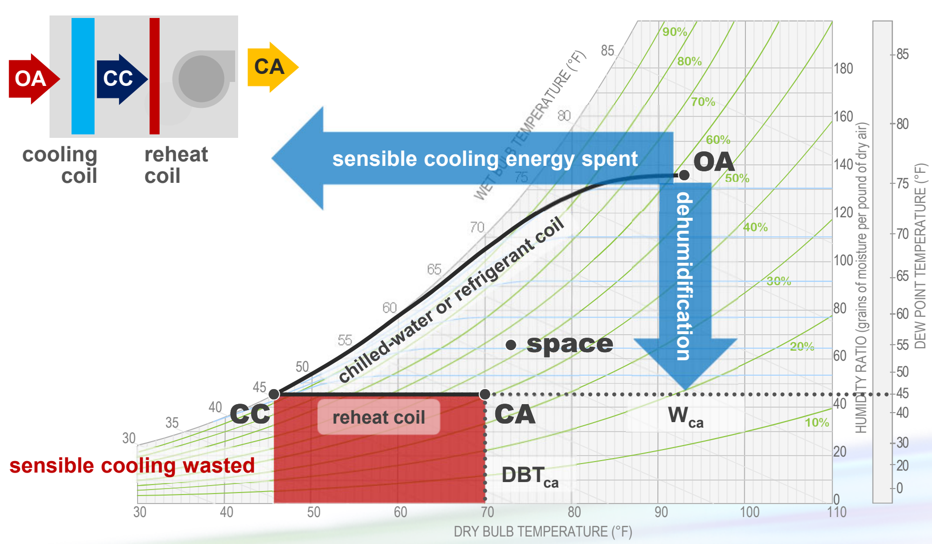
*Units that provide ventilation air to multiple zones and operate in conjunction with zone heating and cooling systems **shall not use heating or heat recovery to warm supply air above 60°F** when representative building loads or outdoor air temperature indicate that the majority of zones require cooling.*

ASHRAE Standard 90.1-2016

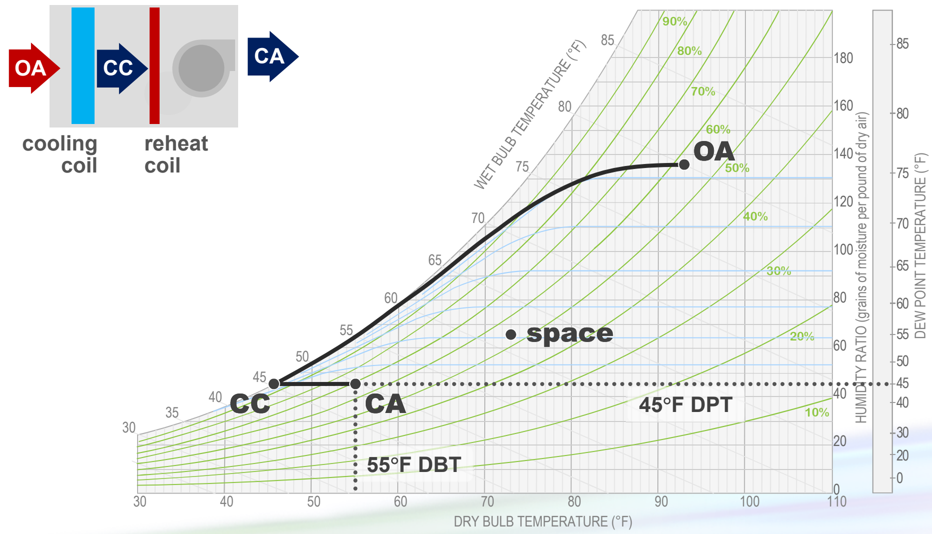
"Neutral" vs. Cold Dry-Bulb Temperature



"Neutral" vs. Cold Dry-Bulb Temperature



"Neutral" vs. Cold Dry-Bulb Temperature



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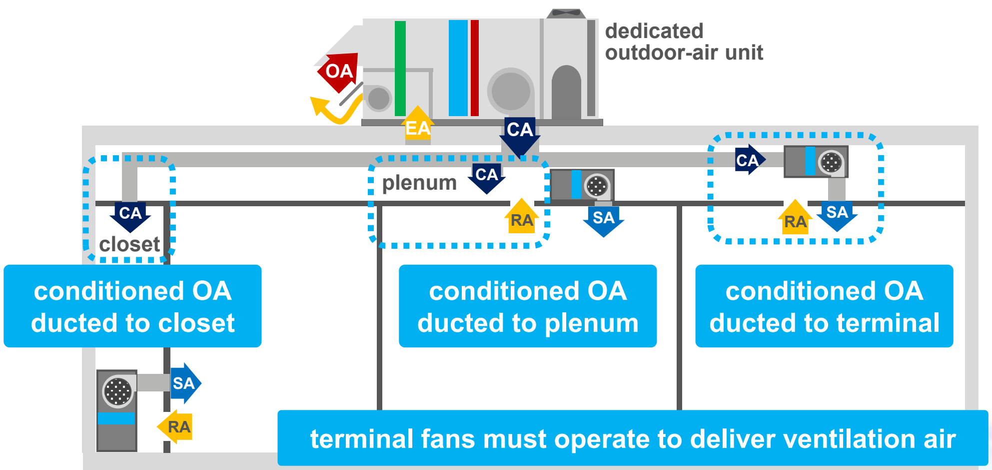
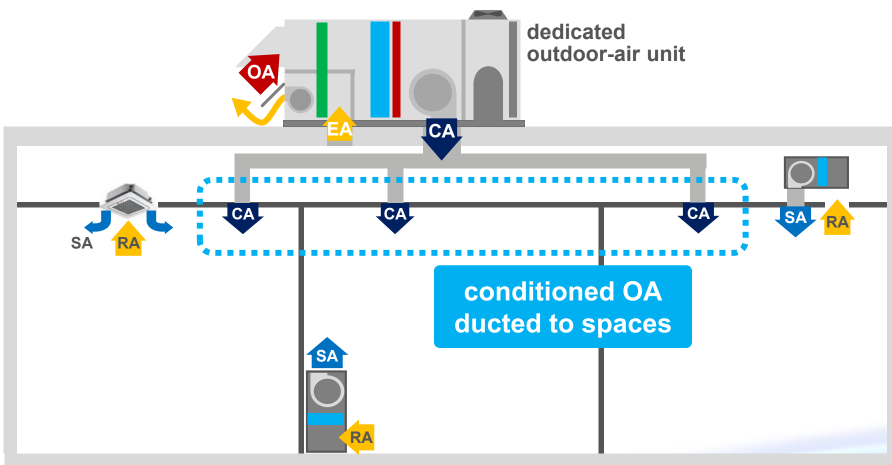
- **DOAS air delivery configurations and control**

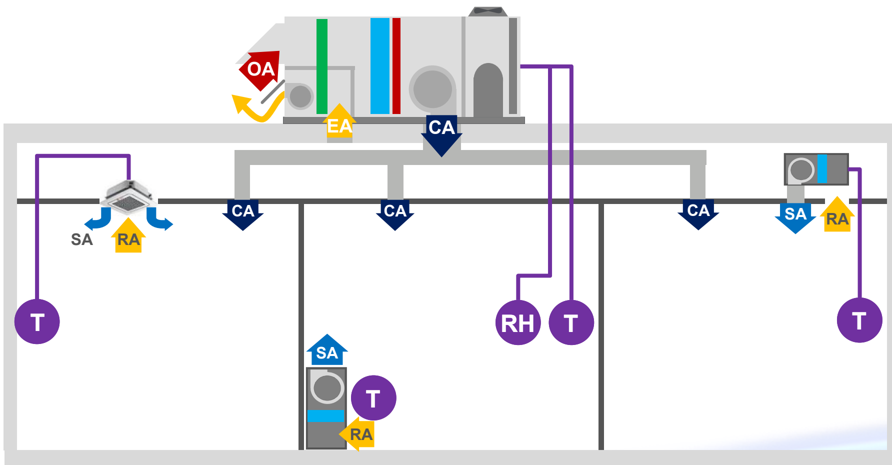
DOAS air delivery methods
Through Zone-Level Terminals



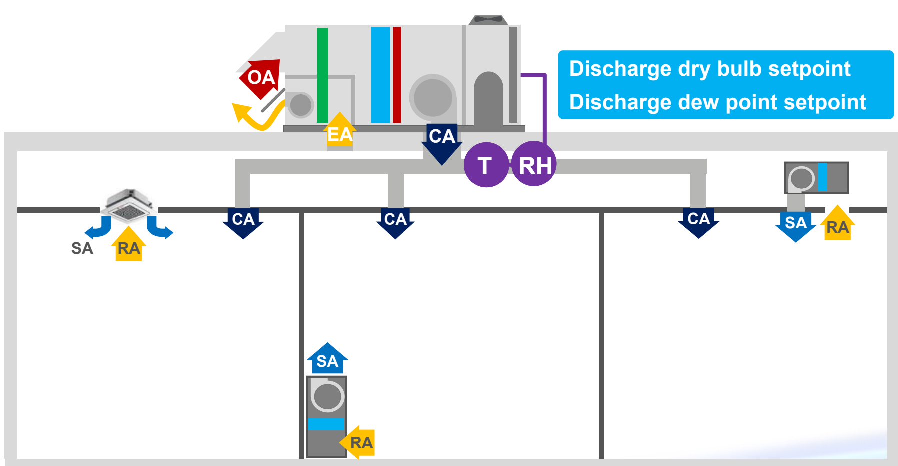
DOAS air delivery methods
Direct to Spaces



dedicated OA unit control
Space Control



dedicated OA unit control
Discharge Air Control



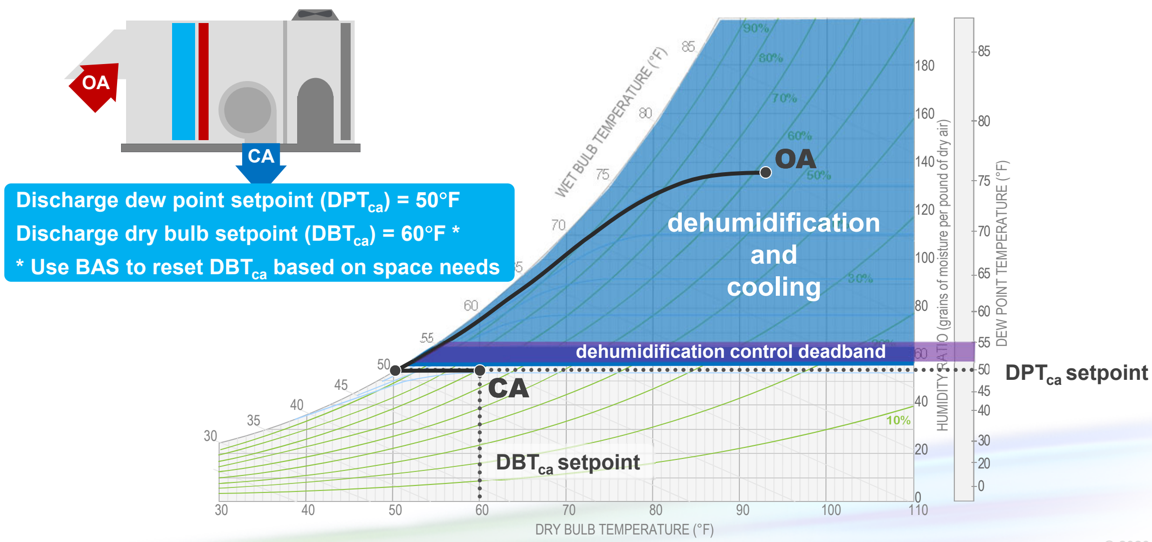
Discharge Air Control: Modes of Operation

- Dehumidification and cooling
- Cooling
- Heating
- Ventilation only

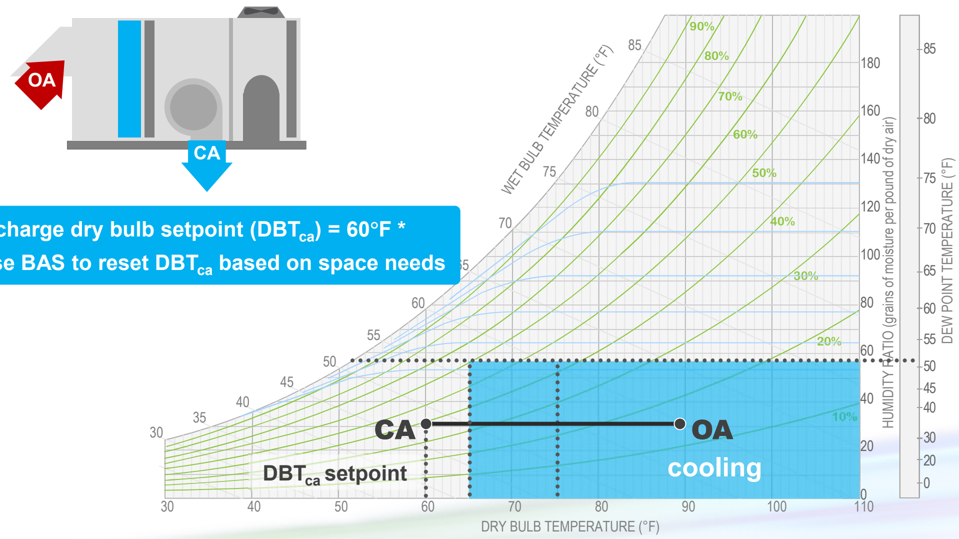
Mode of operation is determined by current outdoor dry-bulb and dew point temperatures

Setpoints may be static, or if a BAS is present may be reset based on space needs

Dehumidification and Cooling Mode



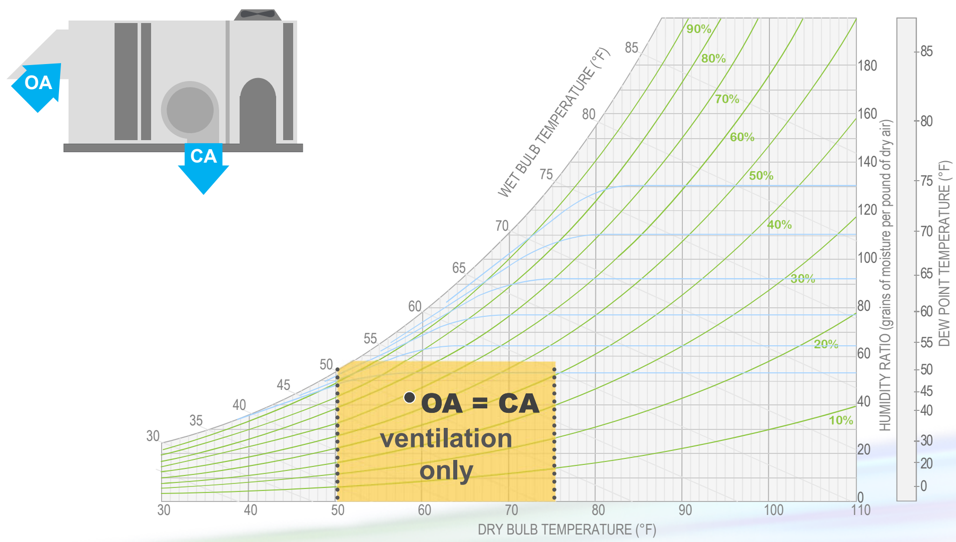
Cooling Mode



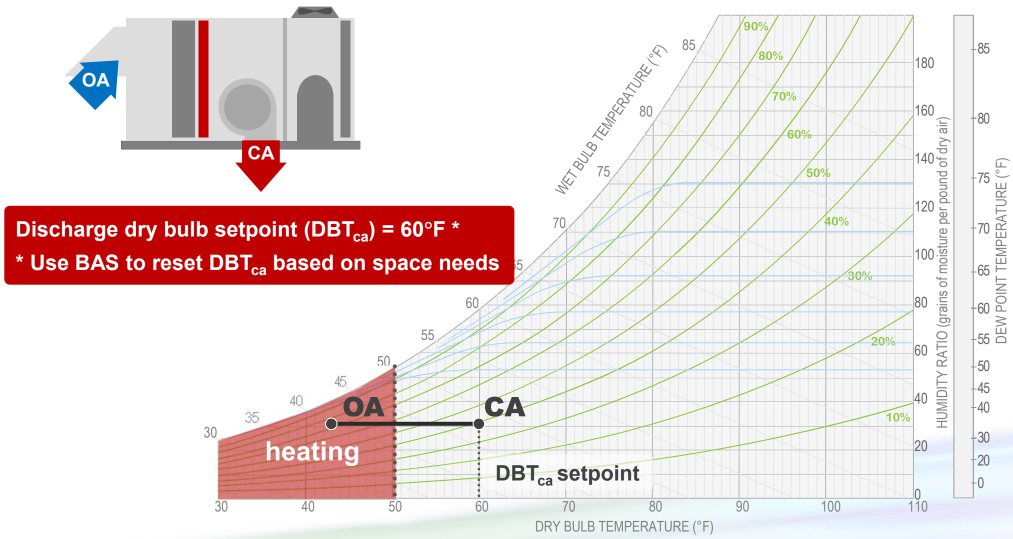
Discharge dry bulb setpoint (DBT_{ca}) = 60°F *

*** Use BAS to reset DBT_{ca} based on space needs**

Ventilation Only Mode

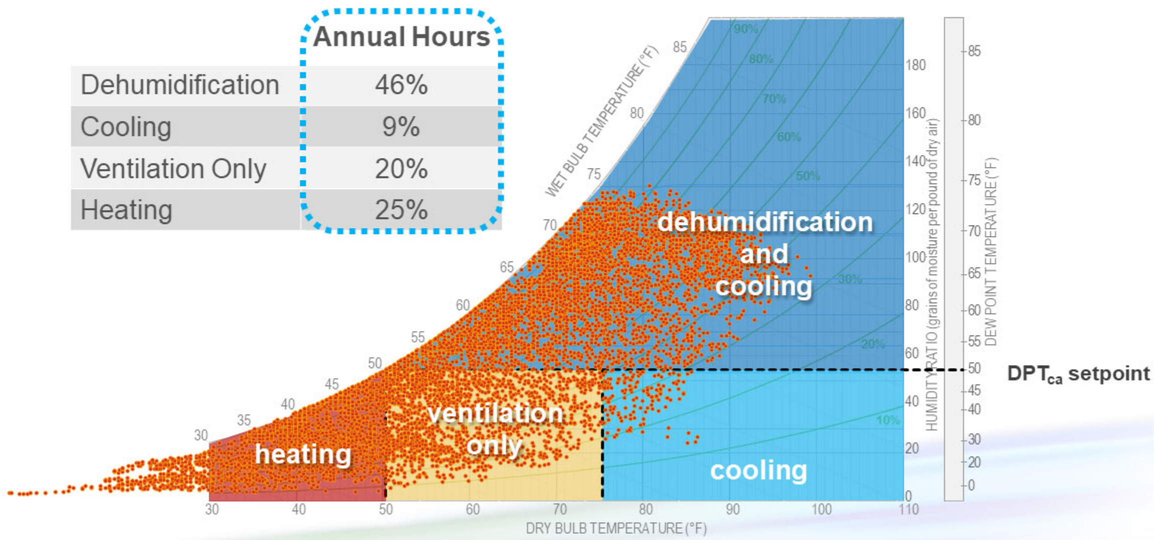


Heating Mode



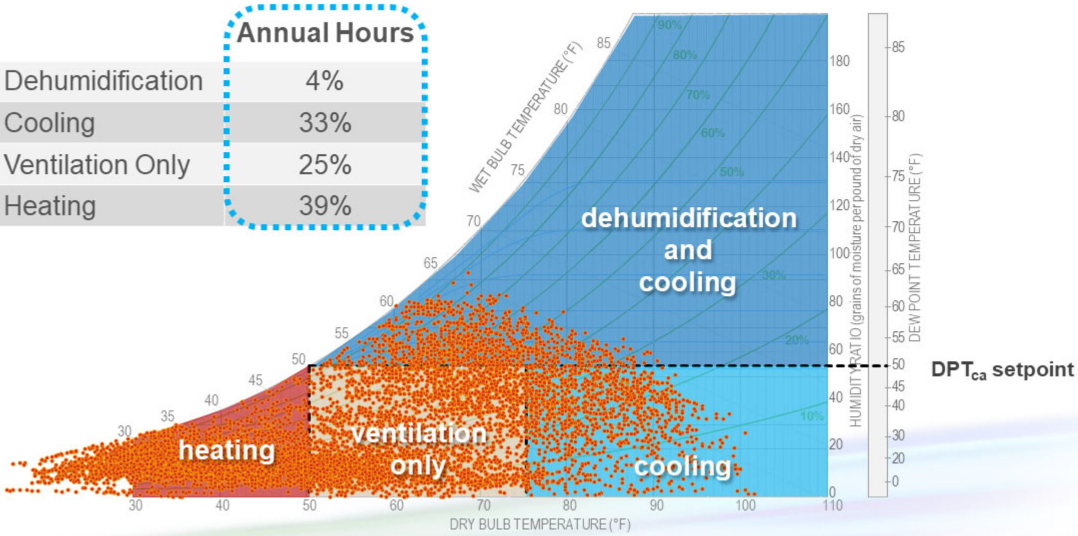
dedicated OA unit modes of operation
"A" Climate Zones (Atlanta)

	Annual Hours
Dehumidification	46%
Cooling	9%
Ventilation Only	20%
Heating	25%



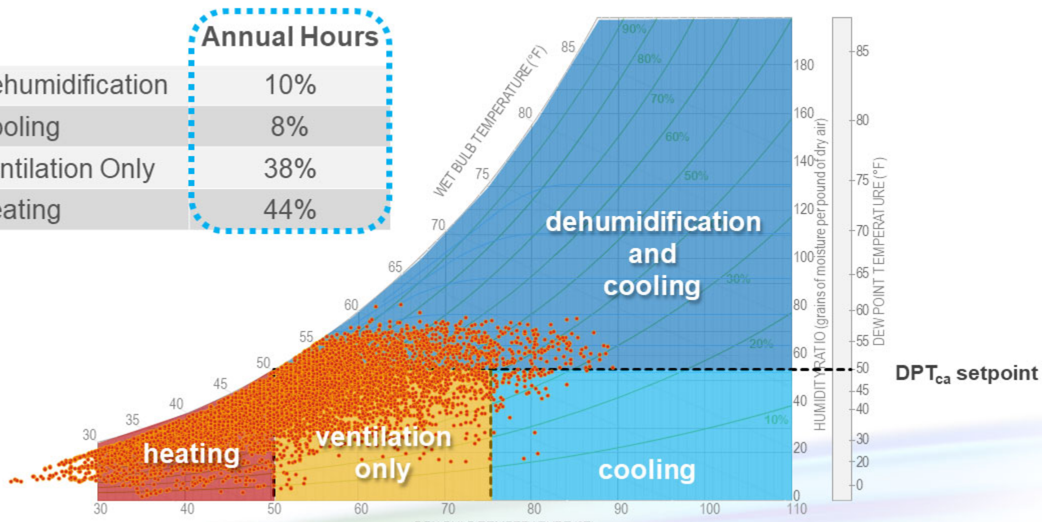
dedicated OA unit modes of operation
"B" Climate Zones (Albuquerque)

	Annual Hours
Dehumidification	4%
Cooling	33%
Ventilation Only	25%
Heating	39%

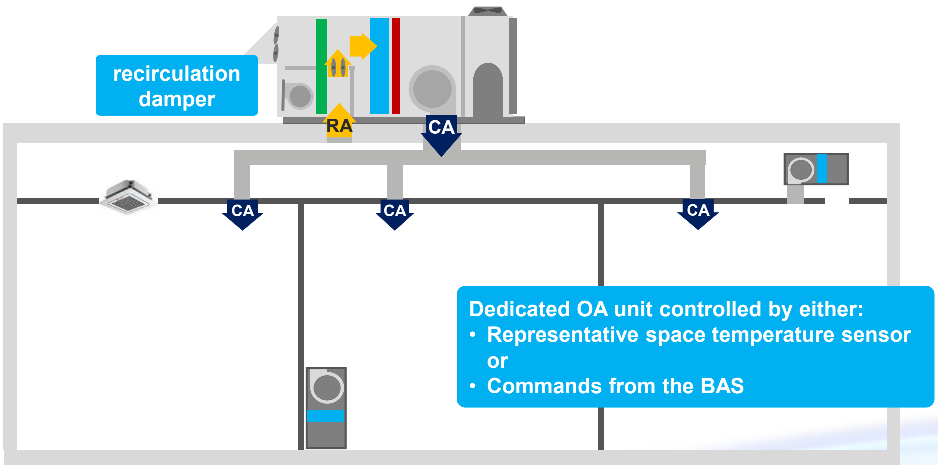


dedicated OA unit modes of operation
"C" Climate Zones (Seattle)

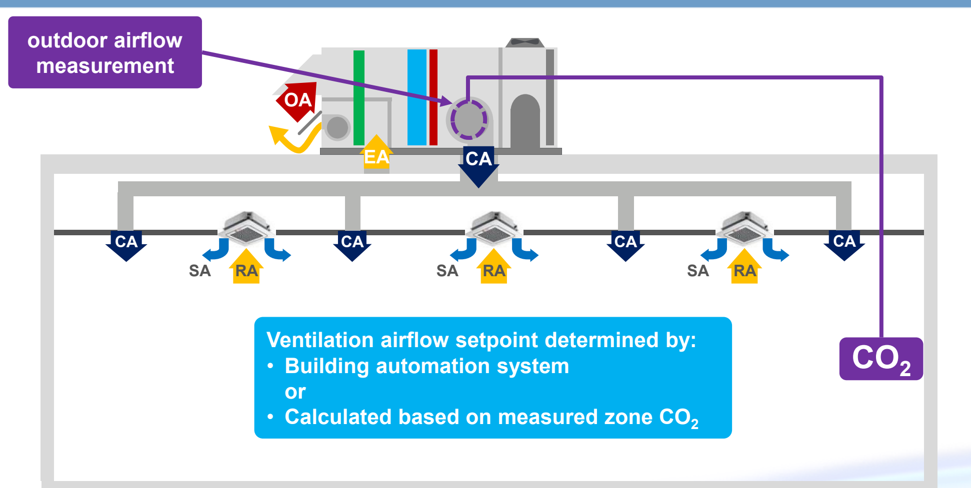
	Annual Hours
Dehumidification	10%
Cooling	8%
Ventilation Only	38%
Heating	44%



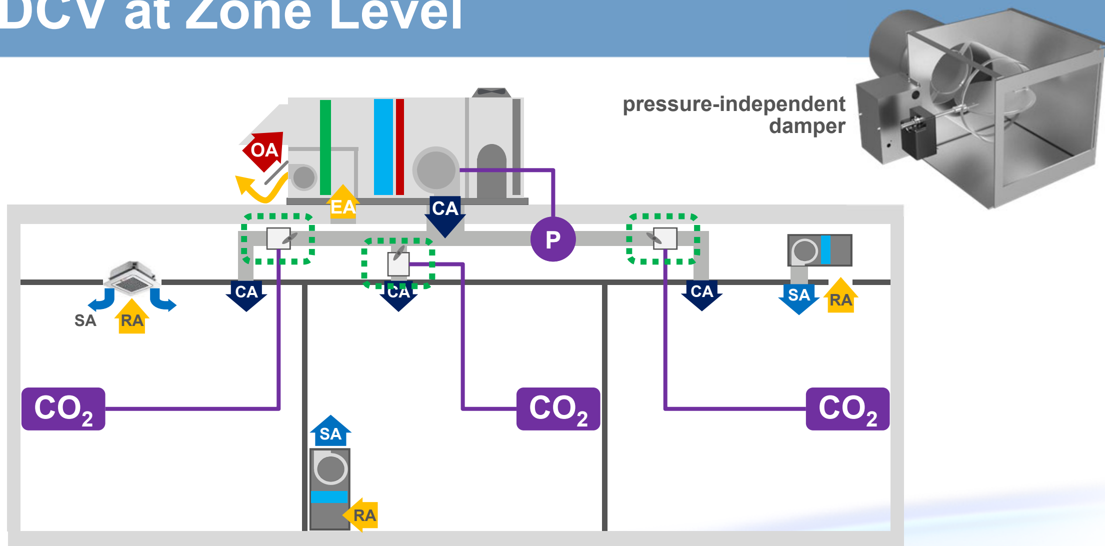
Unoccupied Mode



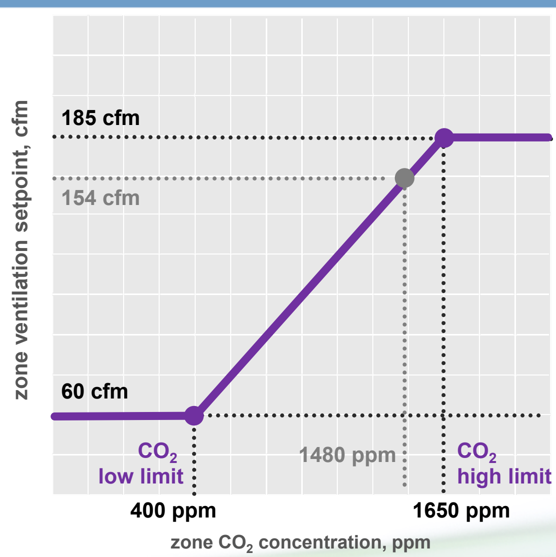
DCV at Dedicated OA Unit Level

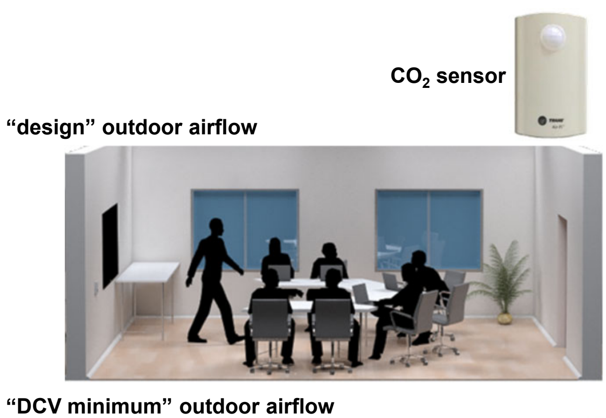


DCV at Zone Level

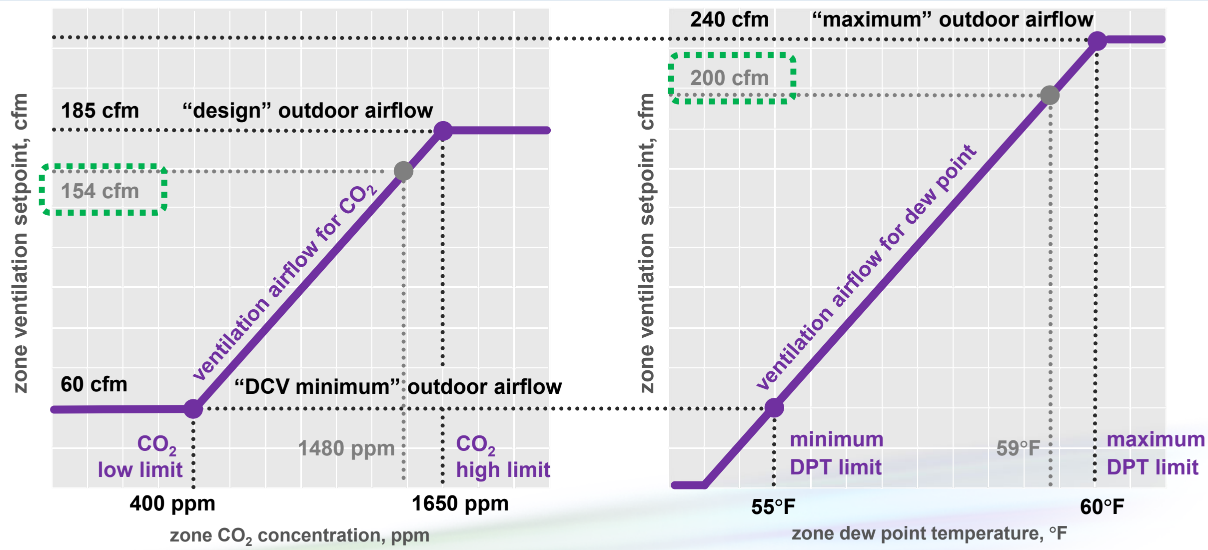


DCV Using Zone CO_2

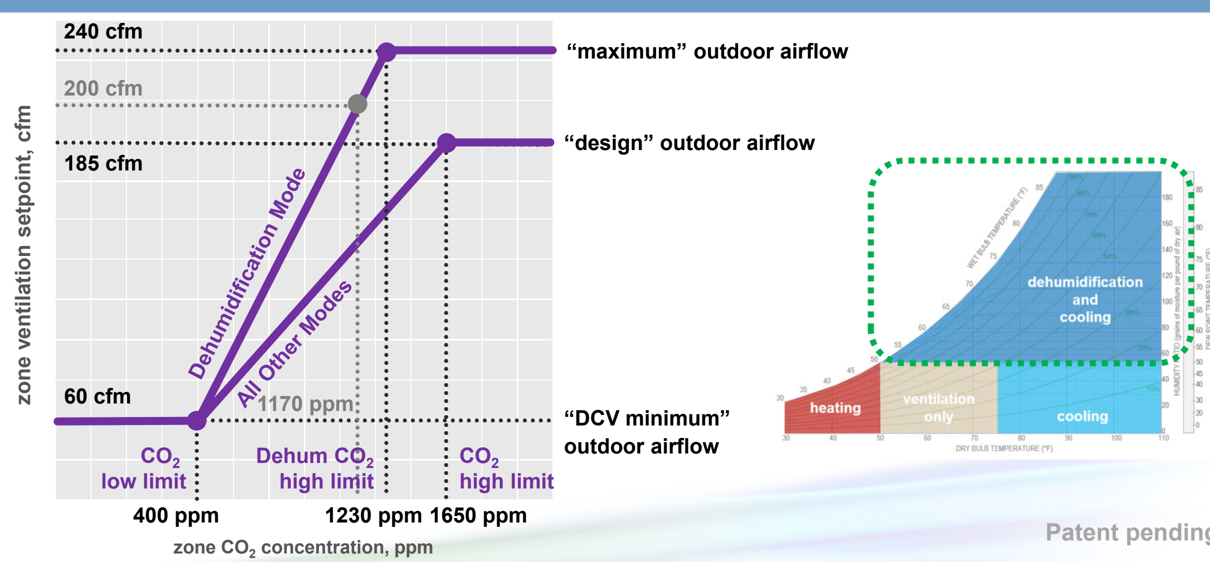




DCV + Active Humidity Control



DCV + Predictive Humidity Control



DCV: How Low of Airflow?

Impacted by dedicated OA equipment:

- DX refrigeration
- Type of heat (gas, electric)
- Fan performance

Impacted by building design:

- Exhaust requirements (building pressure control)
- Air delivery to the space

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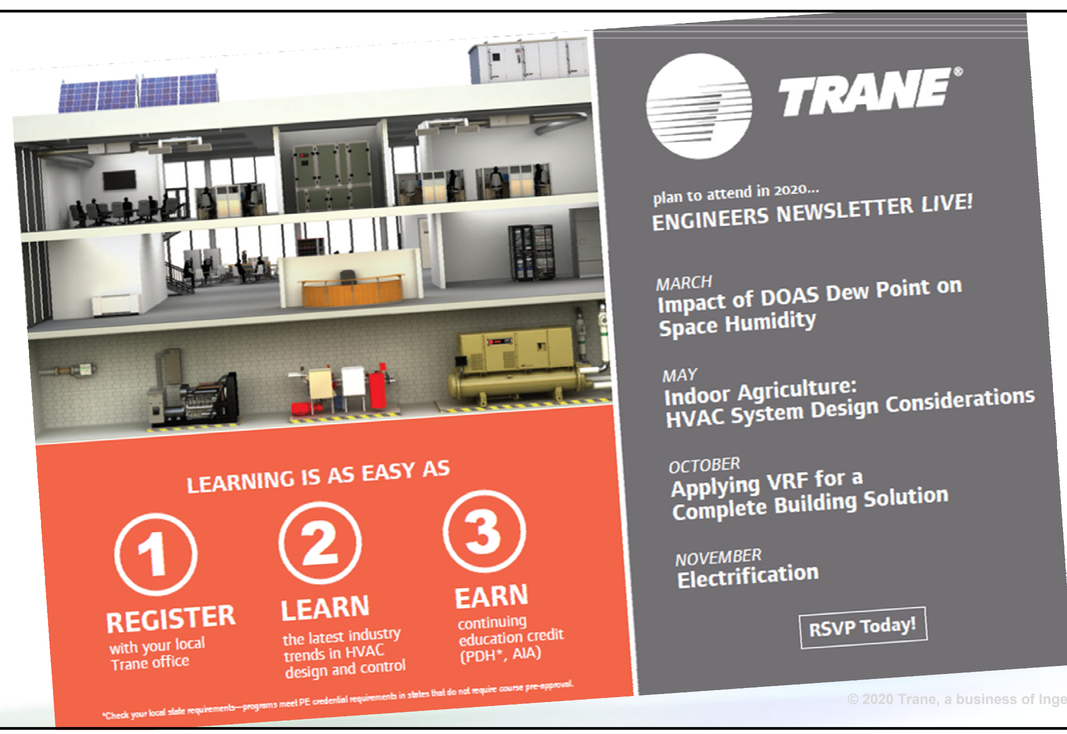

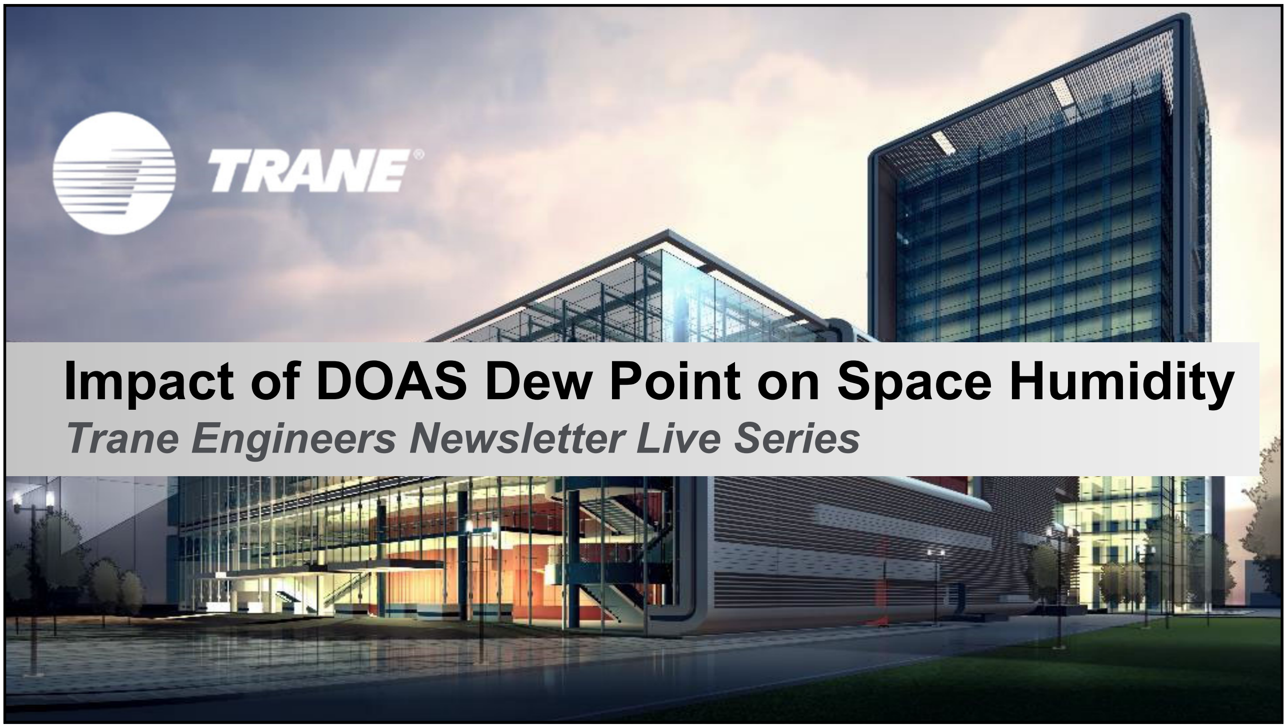

Impact of DOAS Dew Point on Space Humidity

Trane Engineers Newsletter Live Series

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March 2020

Impact of DOAS Dew Point on Space Humidity

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Trane® Horizon™ Dedicated Outdoor Air Systems: www.trane.com/Horizon

Engineers Newsletter Live - **Audience Evaluation**

Impact of DOAS Dew Point on Space Humidity

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Additional questions or comments:

Trane *Engineers Newsletter LIVE: Impact of DOAS Dew Point on Space Humidity*
APP-CMC072-EN QUIZ

1. TRUE or FALSE: Sizing the dedicated outdoor air system (DOAS) to deliver conditioned outdoor air to the spaces at 55°F dew point will ensure sufficiently-low space humidity levels in all applications.

2. Which of the following are variables in the equation to determine the required dew point to be supplied by a dedicated outdoor air system. Select all that apply.
   a. Sensible cooling load in the space
   b. Latent load in the space
   c. CFM of outdoor air to be delivered to the space
   d. Desired space humidity ratio

3. TRUE or FALSE: ASHRAE Standard 90.1-2016 prohibits the DOAS from reheating dehumidified air to any warmer than 60°F when the majority of zone require cooling.

4. A dedicated outdoor air unit should operate in Dehumidification Mode whenever the outdoor dew point temperature is _____ the desired discharge air dew point setpoint.
   a. above
   b. below

5. TRUE or FALSE: When “active humidity control” is integrated with demand-controlled ventilation in a DOAS, the controller will increase ventilation airflow if needed to prevent the space dew point from rising above the desired upper limit.

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