Agenda and Objectives

Trane Engineers Newsletter Live Series

Dedicated Outdoor Air Equipment

Previous ENLs have discussed system design and control considerations for dedicated outdoor-air systems. This ENL will shift the discussion to the various types of equipment used for dedicated OA conditioning, from packaged DX units to split DX systems to air handlers and water chillers.

By attending this ENL you will be able to:

1. Summarize the definition of a dedicated OA unit
2. Identify what leaving-air dew point is required
3. Summarize what the difference between cold versus neutral-temperature air
4. Identify ASHRAE Standard 90.1 requirements related to dedicated OA systems
5. Identify specific dedicated OA equipment configurations

Agenda

1) Opening (welcome, agenda, introductions)
2) Overview
    a) What is a dedicated OA unit?
    b) Review content from previous broadcasts
    c) Review of ASHRAE 90.1 requirements relates to DOAS
3) Specific dedicated OA equipment configurations
    a) Identify the goal(s)/purpose of the dedicated OA unit (
    b) Goals = Dehumidify Ventilation Only + Meet ASHRAE 90.1
    c) Goals = Dehumidify to Offset Space Latent Loads + Meet ASHRAE 90.1
    d) Goals = Dehumidify Ventilation Only + Exceed 90.1 (Higher Efficiency)
    e) Goals = Dehumidify to Offset Space Latent Loads + Exceed 90.1 (Higher Efficiency)
    a) Cooling/heating sources (list advantages and drawbacks of each)
4) Summary

Presenters

Trane Engineers Newsletter Live Series

Dedicated Outdoor Air Equipment

(2011)

Ronnie Moffitt | applications engineer | Trane

Ronnie joined Trane in 1996 and currently is an airside applications engineer whose responsibility is to aid design engineers and Trane sales personnel in the proper design and application of HVAC systems. His primary focus has been dehumidification and air-to-air energy recovery design. This includes the development, design and control optimization of desiccants in commercial HVAC systems. He has several patents related to this subject and serves on related AHRI and ASHRAE engineering committees.

Ronnie 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 is a certified Energy Manager (CEM) by Association of Energy Engineers and received his B.S. in Aerospace Engineering from Syracuse University.

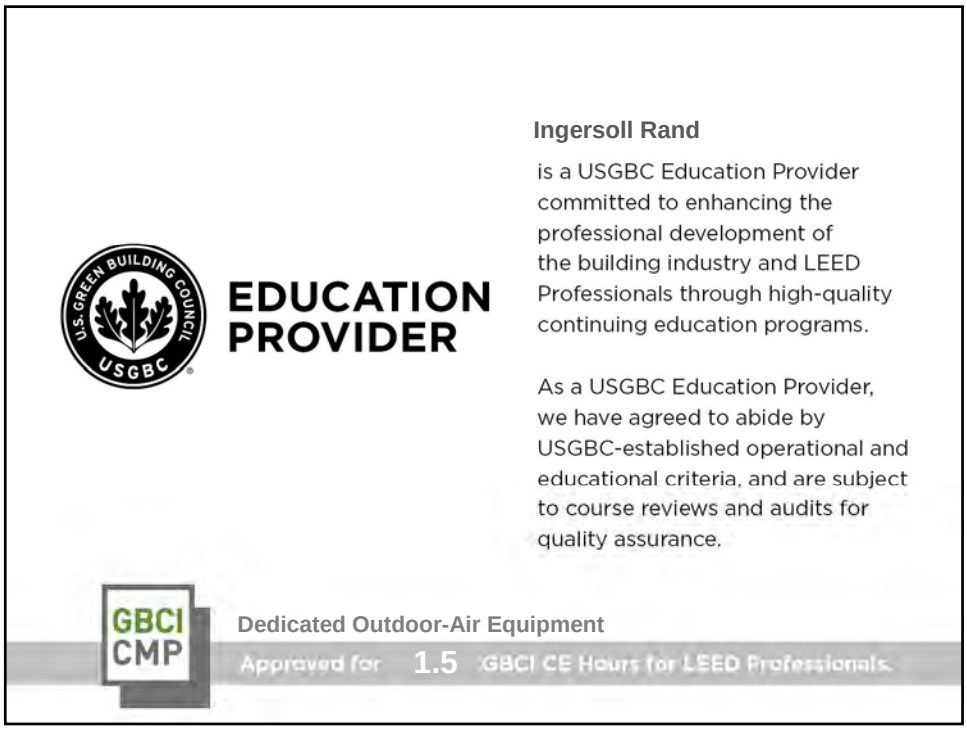
John Murphy | applications engineer | Trane

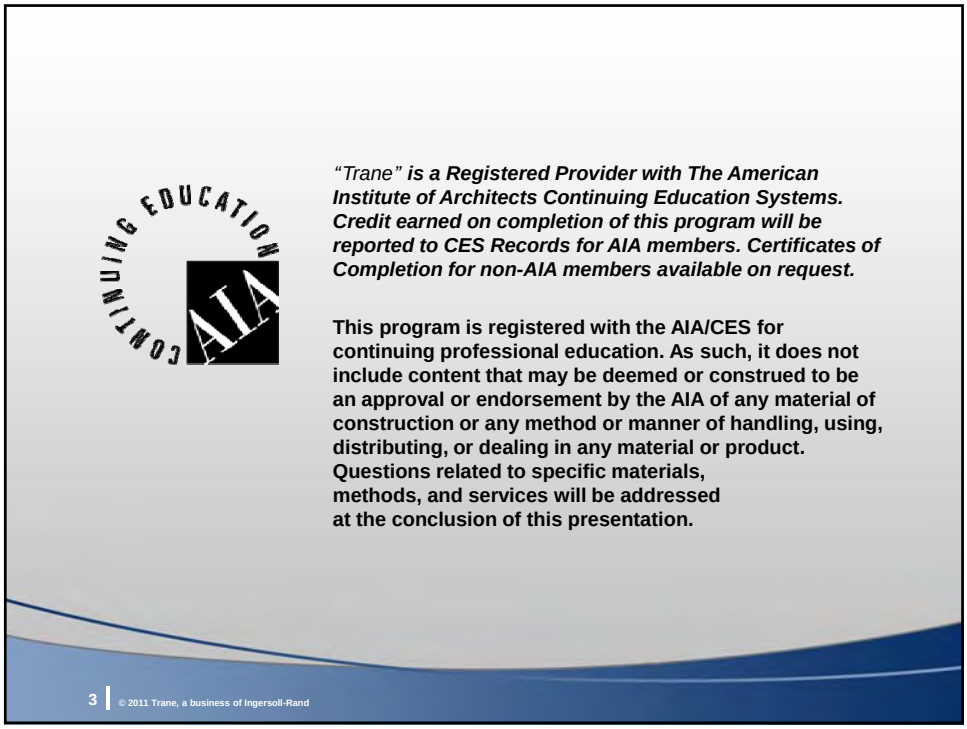
John has been with Trane since 1993. His primary responsibility as an applications engineer is to aid design engineers and Trane sales personnel in the proper design and application of HVAC systems. As a LEED Accredited Professional, he has helped our customers and local offices on a wide range of LEED projects. His main areas of expertise include energy efficiency, dehumidification, dedicated outdoor-air systems, air-to-air energy recovery, psychrometry, and ventilation.

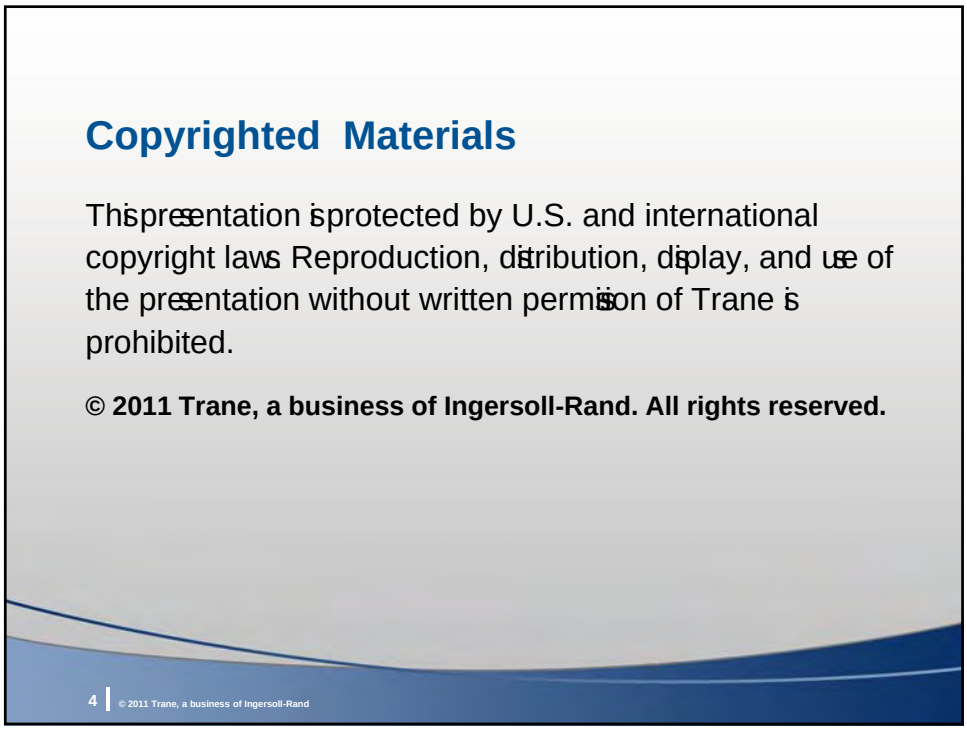
John is the author of numerous Trane application manuals and Engineers Newsletters, and is a frequent presenter on Trane's Engineers Newsletter Live series of broadcasts. He also is a member of ASHRAE, has authored several articles for the ASHRAE Journal, and is a member of ASHRAE's "Moisture Management 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, and technical reviewer for The ASHRAE Guide for Buildings in Hot and Humid Climates.

Paul Solberg | applications engineer | Trane

A mechanical engineer from the University of Wisconsin at Platteville, Paul is a 35-year veteran of Trane. He specializes in compressor and refrigeration systems, and has authored numerous Trane publications on these subjects, including application manuals, engineering bulletins, and Engineers Newsletters. Paul served in the technical service and applications engineering areas at various manufacturing locations, where he developed particular expertise supporting split systems, small packaged chillers, rooftop air conditioners, and other unitary products.







Learning Objectives

- Summarize the definition of a dedicated OA unit
- Identify what leaving-air dew point is required
- Summarize what the difference between cold versus neutral-temperature air
- Identify ASHRAE Standard 90.1 requirements related to dedicated OA systems
- Identify specific dedicated OA equipment configurations

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Dedicated Outdoor-Air Equipment

Today's Topics

- Definition of a dedicated OA unit
  - What leaving-air dew point is required?
  - Cold versus neutral-temperature air?
- ASHRAE 90.1 requirements related to dedicated OA systems
- Specific dedicated OA equipment configurations

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Today's Presenters

John Murphy
Applications Engineer

Ronnie Moffitt
Applications Engineer

Paul Solberg
Applications Engineer

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Dedicated Outdoor-Air Equipment

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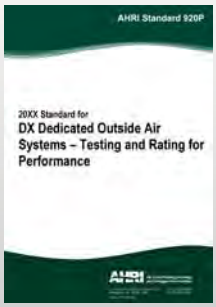
Definition of a Dedicated OA Unit

What is a Dedicated OA Unit?

AHRI Standard 920 (currently in development)

A dedicated OA unit "operates 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 containing an enthalpy wheel, sensible wheel, desiccant wheel, plate heat exchanger, heat pipes or other heat or mass transfer apparatus. It **may reheat the ventilation air** by containing a reheat refrigerant circuit, sensible wheel, heat pipe, or other heat or mass transfer apparatus."



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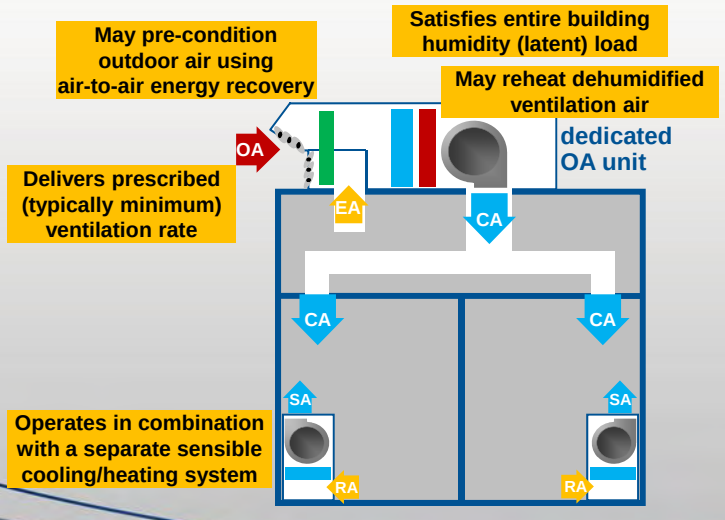

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Dedicated OA Systems

- What leaving-air dew point is required?
  - Cooled, but not dehumidified
  - Cooled and dehumidified

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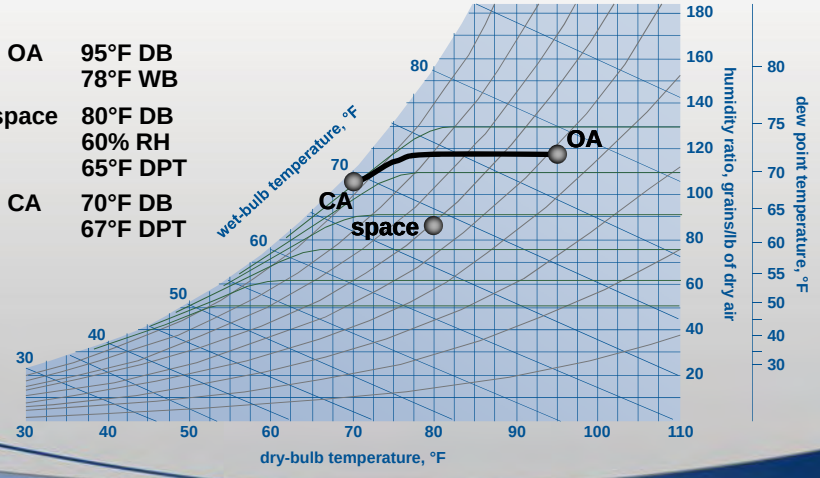
example: kitchen

Cooled But Not Dehumidified

OA	95°F DB 78°F WB
space	80°F DB 60% RH 65°F DPT
CA	70°F DB 67°F DPT



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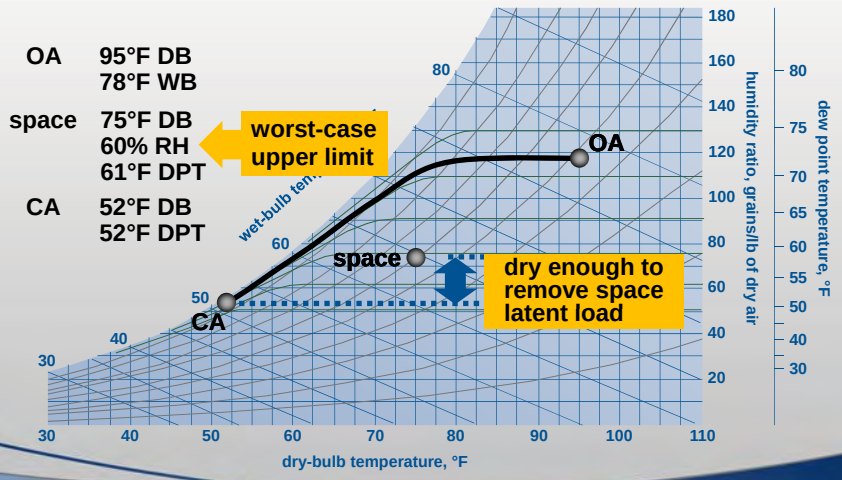
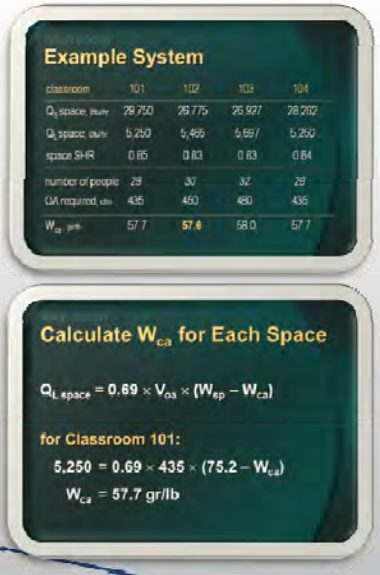
example: fan-coils, VAV, WSHPs, VRF

Cooled and Dehumidified



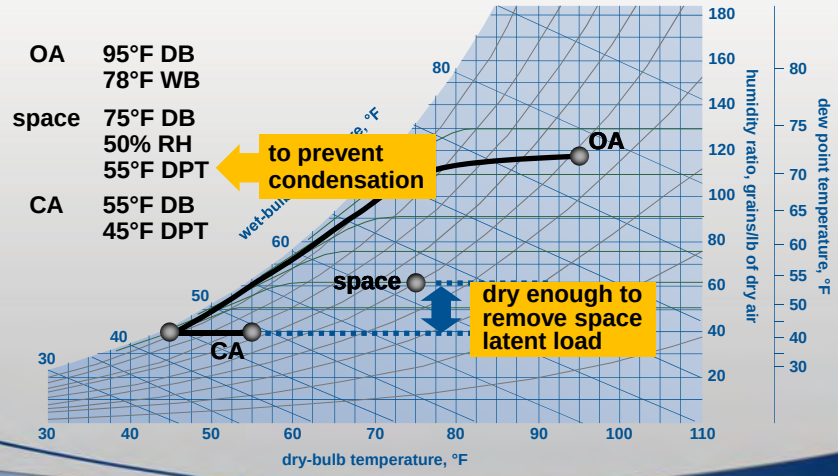


What Leaving-Air Dew Point is Required?

- "Dedicated Outdoor-Air Ventilation Systems" *Engineers Newsletter Live* broadcast, APP-CMC008-EN (2001)
- "Designing Dedicated Outdoor-Air Systems" Trane application guide SYS-APG001-EN (2003)
- "Dedicated Ventilation Systems," *Engineers Newsletter* 30-3 (2001)
- Morris, W. 2003. "The ABCs of DOAS: Dedicated Outdoor Air Systems" *ASHRAE Journal* (May)
- Murphy, J. 2006. "Smart Dedicated Outdoor Air Systems" *ASHRAE Journal* (July)

example: chilled beams, radiant cooling

Cooled and Over-Dehumidified



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Dedicated OA Systems

- What leaving-air dew point is required?
- Cold versus neutral-temperature air?

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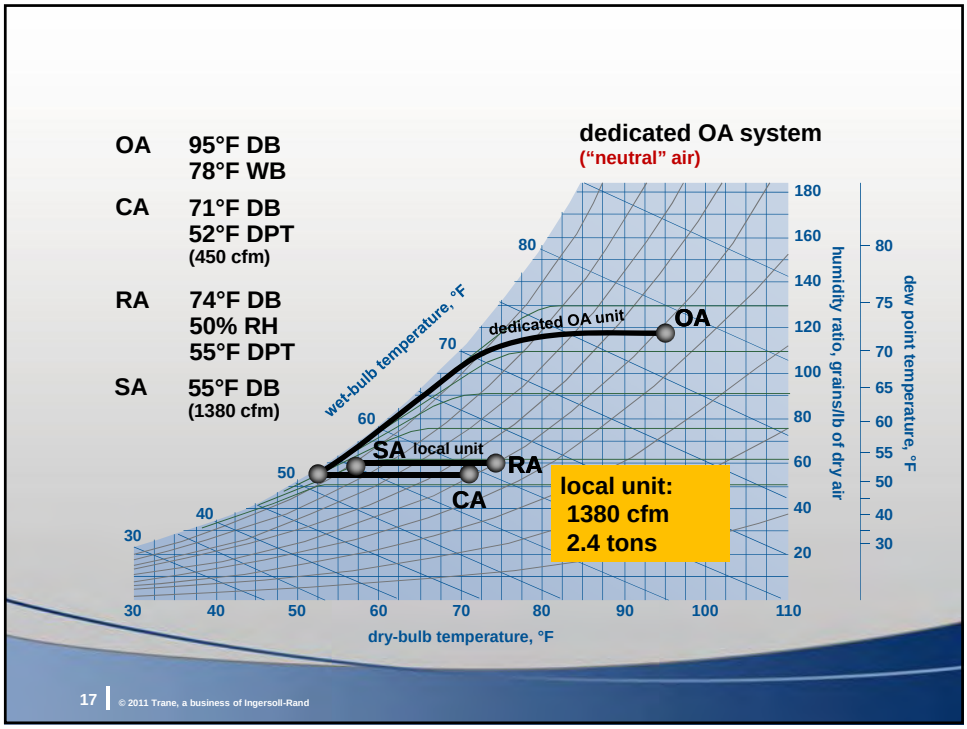
OA 95°F DB
78°F WB
CA 71°F DB
52°F DPT
(450 cfm)
RA 74°F DB
50% RH
55°F DPT
SA 55°F DB
(1380 cfm)
dedicated OA system
("neutral" air)
dedicated OA unit
OA
SA local unit
RA
CA
local unit:
1380 cfm
2.4 tons
wet-bulb temperature, °F
humidity ratio, grains/lb of dry air
dew point temperature, °F
dry-bulb temperature, °F
17
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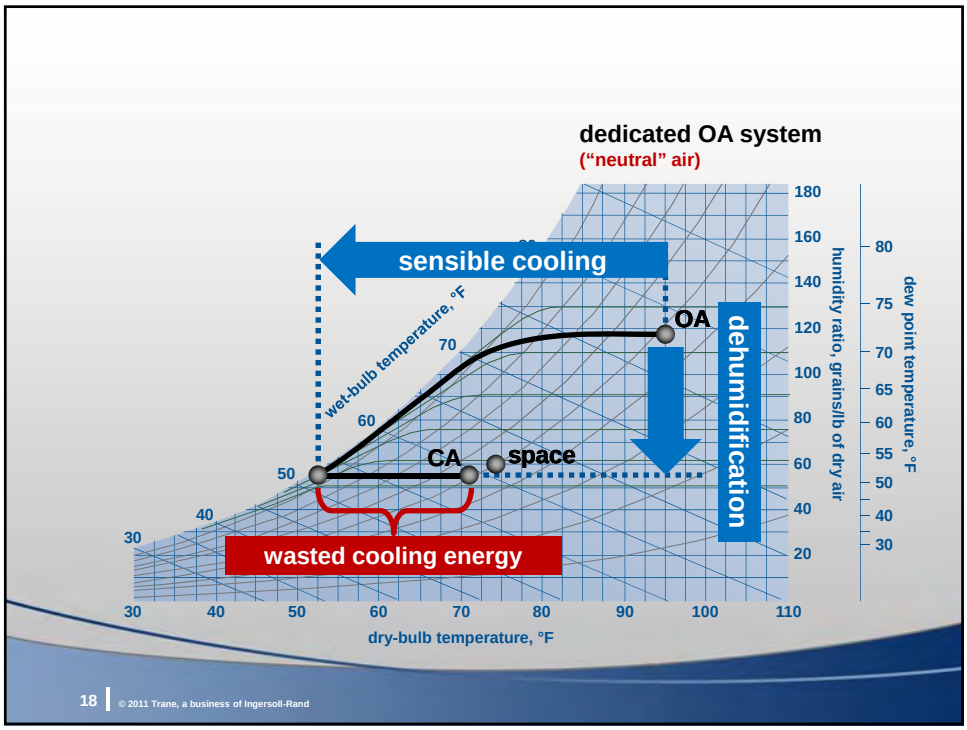
dedicated OA system
("neutral" air)
sensible cooling
OA
dehumidification
CA
space
wasted cooling energy
wet-bulb temperature, °F
humidity ratio, grains/lb of dry air
dew point temperature, °F
dry-bulb temperature, °F
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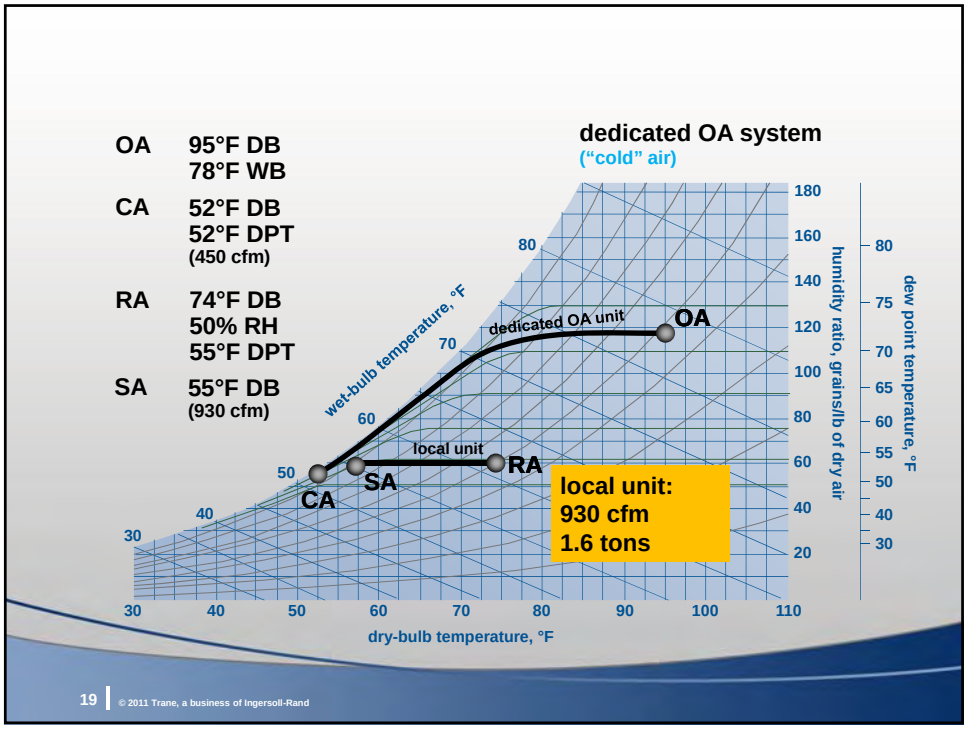
OA 95°F DB
78°F WB
CA 52°F DB
52°F DPT
(450 cfm)
RA 74°F DB
50% RH
55°F DPT
SA 55°F DB
(930 cfm)
dedicated OA system
("cold" air)
dedicated OA unit
OA
local unit
RA
SA
CA
local unit:
930 cfm
1.6 tons
wet-bulb temperature, °F
humidity ratio, grains/lb of dry air
dew point temperature, °F
dry-bulb temperature, °F
19
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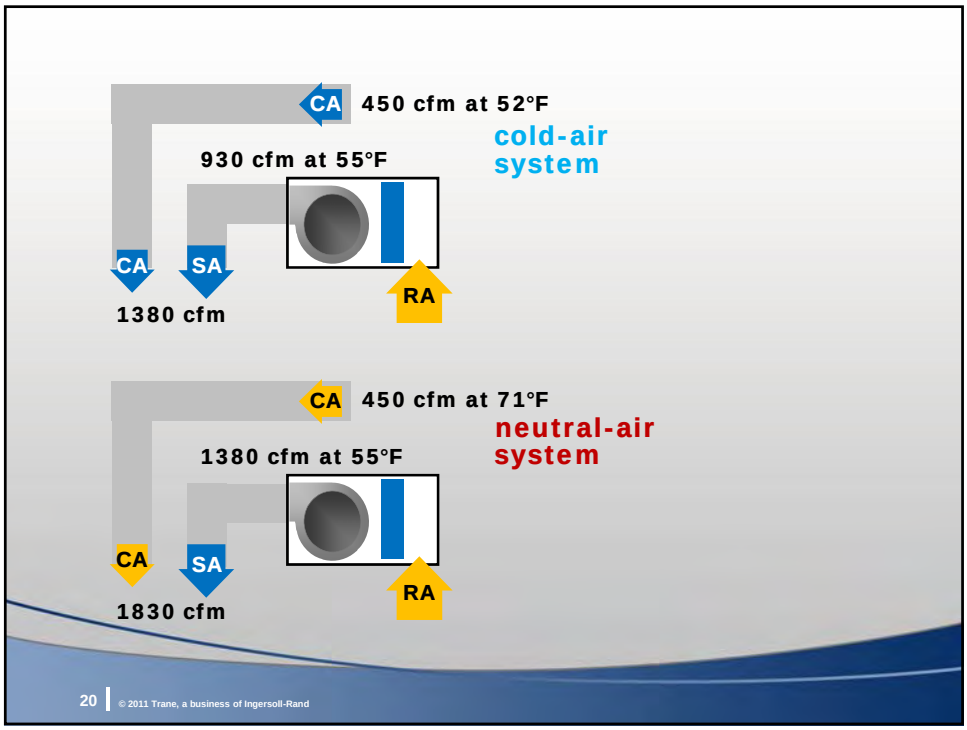
CA
450 cfm at 52°F
cold-air system
930 cfm at 55°F
CA
SA
RA
1380 cfm
CA
450 cfm at 71°F
neutral-air system
1380 cfm at 55°F
CA
SA
RA
1830 cfm
20
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Cold versus Neutral

- Less overall cooling capacity
  - Sensible cooling provided by cold conditioned OA reduces required cooling capacity of local HVAC units
  - Cooling (dehumidification) capacity of the dedicated OA unit is the same in either case
- Less overall cooling energy
  - Sensible cooling provided by cold conditioned OA reduces cooling required from local HVAC units

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Cold versus Neutral

	neutral to space/unit	cold to space	cold to local unit
dedicated OA unit			
cooling capacity, tons	3.4	3.4	3.4
reheat capacity, MBh	9.3	0	0
fan airflow, cfm	450	450	450
local HVAC unit			
cooling capacity, tons	2.4	1.6	1.6
fan airflow, cfm	1380	930	1380

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Cold versus Neutral

- Less overall fan energy, if OA is delivered cold (or cool) directly to spaces
  - Cold conditioned OA removes some of the space sensible cooling load, which reduces the airflow needed from local HVAC units
  - Airflow delivered by the dedicated OA unit is the same in either case

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Won't Delivering OA Cold Overcool the Space?

$Q_{s,space}$ = **29,750 Btu/h (design load)**

$Q_{s,ca}$ = **1.085 × 450 cfm × (74°F – 52°F)**
= **10,740 Btu/h**

Space sensible cooling load must be < 36% of design before overcooling will occur!

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When Should I Reheat Dehumidified OA?

- Applications where space sensible cooling loads differ greatly at any given time (e.g., hotels, dormitories)
- To avoid overcooling at part-load conditions
  - Implement demand-controlled ventilation to reduce outdoor airflow as population changes
  - Activate heat in the local HVAC unit (few zones, WSHP)
  - Reheat dehumidified air in dedicated OA unit (consider using recovery energy)

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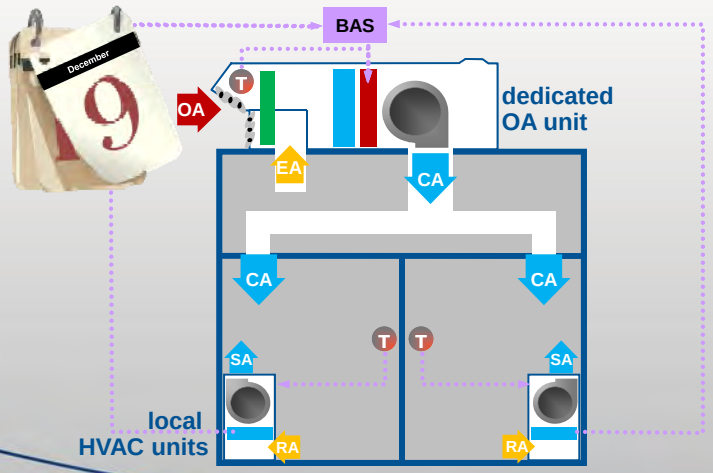
Reheating Dehumidified OA



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When Should I Reheat Dehumidified OA?

- Applications where space sensible cooling loads differ greatly at any given time (e.g., hotels, dormitories)
- To avoid overcooling at part-load conditions
  - Implement demand-controlled ventilation
  - Activate heat in the local HVAC unit
  - Reheat dehumidified air in dedicated OA unit
- Applications requiring lower-than-normal dew points
- To avoid condensation when conditioned OA is delivered to the ceiling plenum

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Dedicated OA Systems

- What leaving-air dew point is required?
- Cold versus neutral-temperature air?
- How will conditioned OA be delivered to spaces?
  - Directly to each space
  - To intake of each local unit
  - To supply-side of each local unit
  - To ceiling plenum, near each local unit

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Dedicated Outdoor-Air Equipment

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ASHRAE 90.1-2010 Requirements

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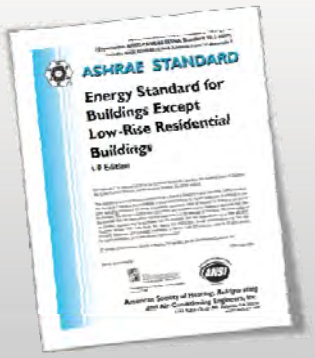
ASHRAE 90.1 and Dedicated OA Systems

- Minimum equipment efficiencies
- Fan power limitation
- Economizer
- Exhaust-air energy recovery
- Limitation on simultaneous heating and cooling



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Section 6.4.1, mandatory requirements

Minimum Equipment Efficiencies

- Currently there is no rating or certification standard for DX dedicated OA equipment, so ASHRAE 90.1 does not list a minimum efficiency requirement

  > ***"6.4.1.3 Equipment Not Listed.*** *Equipment not listed in the tables referenced in Sections 6.4.1.1 and 6.4.1.2 may be used."*

- AHRI Standard 920 is under development

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Section 6.5.3.1, prescriptive requirements

Fan Power Limitation

- **What is a "fan system"?**

  > *"**fan system bhp:** the sum of the fan brake horsepower (bhp) of all fans that are required to operate at fan system design conditions to supply air from the heating or cooling source to the conditioned space(s) and return it to the source or exhaust it to the outdoors" (Section 3.2)*

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example 6-DDD

User's Manual for 90.1-2010

QUESTION: A wing of an elementary school building is served by eight WSHPs, each equipped with a ¾-hp fan motor and serving a single classroom. Ventilation air is supplied directly to each classroom by a dedicated outdoor-air system. Each classroom requires 500 cfm of outdoor air, so the DOAS delivers the total of 4000 cfm of conditioned outdoor air using a 5-hp fan. Does this system need to comply with section 6.5.3.1?

ANSWER: **Each WSHP is a separate fan system** because each has a separate cooling and heating source. The **power of the DOAS fan must be allocated to each heat pump** on a cfm-weighted basis

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example 6-DDD

User's Manual for 90.1-2010

- DOAS delivers 500 cfm to each classroom
- 1/8 (500/4000 cfm) of the DOAS fan power is added to the fan power for each WSHP
  - 1/8 of 5 hp = 5/8 hp
  - 3/4 (heat pump) + 5/8 (DOAS) = 1 3/8 hp
- Even with DOAS fan allocated, each heat pump "fan system" is less than the 5 hp threshold, so the system does not need to comply with the fan power limitation of Section 6.5.3.1

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Section 6.5.3.1, prescriptive requirements

Fan Power Limitation

- Only applies to fan systems > 5 hp
- Each fan system shall not exceed:
  - Option 1: fan system motor nameplate hp
  - Option 2: fan system bhp
- Exceptions:
  a. Health and safety (systems maintaining space-to-space pressure differences)
  b. Individual exhaust fans ≤ 1 hp

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Section 6.5.1, prescriptive requirements

Economizers

> ***"6.5.1 Economizers.*** *Each cooling system that has a fan shall include either an air or water economizer meeting the requirements of Sections 6.5.1.1 through 6.5.1.4."*

- Most notable exceptions:
  a. Cooling capacity < 54,000 Btu/hr (4.5 tons)
  b. Systems that use non-particulate air treatment
  d. Systems with condenser heat recovery
  e. Residential with cooling capacity < 270,000 Btu/hr

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If an Economizer is Required…

- Oversize the dedicated OA system to "provide up to 100% of design supply air quantity air for cooling"
- Include a second OA intake (path) for airside economizing
- Waterside economizing
  - Fan-coils, radiant cooling
- Comply using Energy Cost Budget (Section 10) method, rather than prescriptive requirements

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Section 6.5.6.1, prescriptive requirements

Exhaust-Air Energy Recovery

- For dedicated (100%) OA systems, exhaust-air energy recovery is required on more (smaller) systems for many climate zones

TABLE 6.5.6.1 Energy Recovery Requirement

Zone	% *Outdoor Air* at Full Design Airflow Rate					
	≥30% and < 40%	≥40% and < 50%	≥50% and < 60%	≥60% and < 70%	≥70% and < 80%	≥80%
	Design Supply Fan Airflow Rate (cfm)					
3B, 3C, 4B, 4C, 5B	NR	NR	NR	NR	≥5000	≥5000
1B, 2B,5C	NR	NR	≥26000	≥12000	≥5000	≥4000
6B	≥11000	≥5500	≥4500	≥3500	≥2500	≥1500
1A, 2A, 3A, 4A, 5A, 6A	≥5500	≥4500	≥3500	≥2000	≥1000	>0
7,8	≥2500	≥1000	>0	>0	>0	>0

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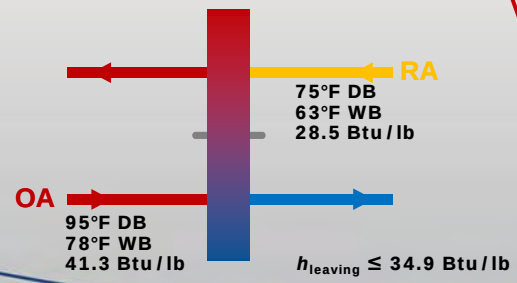
Section 6.5.6.1, prescriptive requirements

Exhaust-Air Energy Recovery

*"…at least 50% energy recovery **effectiveness**. Fifty percent energy recovery effectiveness shall mean a change in the enthalpy of the outdoor air supply equal to 50% of the difference between the outdoor air and return air enthalpies at design conditions."*

Be careful of this term!



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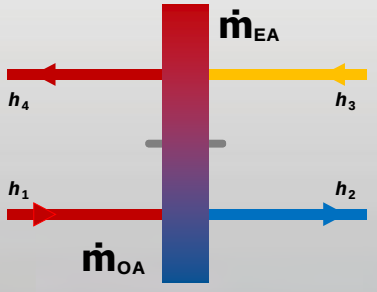
ASHRAE Standard 84 and AHRI Standard 1060

Effectiveness

$$\varepsilon_T = \frac{\dot{m}_{OA}}{\dot{m}_{min}} \times \frac{(h_1 - h_2)}{(h_1 - h_3)}$$

"total energy exchange rate"

"maximum energy exchange rate"



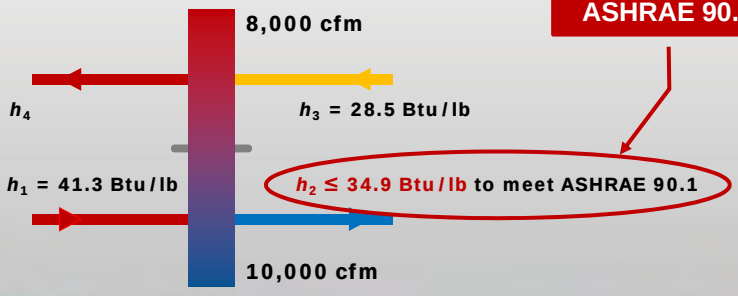
40

different definitions of effectiveness

Example of Unbalanced Airflows ($\dot{m}_{EA} < \dot{m}_{OA}$)

$$50\% = \frac{10{,}000 \text{ cfm}}{8{,}000 \text{ cfm}} \times \frac{(41.3 - h_2)}{(41.3 - 28.5)} \Rightarrow h_2 = 36.2 \text{ Btu/lb}$$

Does not meet ASHRAE 90.1



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"As-Applied" vs. "Rated" Effectiveness

- Be careful not to confuse "as-applied" effectiveness (required by ASHRAE 90.1) with "rated" effectiveness per AHRI 1060
- Strive for balanced airflows
  - Bring back as much exhaust air as possible

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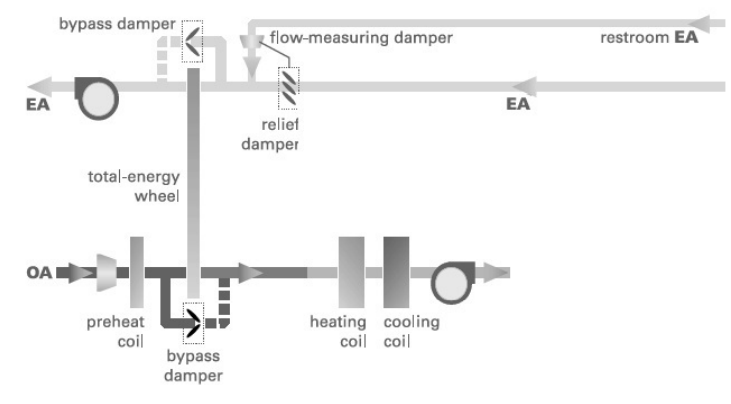
exhaust-air energy recovery

Using Restroom Exhaust



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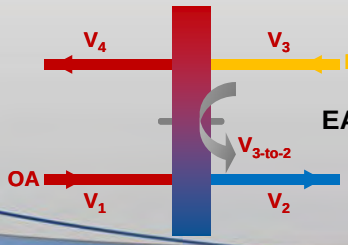
ASHRAE 62.1-2010

Recirculation of Restroom Exhaust

*"**5.16.3.2.5.** Class 2 air [which includes restrooms] shall not be recirculated or transferred to Class 1 spaces.*

***Exception:** When using an energy recovery device, recirculation from leakage, carryover, or transfer from the exhaust side of the energy recovery device is permitted. Recirculated Class 2 air shall not exceed 10% of the outdoor air intake flow."*



EATR ≤ 10%

Exhaust Air Transfer Ratio is defined by ASHRAE Standard 84 and certified by AHRI Standard 1060

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Section 6.5.2, prescriptive requirements

Simultaneous Heating and Cooling

"6.5.2.3 Dehumidification. *Where humidistatic controls are provided, such controls shall prevent reheating, mixing of hot and cold airstreams, or other means of simultaneous heating and cooling of the same airstream."*

- **Exception A:**

  "The system is capable of ***reducing supply air volume to*** *50% or less of the design airflow rate or* ***the minimum outdoor air ventilation rate specified in ASHRAE Standard 62.1*** *… whichever is larger, before simultaneous heating and cooling takes place."*

- **See example 6-TT, User's Manual for 90.1-2010**

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Dedicated Outdoor-Air Equipment

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Specific Dedicated OA Equipment Configurations

dedicated outdoor-air equipment

Which Configuration is Best?

1) Dehumidification Duty

3) Efficiency Target

2) Cooling Duty

4) Cooling Source

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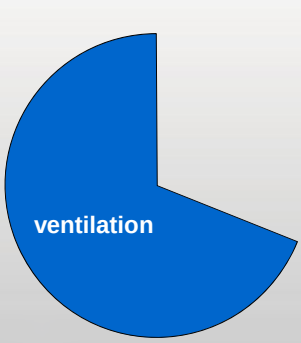
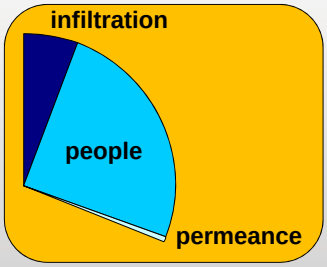
1 What is the Dehumidification Duty?



typical latent loads
for a school classroom



space (indoor)
latent loads

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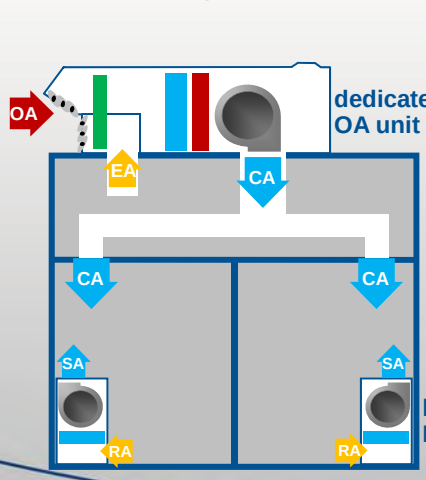
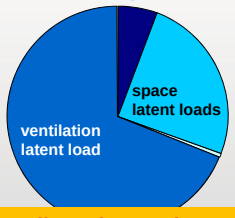
Source: *Humidity Control Design Guide*, ASHRAE © 2001, p. 278

what is the dehumidification duty?

Dehumidify Ventilation Air Only

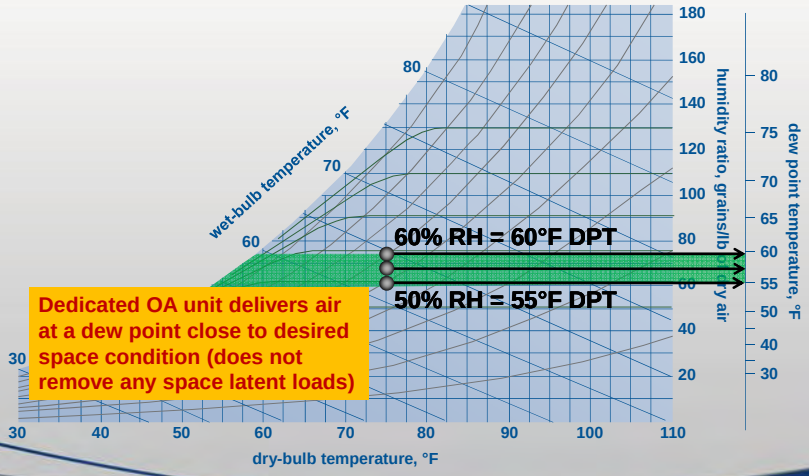




- Dedicated OA unit removes latent load due to ventilation
- Space latent loads must be removed by local units (any space dehumidification is coincidental)

49 |

Dehumidify Ventilation Air Only

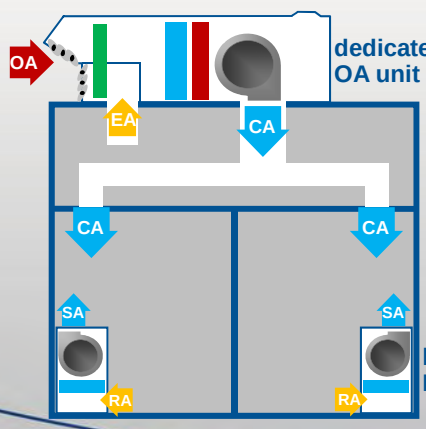


Dedicated OA unit delivers air at a dew point close to desired space condition (does not remove any space latent loads)

50 |

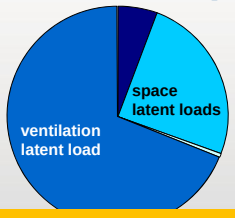
what is the dehumidification duty?

Dehumidify the Space (for Comfort)



dedicated OA unit

local HVAC unit

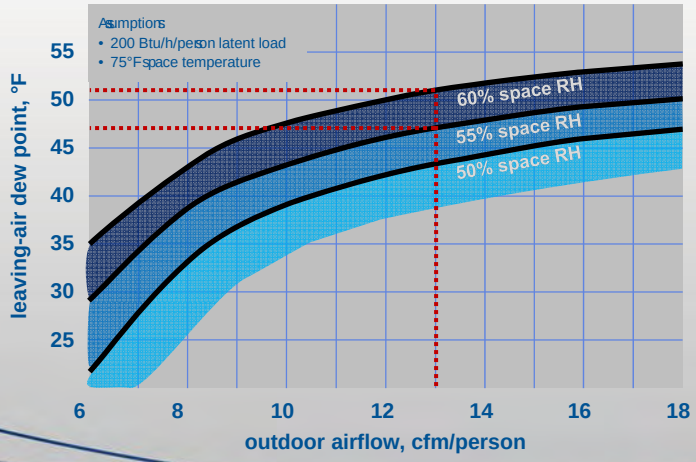


- Dedicated OA unit removes both ventilation and space latent loads (controls space humidity)
- Local HVAC units need only remove space sensible loads

51

dehumidify the space (for comfort)

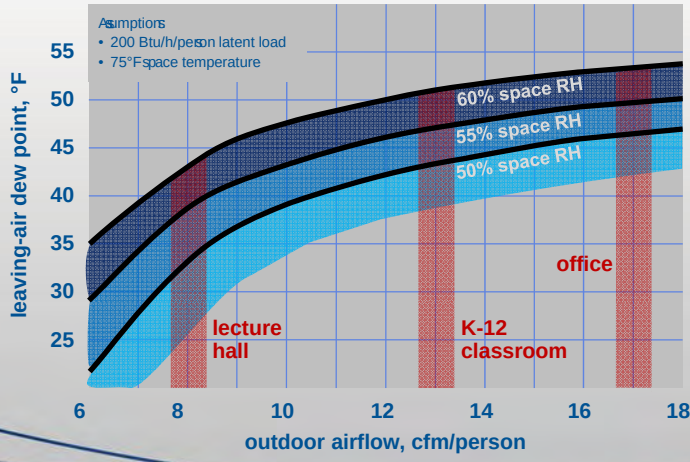
What Leaving-Air Dew Point is Required?



52

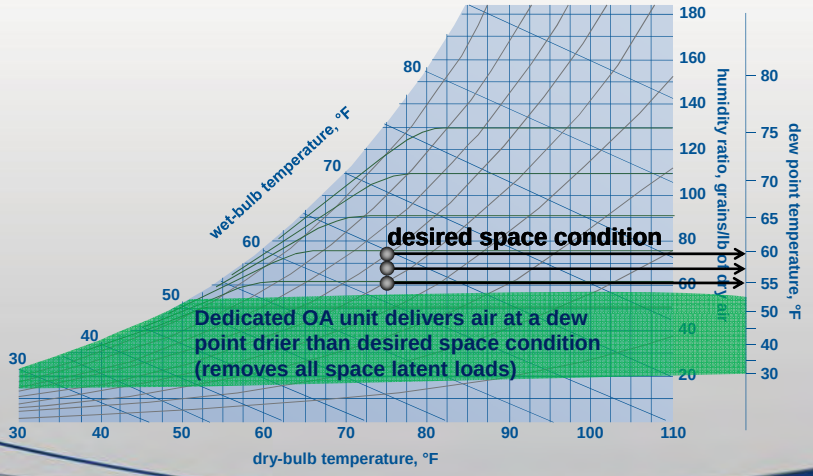
dehumidify the space (for comfort)

What Leaving-Air Dew Point is Required?



53

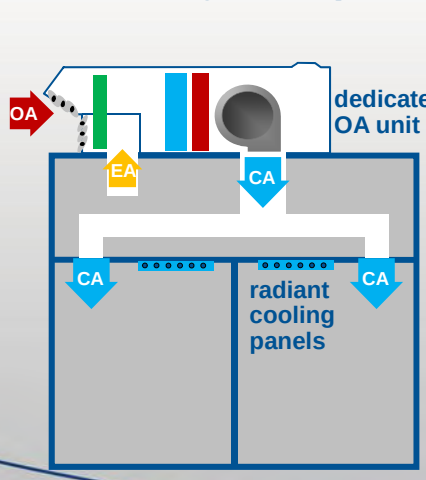
Dehumidify to Space (for Comfort)

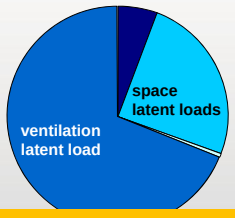


54

what is the dehumidification duty?

Dehumidify the Space (for Condensation)

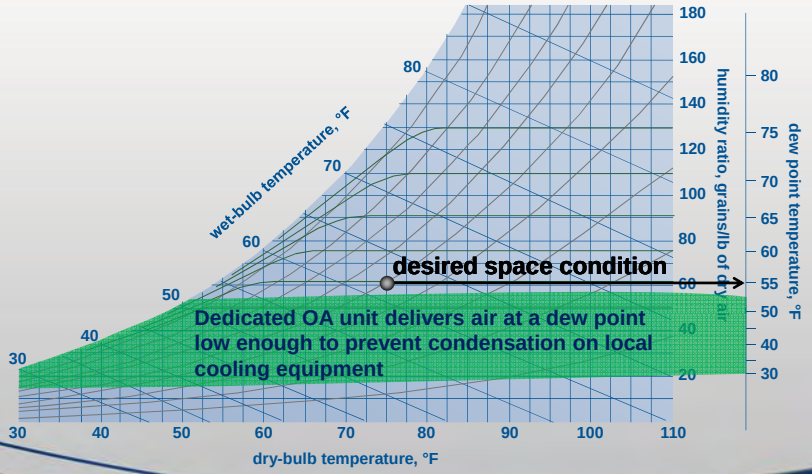




- Dedicated OA unit removes both ventilation and space latent loads (leaving-air DPT low enough to prevent condensation on local units)
- Local HVAC units only remove space sensible loads

55 |

Dehumidify the Space (for Condensation)



56 |

dedicated outdoor-air equipment

1 What is the Dehumidification Duty?

1) Dehumidification Duty
- Dehumidify ventilation only
- Dehumidify space (comfort)
- Dehumidify space (condensation)

57

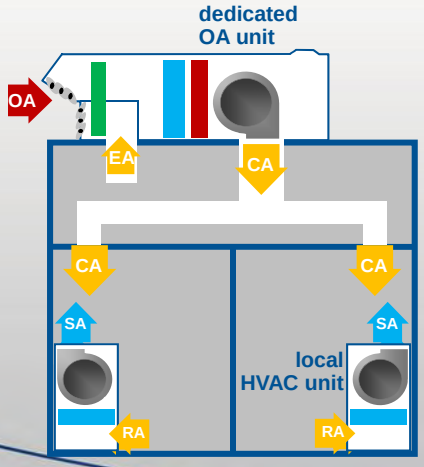
2 What is the Cooling Duty?

- **Neutral air**
  - Remove the sensible ventilation load only
- **Cool air**
  - Trim some of the space sensible cooling load
- **Cold air**
  - Remove as much of the space sensible cooling load as possible

58

what is the cooling duty?

Neutral Air

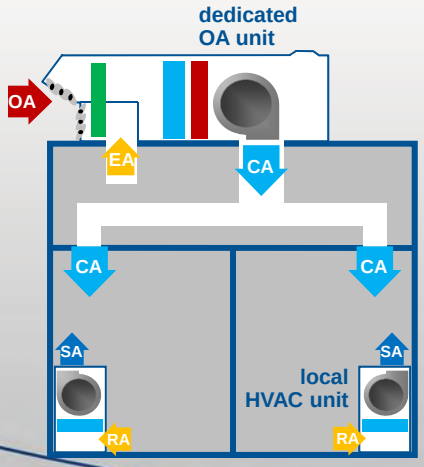


- Dedicated OA unit delivers air at dry-bulb temperature close to desired space condition
  - Does not remove any space sensible loads
- Space sensible loads must be removed by local cooling equipment

59

what is the cooling duty?

Cold Air

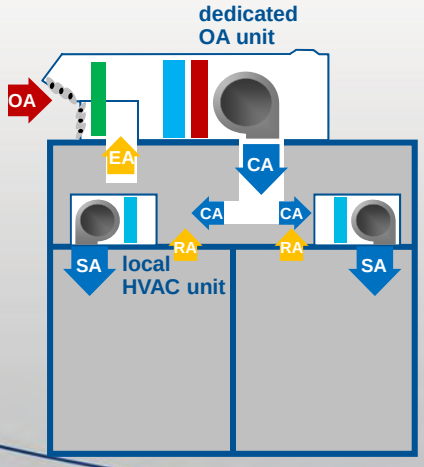


- Dedicated OA unit delivers air at dry-bulb temperature cooler than the space
  - Removes some of the space sensible loads
- Remainder of space sensible loads removed by local cooling equipment

60

what is the cooling duty?

Cool Air



- Dedicated OA unit delivers air at dry-bulb temperature cooler than the space
  - Air is reheated some before delivery
  - Removes some of the space sensible loads
- Remainder of space sensible loads removed by local cooling equipment

61

dedicated outdoor-air equipment

2 What is the Cooling Duty?

1) Dehumidification Duty
- Dehumidify ventilation only
- Dehumidify space (comfort)
- Dehumidify space (condensation)

2) Cooling Duty
- Neutral air
- Cool air
- Cold air

62

3 What is the Efficiency Target?

- **Code or ASHRAE 90.1 minimum**
  - Meet the minimum requirements of the local energy code or ASHRAE Standard 90.1
- **Higher level of efficiency**
  - More efficient than the minimum requirements

63

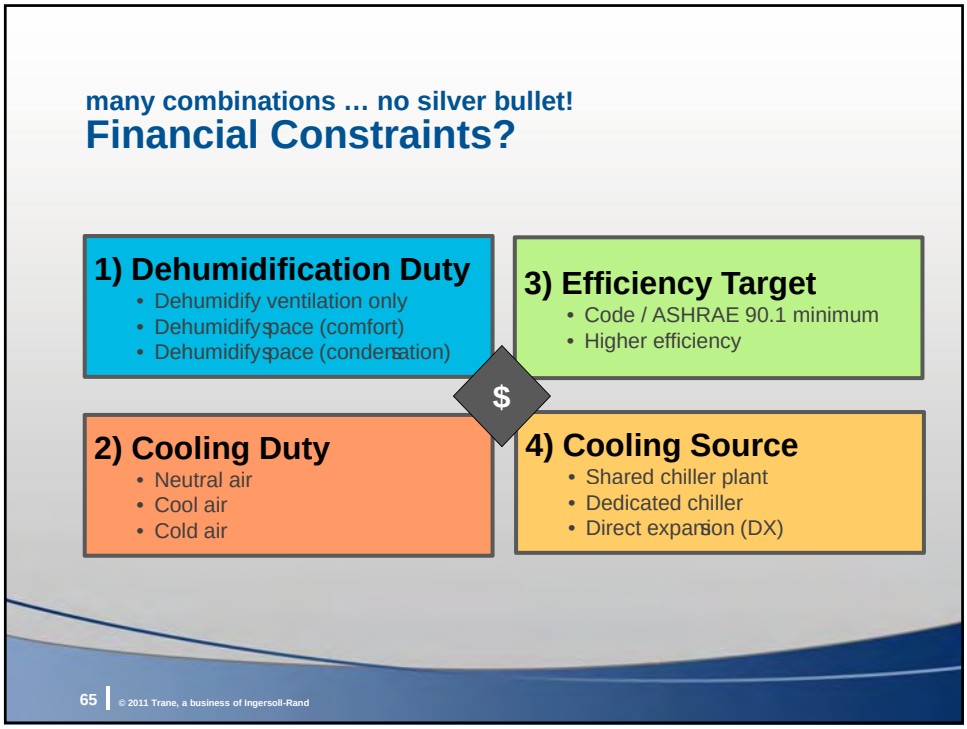
4 What is the Cooling Source?

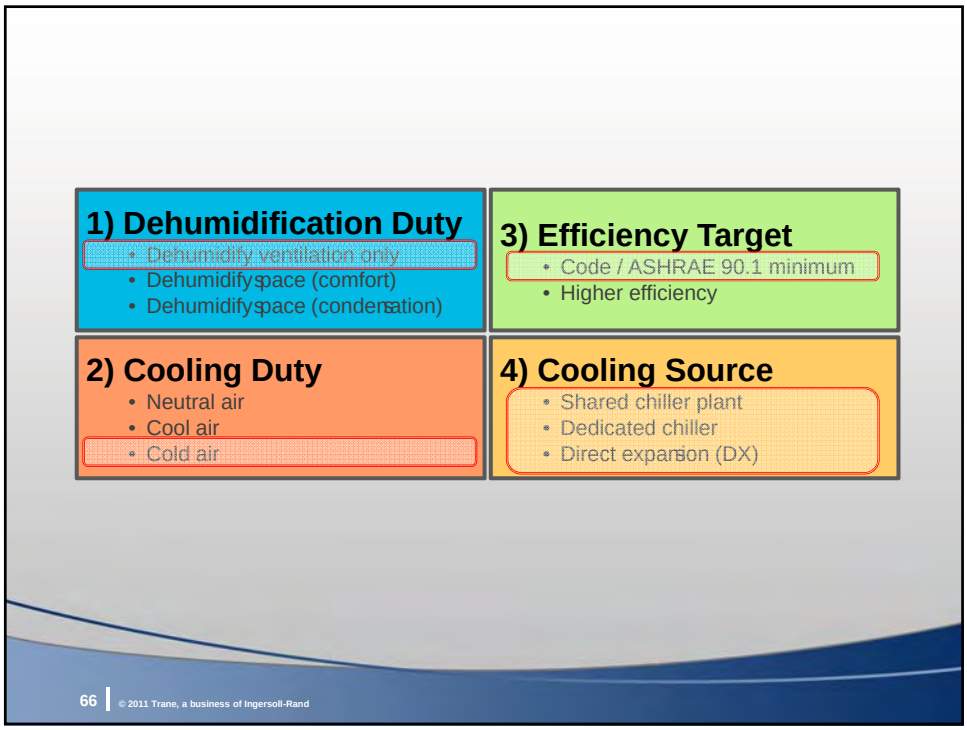
- **Shared chiller plant**
  - Chiller plant that serves both the dedicated outdoor-air equipment and the local cooling equipment
- **Dedicated chiller**
  - Chiller that serves only the dedicated outdoor-air equipment
- **Direct expansion (DX) unit**
  - Packaged or split
  - Air-cooled or water-cooled

air-cooled chiller

packaged DX dedicated OA unit

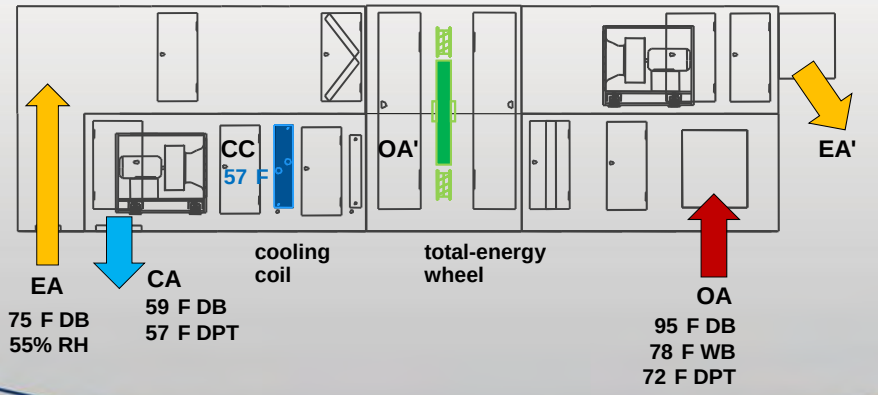
64





energy wheel + cooling coil

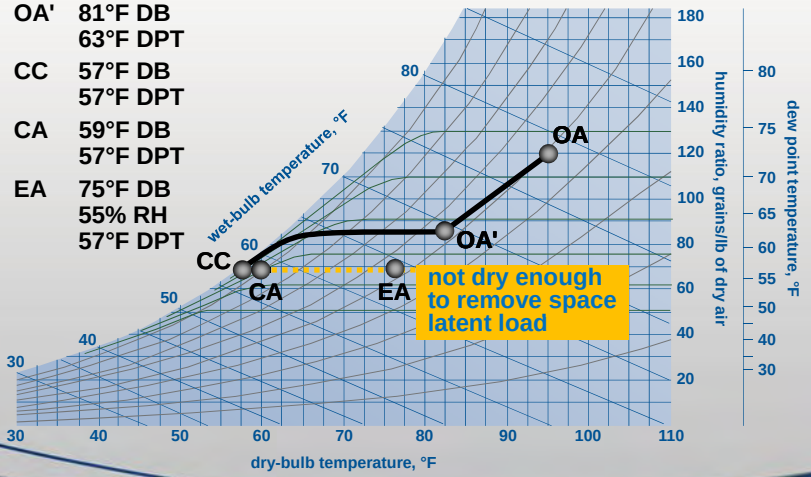
Dehumidify Ventilation Only (Cold Air)

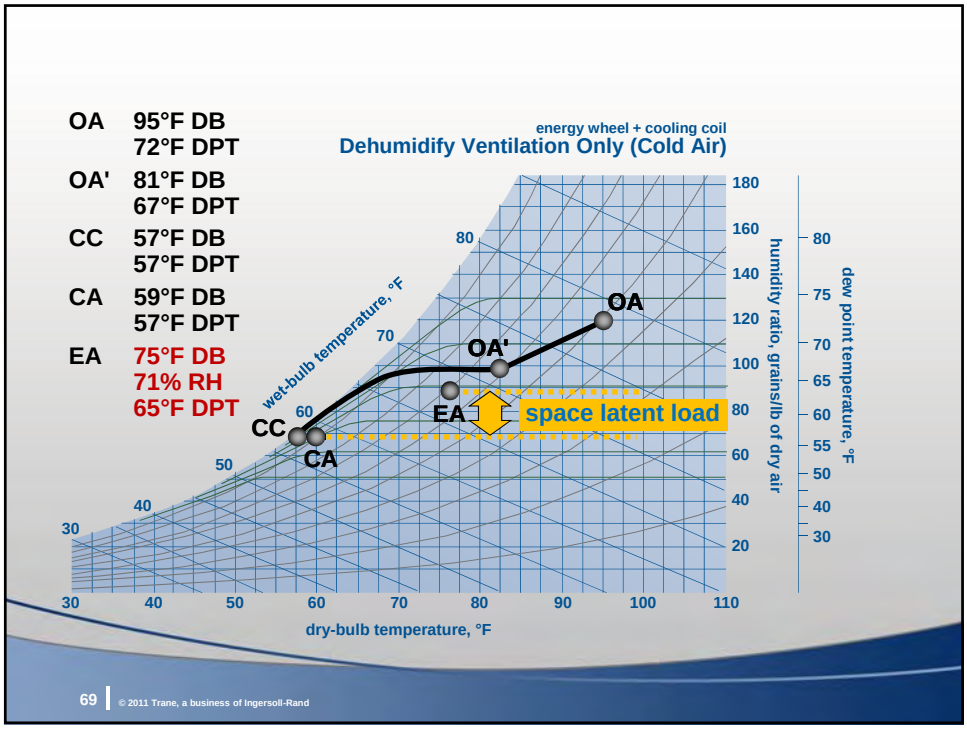


OA	95°F DB 72°F DPT
OA'	81°F DB 63°F DPT
CC	57°F DB 57°F DPT
CA	59°F DB 57°F DPT
EA	75°F DB 55% RH 57°F DPT

energy wheel + cooling coil

Dehumidify Ventilation Only (Cold Air)




OA 95°F DB
72°F DPT
OA' 81°F DB
67°F DPT
CC 57°F DB
57°F DPT
CA 59°F DB
57°F DPT
EA 75°F DB
71% RH
65°F DPT
energy wheel + cooling coil
Dehumidify Ventilation Only (Cold Air)
wet-bulb temperature, °F
OA
OA'
EA
CC
CA
space latent load
humidity ratio, grains/lb of dry air
dew point temperature, °F
dry-bulb temperature, °F
69
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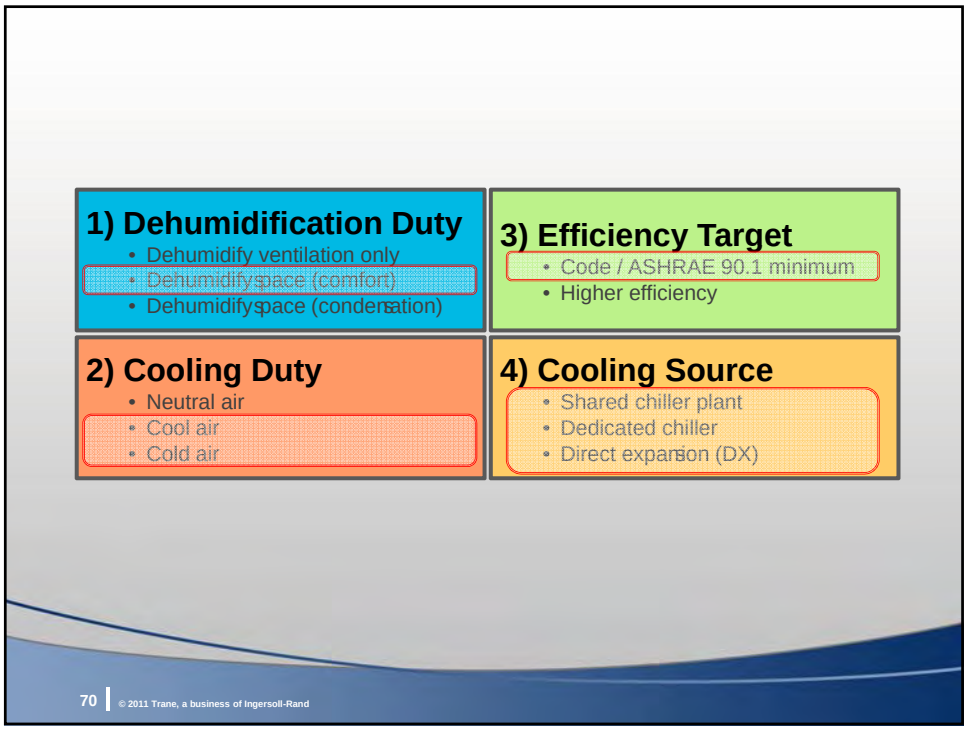
1) Dehumidification Duty
• Dehumidify ventilation only
• Dehumidify space (comfort)
• Dehumidify space (condensation)
2) Cooling Duty
• Neutral air
• Cool air
• Cold air
3) Efficiency Target
• Code / ASHRAE 90.1 minimum
• Higher efficiency
4) Cooling Source
• Shared chiller plant
• Dedicated chiller
• Direct expansion (DX)
70
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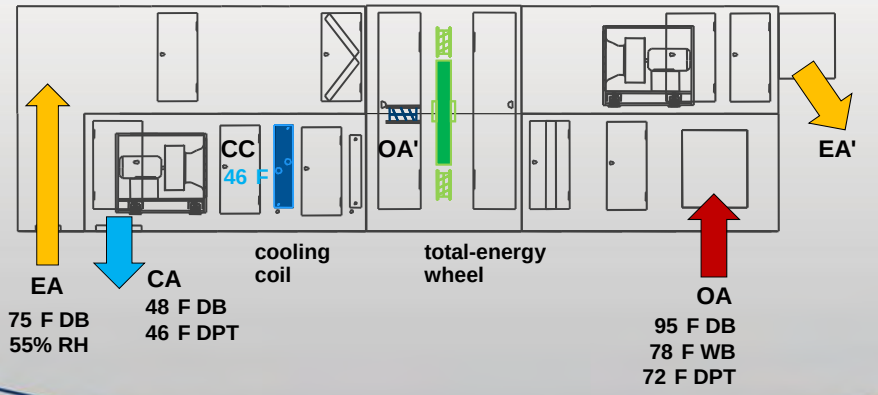
energy wheel + cooling coil

Dehumidify Space (Cold Air)



71

OA 95°F DB
72°F DPT

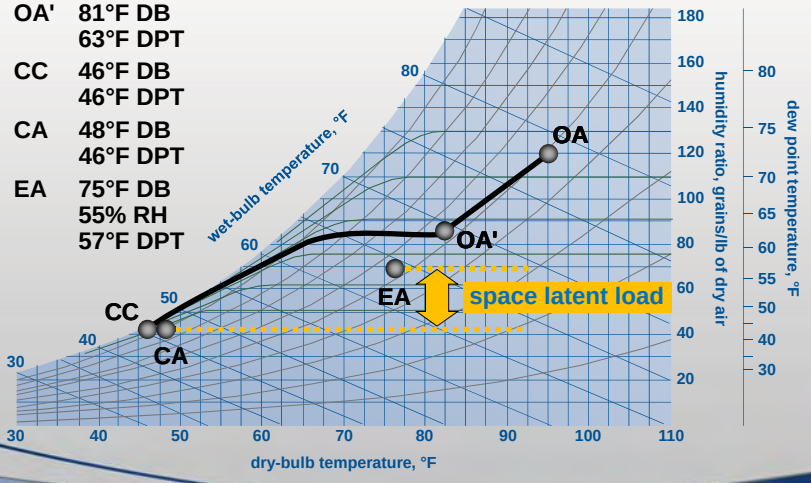
OA' 81°F DB
63°F DPT

CC 46°F DB
46°F DPT

CA 48°F DB
46°F DPT

EA 75°F DB
55% RH
57°F DPT

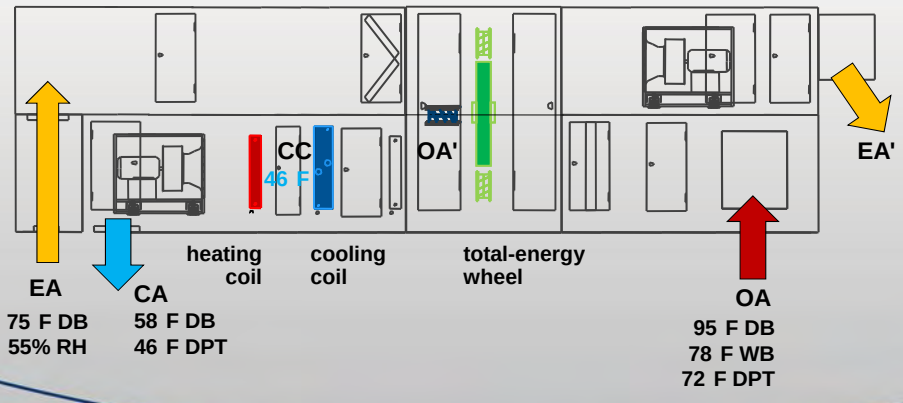
energy wheel + cooling coil
Dehumidify Space (Cold Air)



72

energy wheel + cooling coil

Dehumidify Space (Cool Air)



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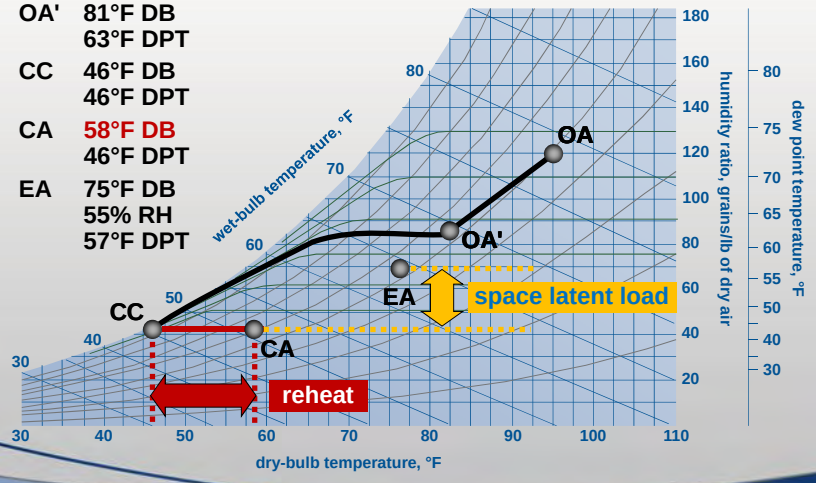
OA	95°F DB 72°F DPT
OA'	81°F DB 63°F DPT
CC	46°F DB 46°F DPT
CA	58°F DB 46°F DPT
EA	75°F DB 55% RH 57°F DPT

energy wheel + cooling coil
Dehumidify Space (Cool Air)



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Consider Unoccupied Humidity Control

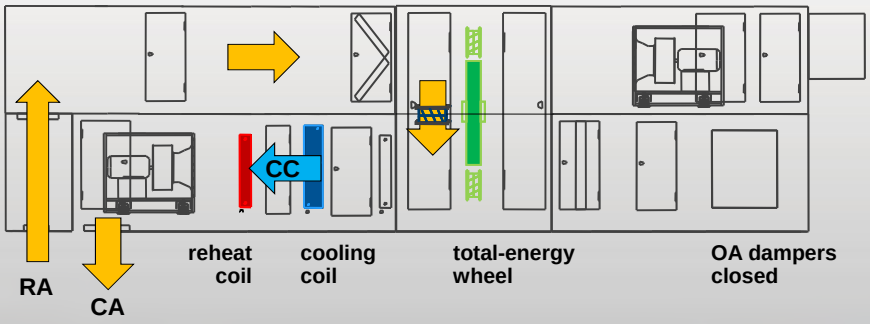
"In humid climates, seriously consider providing dehumidification during the summer, even if school is unoccupied, to prevent mold and mildew."

Chapter 7 (p. 7.3), 2011 *ASHRAE Handbook—HVAC Applications*

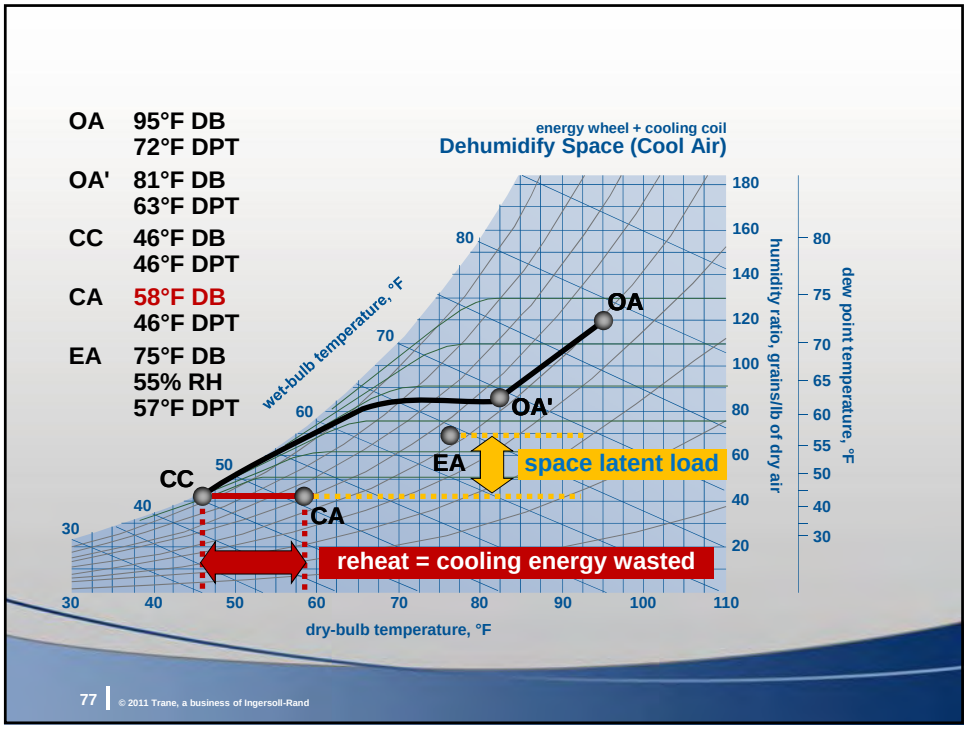
75

energy wheel + cooling coil

Dehumidify Space (Unoccupied Mode)



76


OA 95°F DB
72°F DPT
OA' 81°F DB
63°F DPT
CC 46°F DB
46°F DPT
CA 58°F DB
46°F DPT
EA 75°F DB
55% RH
57°F DPT
energy wheel + cooling coil
Dehumidify Space (Cool Air)
wet-bulb temperature, °F
humidity ratio, grains/lb of dry air
dew point temperature, °F
dry-bulb temperature, °F
OA
OA'
EA
CC
CA
space latent load
reheat = cooling energy wasted
77
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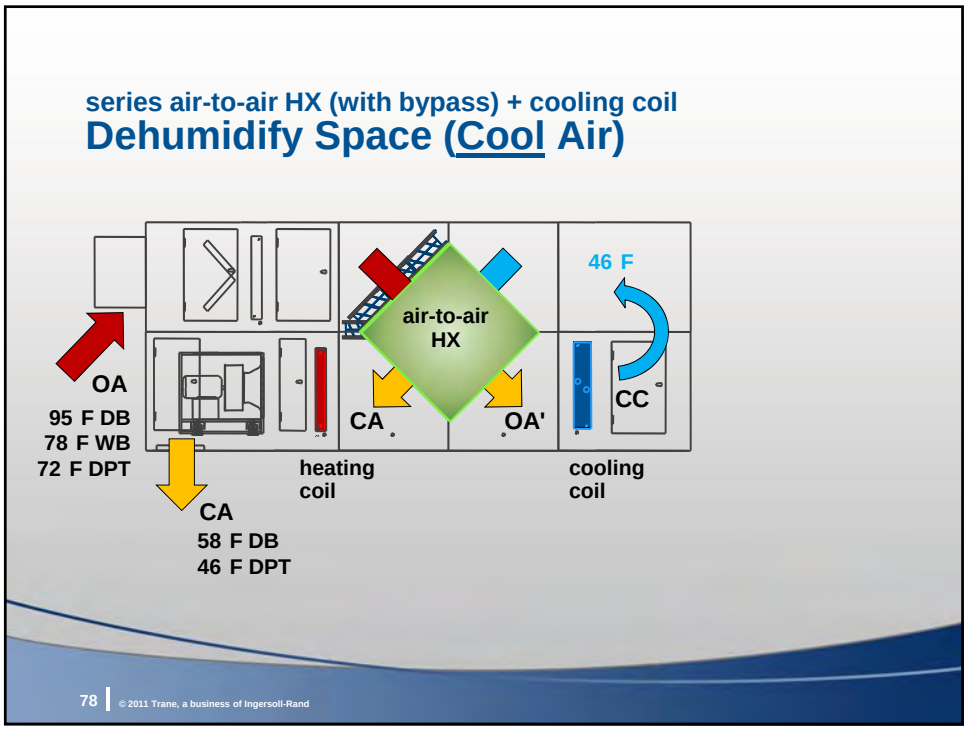
series air-to-air HX (with bypass) + cooling coil
Dehumidify Space (Cool Air)
air-to-air HX
46 F
OA
95 F DB
78 F WB
72 F DPT
CA
OA'
CC
heating coil
cooling coil
CA
58 F DB
46 F DPT
78
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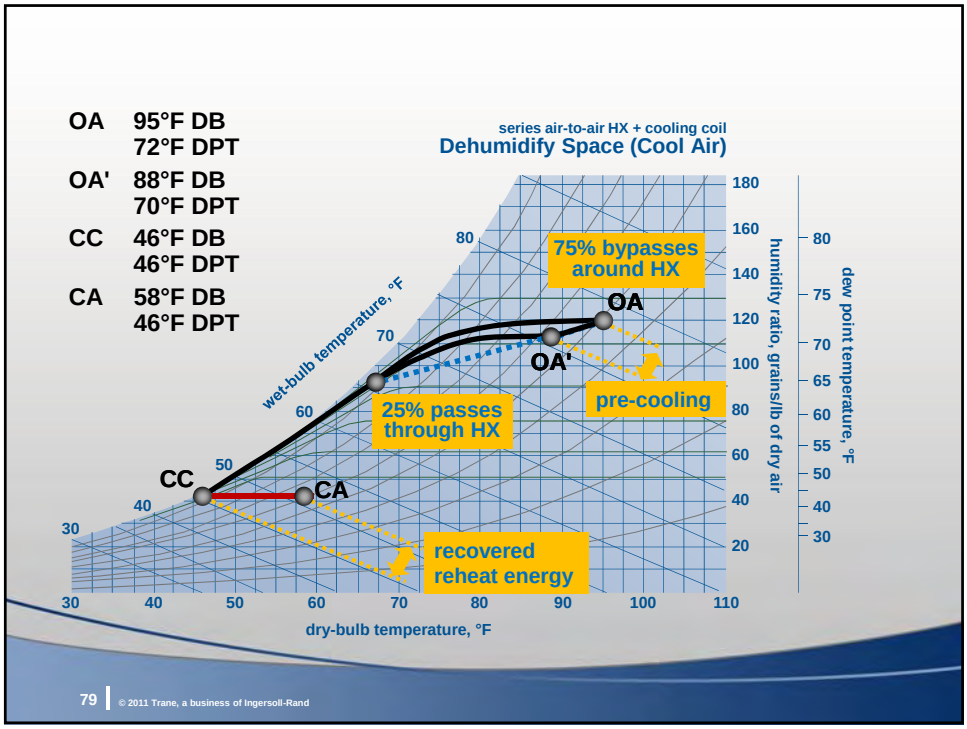

Series Air-to-Air Devices (Cool Air)

	sensible effectiveness	pressure drop (per pass)	OA temp below which reheat is required*
heat pipe	40%	0.5 in. H_2O	76°F
coil loop	50%	0.5 in. H_2O	70°F
fixed-plate HX	65%	0.5 in. H_2O	64°F

* to achieve 58°F leaving dry-bulb temperature with 46°F dew point

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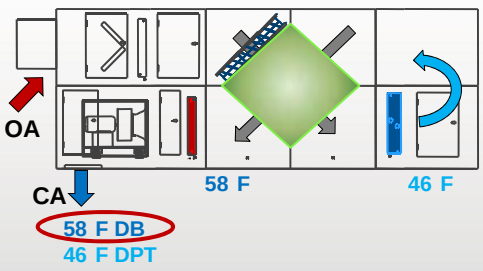

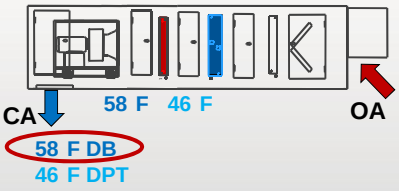

series HX + cooling coil
- 13% less cooling capacity
- 12 F less reheat

cooling coil + reheat (cool air)
- Delivering conditioned OA at same dew point and dry bulb

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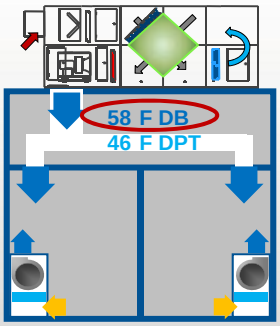

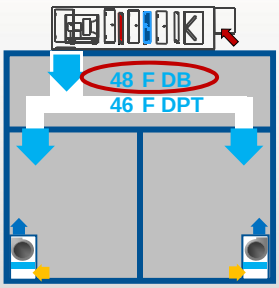

series HX + cooling coil
- Dedicated OA unit
  - 13% less cooling capacity
  - 12°F less reheat
- Local HVAC equipment
  - 13% more cooling capacity
  - 13% more airflow

cooling coil + reheat (cold air)
- Dedicated OA unit
  - 13% more cooling capacity
- Local HVAC equipment
  - 13% less cooling capacity
  - 13% less airflow

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1) Dehumidification Duty
- Dehumidify ventilation only
- Dehumidify space (comfort)
- Dehumidify space (condensation)

3) Efficiency Target
- Code / ASHRAE 90.1 minimum
- Higher efficiency

2) Cooling Duty
- Neutral air
- Cool air
- Cold air

4) Cooling Source
- Shared chiller plant
- Dedicated chiller
- Direct expansion (DX)

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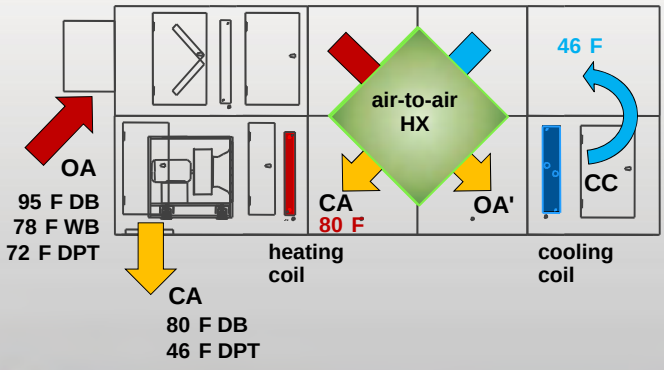
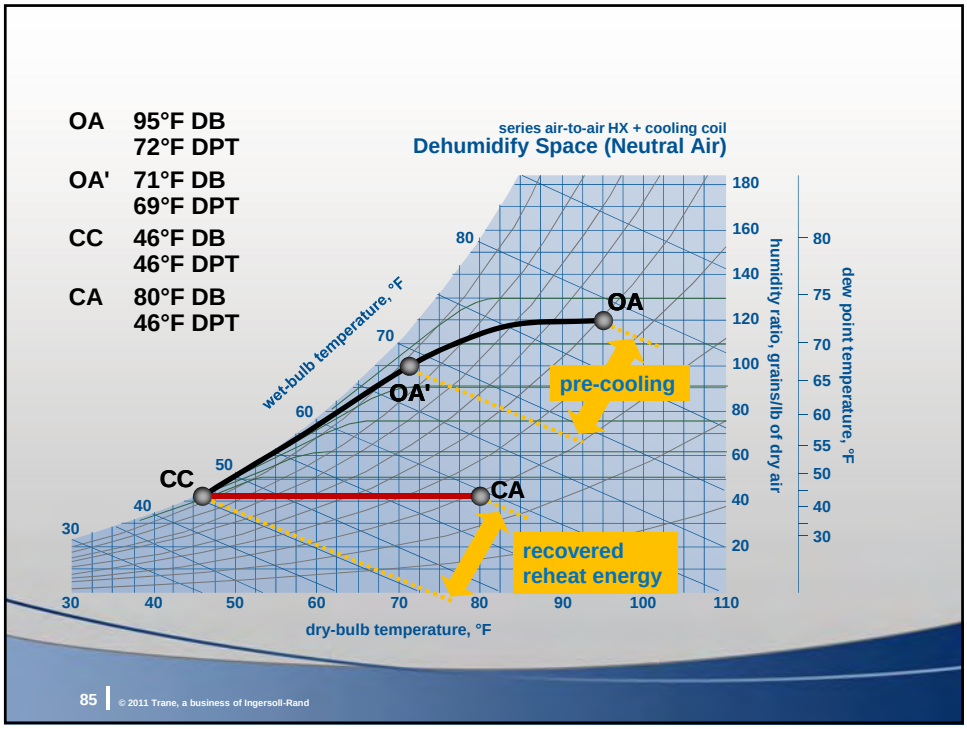
series air-to-air HX (without bypass) + cooling coil

Dehumidify Space (Neutral Air)



84



Series Air-to-Air Devices (Neutral Air)

	sensible effectiveness	pressure drop (per pass)	OA temp below which reheat is required*
heat pipe	40%	0.5 in. H_2O	118°F
coil loop	50%	0.5 in. H_2O	100°F
fixed-plate HX	65%	0.5 in. H_2O	90°F

* to achieve 75°F leaving dry-bulb temperature with 46°F dew point

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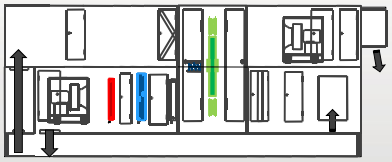
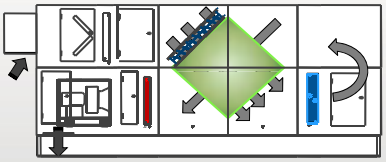
Parallel or Series?



energy wheel + cooling coil (parallel)

- Exhaust air is available for recovery
- Deliver air at a cool (or cold) temperature
- Recoverable reheat (if needed) energy is available



series HX + cooling coil (series)

- Exhaust air NOT available for recovery
- Deliver air at a neutral temperature
- Recoverable reheat energy is NOT available

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1) Dehumidification Duty

- Dehumidify ventilation only
- Dehumidify space (comfort)
- Dehumidify space (condensation)

2) Cooling Duty

- Neutral air
- Cool air
- Cold air

3) Efficiency Target

- Code / ASHRAE 90.1 minimum
- Higher efficiency

4) Cooling Source

- Shared chiller plant
- Dedicated chiller
- Direct expansion (DX)

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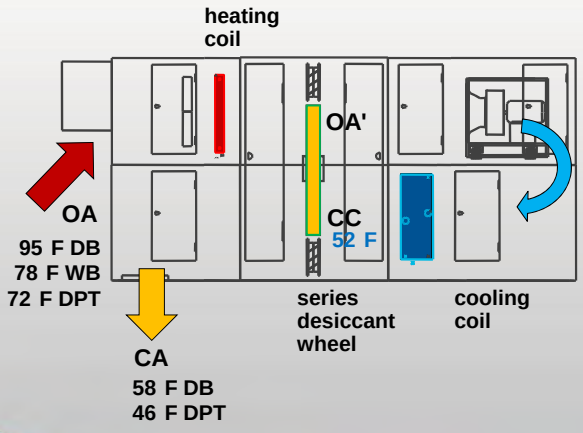
series desiccant wheel + cooling coil

Dehumidify Space (Cool Air)



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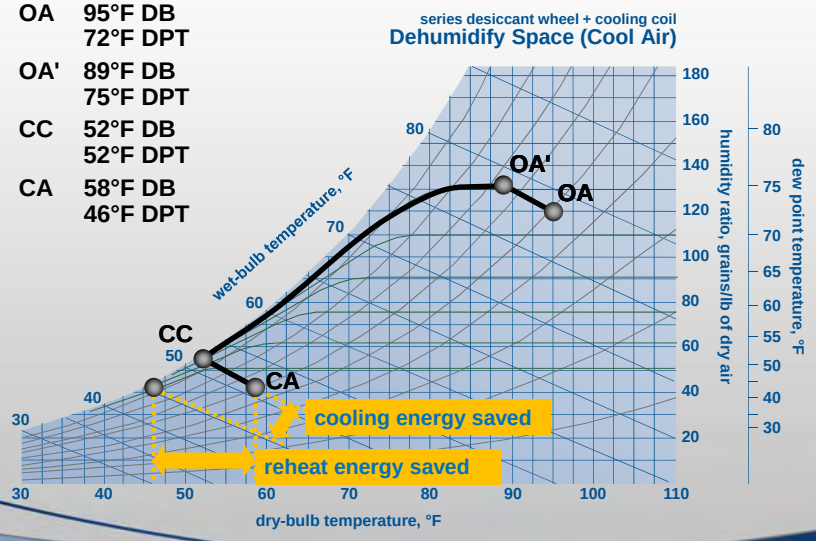
OA 95°F DB 72°F DPT
OA' 89°F DB 75°F DPT
CC 52°F DB 52°F DPT
CA 58°F DB 46°F DPT



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1) Dehumidification Duty
- Dehumidify ventilation only
- Dehumidify space (comfort)
- Dehumidify space (condensation)

3) Efficiency Target
- Code / ASHRAE 90.1 minimum
- Higher efficiency

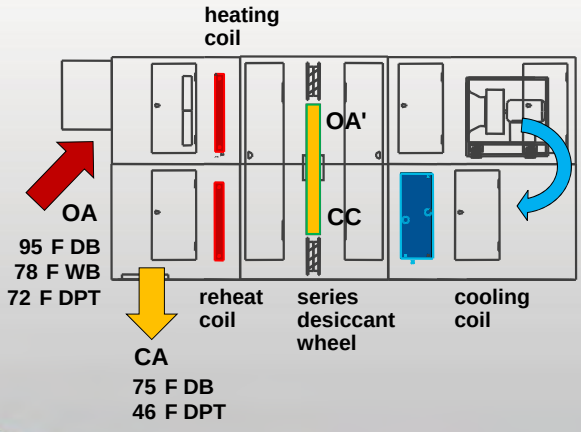
2) Cooling Duty
- Neutral air
- Cool air
- Cold air

4) Cooling Source
- Shared chiller plant
- Dedicated chiller
- Direct expansion (DX)

91

series desiccant wheel + cooling coil

Dehumidify Space (Neutral Air)



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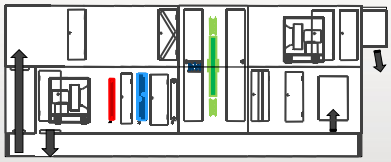
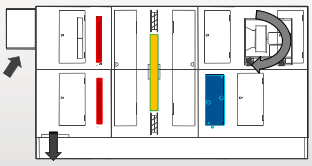
Parallel or Series?



energy wheel + cooling coil (parallel)

- Exhaust air is available for recovery
- Deliver air at a cool (or cold) temperature
- Recoverable reheat (if needed) energy is available



series desiccant + cooling coil (series)

- Required leaving-air DPT < CHW temp + 5 F
- Deliver air at a cool temperature
- Recoverable reheat energy is NOT available

93 |

1) Dehumidification Duty

- Dehumidify ventilation only
- Dehumidify space (comfort)
- Dehumidify space (condensation)

2) Cooling Duty

- Neutral air
- Cool air
- Cold air

3) Efficiency Target

- Code / ASHRAE 90.1 minimum
- Higher efficiency

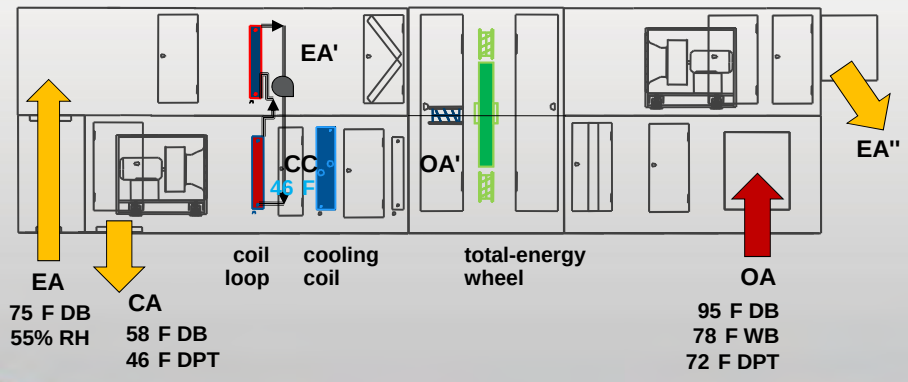
4) Cooling Source

- Shared chiller plant
- Dedicated chiller
- Direct expansion (DX)

94 |

total-energy wheel + cooling coil + coil loop

Dehumidify Space (Cool Air)



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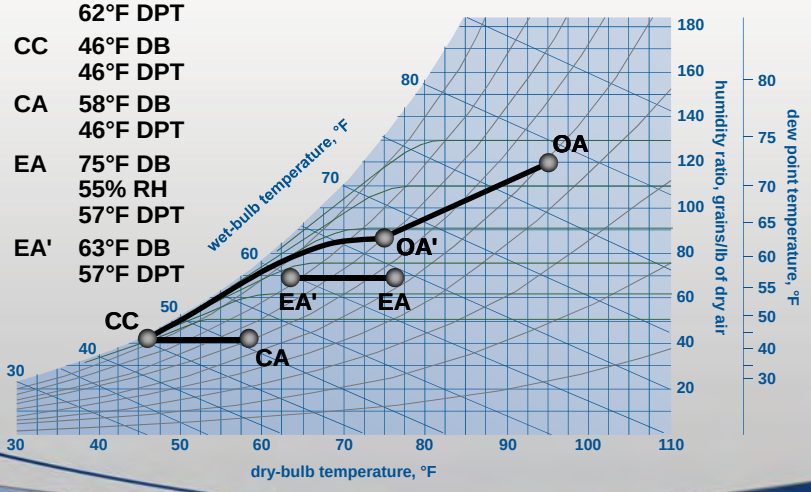
OA 95°F DB 72°F DPT
OA' 75°F DB 62°F DPT
CC 46°F DB 46°F DPT
CA 58°F DB 46°F DPT
EA 75°F DB 55% RH 57°F DPT
EA' 63°F DB 57°F DPT

energy wheel + cooling coil + coil loop

Dehumidify Space (Cool Air)



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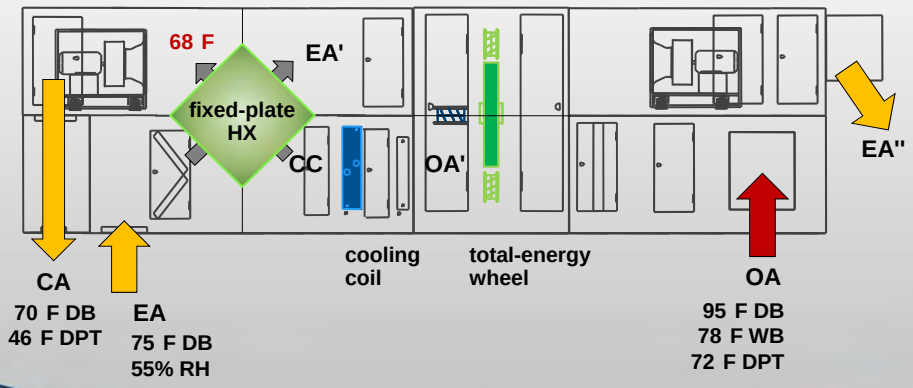
total-energy wheel + cooling coil + fixed-plate HX

Dehumidify Space (Cool Air)



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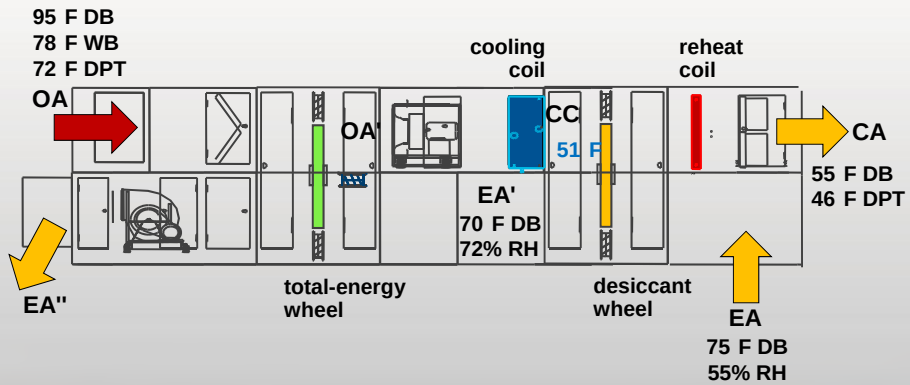
total-energy wheel + cooling coil + <u>parallel</u> desiccant wheel

Dehumidify Space (Cool Air)



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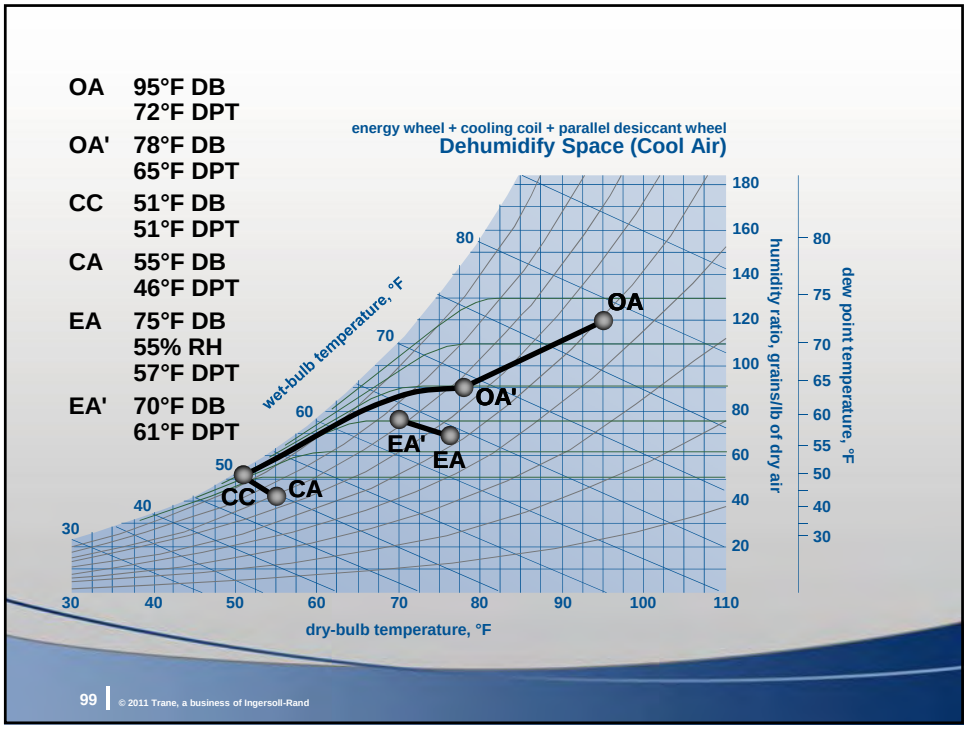
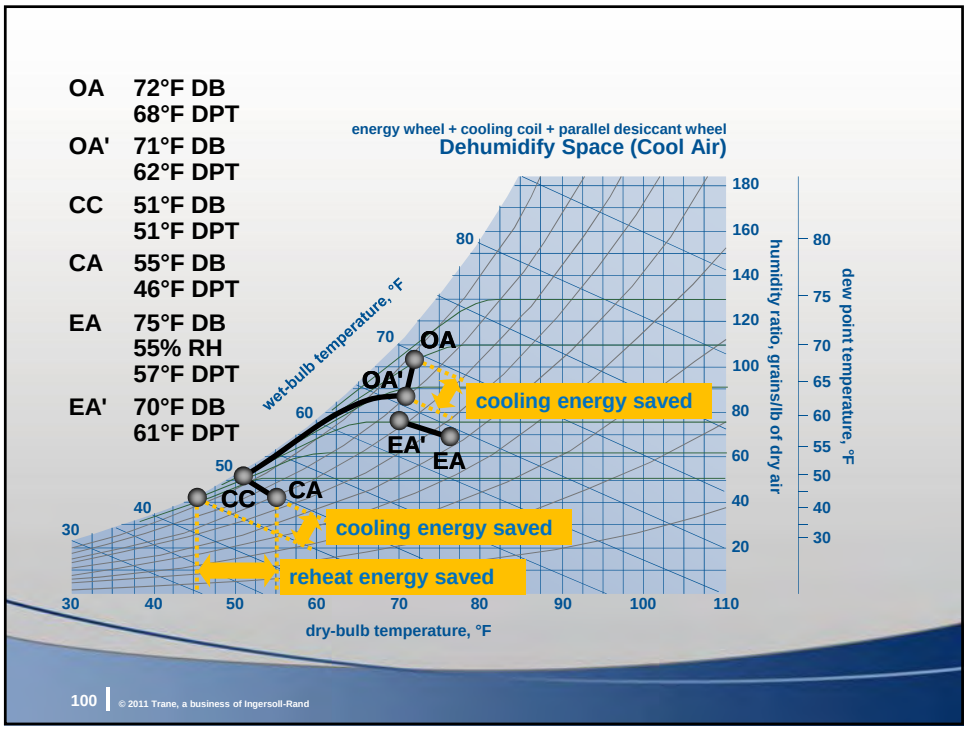
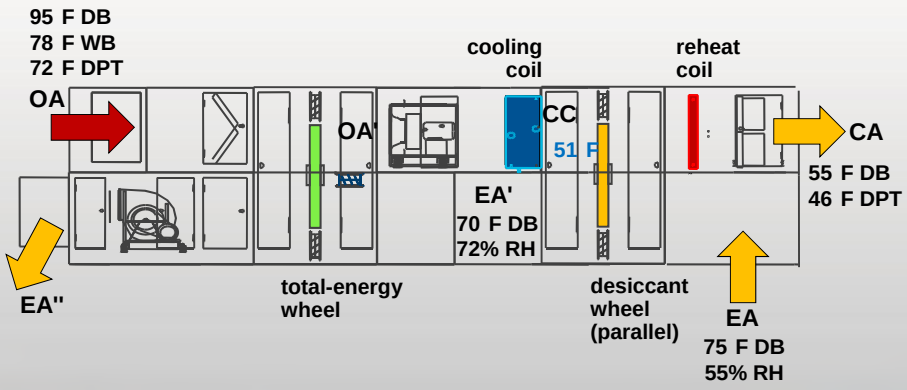




total-energy wheel + cooling coil + parallel desiccant wheel

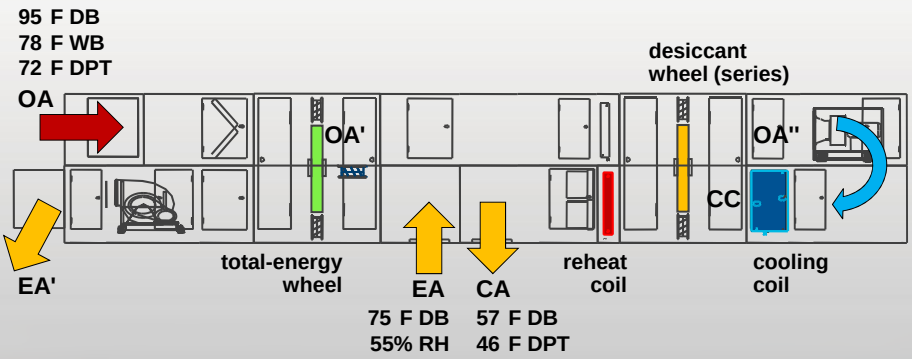
Dehumidify Space (Cool Air)



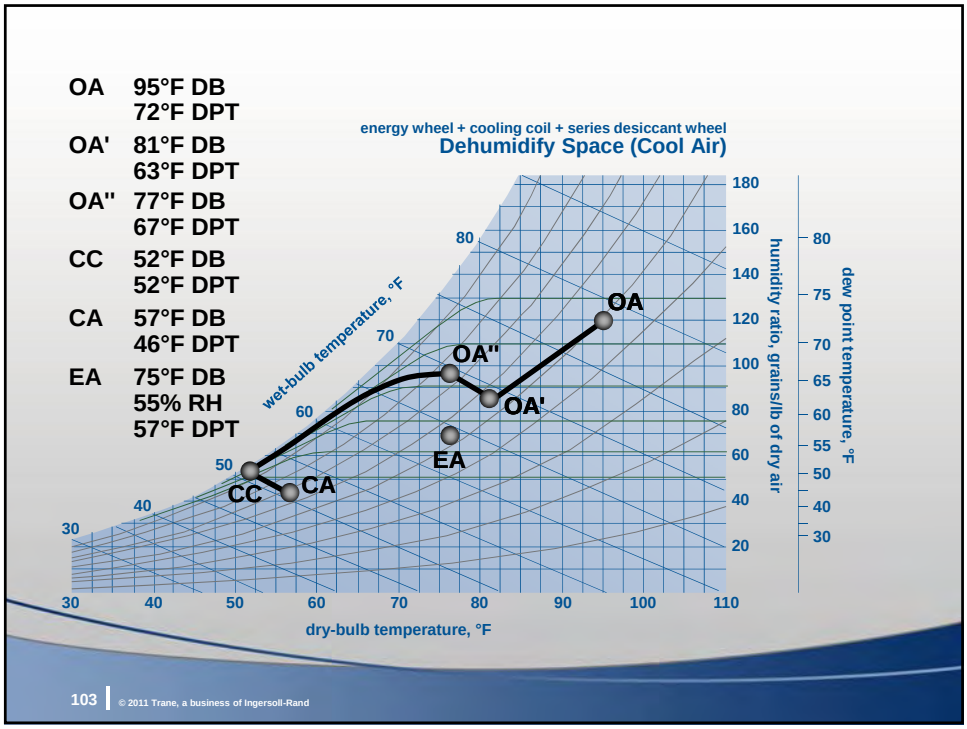
101

total-energy wheel + cooling coil + series desiccant wheel

Dehumidify Space (Cool Air)



102


OA 95°F DB
72°F DPT
OA' 81°F DB
63°F DPT
OA" 77°F DB
67°F DPT
CC 52°F DB
52°F DPT
CA 57°F DB
46°F DPT
EA 75°F DB
55% RH
57°F DPT
energy wheel + cooling coil + series desiccant wheel
Dehumidify Space (Cool Air)
wet-bulb temperature, °F
humidity ratio, grains/lb of dry air
dew point temperature, °F
dry-bulb temperature, °F
OA
OA"
OA'
EA
CC
CA
103
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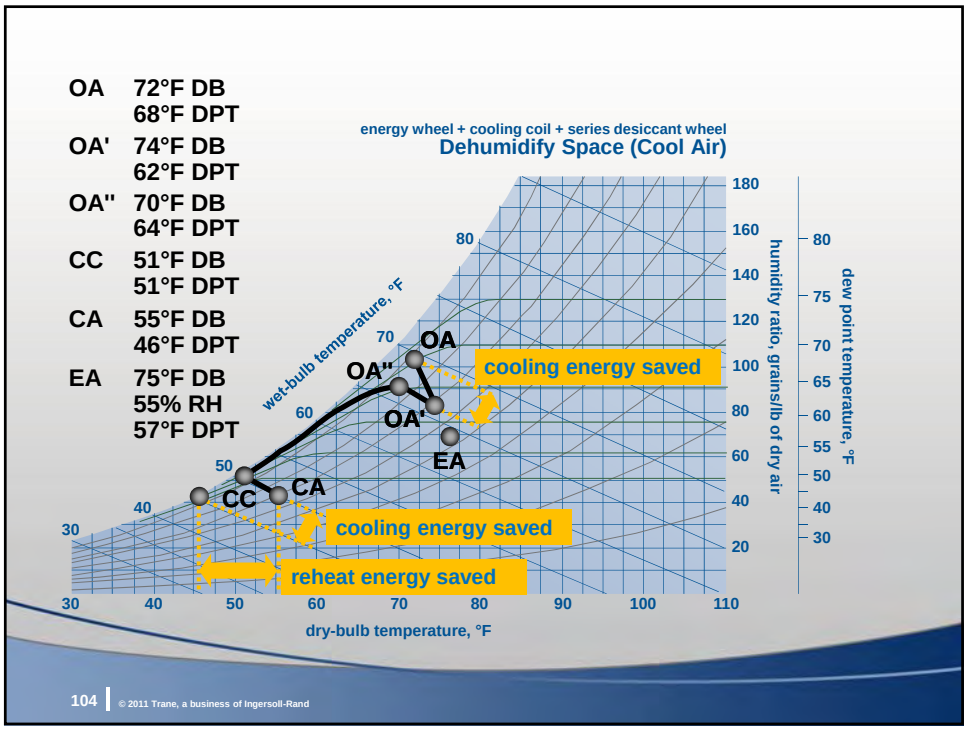
OA 72°F DB
68°F DPT
OA' 74°F DB
62°F DPT
OA" 70°F DB
64°F DPT
CC 51°F DB
51°F DPT
CA 55°F DB
46°F DPT
EA 75°F DB
55% RH
57°F DPT
energy wheel + cooling coil + series desiccant wheel
Dehumidify Space (Cool Air)
wet-bulb temperature, °F
humidity ratio, grains/lb of dry air
dew point temperature, °F
dry-bulb temperature, °F
OA
OA"
OA'
EA
CC
CA
cooling energy saved
cooling energy saved
reheat energy saved
104
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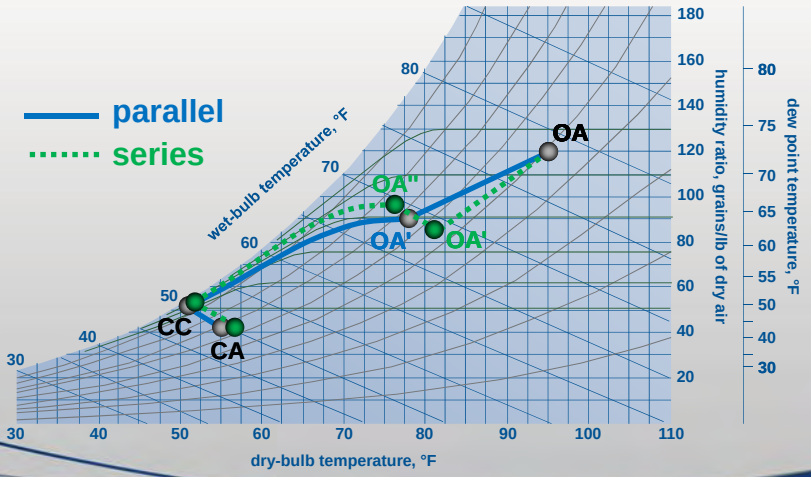
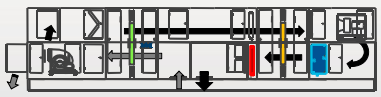
energy wheel + cooling coil + downstream desiccant wheel
Parallel vs. Series



105 |

energy wheel + cooling coil + downstream desiccant wheel
Parallel vs. Series



parallel

cooling coil load	leaving-air conditions	outdoor air conditions
52 tons	55°F DB 46°F DPT	95°F DB 48% RH
41 tons	55°F DB 46°F DPT	72°F DB 88% RH
23 tons	55°F DB 46°F DPT	60°F DB 95% RH

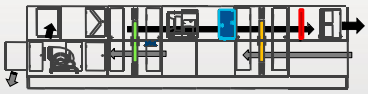
series

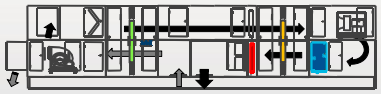
cooling coil load	leaving-air conditions
49 tons	57°F DB 46°F DPT
41 tons	55°F DB 46°F DPT
32 tons	55°F DB 46°F DPT

106 |

energy wheel + cooling coil + downstream desiccant wheel

Parallel vs. Series





desiccant wheel in parallel
- Better on mild, humid days
- Horizontal duct connections

desiccant wheel in series
- Better on hot and warm days
- Ratio of EA/OA flows < 0.9
- High external static pressures

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1) Dehumidification Duty
- Dehumidify ventilation only
- Dehumidify space (comfort)
- Dehumidify space (condensation)

2) Cooling Duty
- Neutral air
- Cool air
- Cold air

3) Efficiency Target
- Code / ASHRAE 90.1 minimum
- Higher efficiency

4) Cooling Source
- Shared chiller plant
- Dedicated chiller
- Direct expansion (DX)

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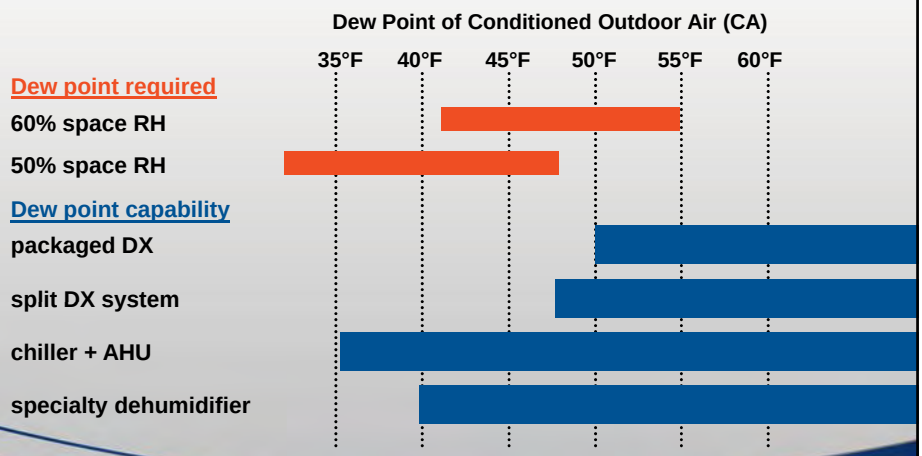
Dedicated OA Cooling Sources



109 |

considerations for

Packaged DX Dedicated OA Equipment

- Air-cooled or water-cooled condensing
- Required leaving-air dew point
  - Reheat only as much as necessary
  - Cool or cold air reduces capacity of local equipment

packaged DX
dedicated OA unit

110 |

Packaged vs. Split DX

Packaged DX Unit

- Pre-engineered
- Laboratory tested
- Smaller footprint
- Integral reheat and hot gas bypass

Split DX System

- Local design to the specific application
- Potentially long line lengths (and more refrigerant)
- Difficult reheat design
- Indoor or outdoor location
- HGBP line length
- Oil management

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DX Compressor Unloading

- Single, on/off compressor
- Single, unloading compressor (including pulsed)
- Single, variable-speed compressor
- Manifolded, on/off compressors
- Manifolded compressors, one unloading
- Manifolded compressors, one variable-speed

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ASHRAE Standard 90.1-2010

Hot Gas Bypass

"6.5.9 Hot Gas Bypass Limitation. *Cooling systems shall not use hot gas bypass or other evaporator pressure control systems unless the system is designed with multiple steps of unloading or continuous capacity modulation. The capacity of the hot gas bypass shall be limited as indicated in Table 6.5.9."*

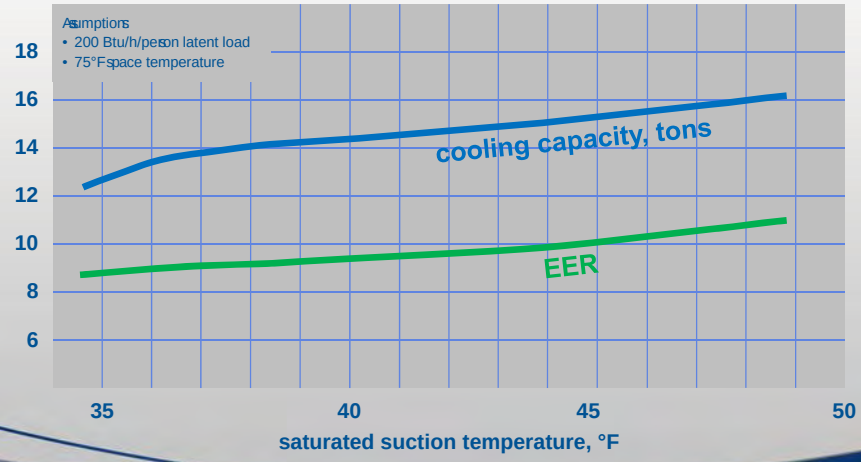
Rated Capacity	Maximum Hot Gas Bypass Capacity (% of Total Capacity)
≤240,000 Btu/h	50%
>240,000 Btu/h	25%

hot gas reheat

Refrigerant Heat Recovery

- Prudent to use recovered heat for reheat
- Deliver conditioned outdoor cold, if possible
- For a split DX system:
  - Design reheat coil for little reheat
  - Actively control head pressure
  - Pay particular attention to oil management

Split DX System Selection



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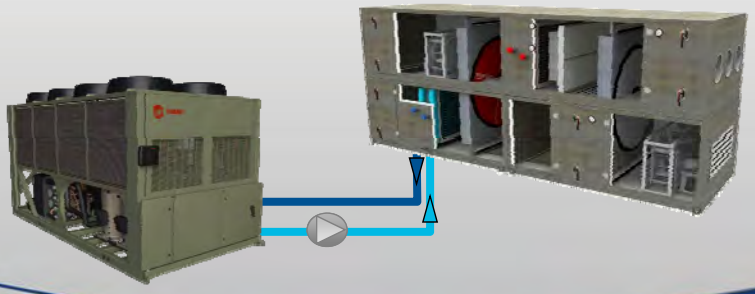
Chilled-Water DOAS

- Standalone or shared chiller
- Air-cooled or water-cooled
- Indoor or outdoor equipment



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Benefits of Chilled-Water DOAS

- Can achieve lower dew points
- Wider operating envelope
  - Especially when using variable airflow
  - DX equipment often requires hot gas bypass (energy waste)
- Greater flexibility and efficiency
  - Fans, air cleaning, energy recovery, desiccant wheel, airflow measurement, ice storage, potential to eliminate HGBP
- Certified performance
  - AHRI, UL, ETL
  - No AHRI certification for DX dedicated OA units (EER's typically not published)
- Reduced refrigerant charge

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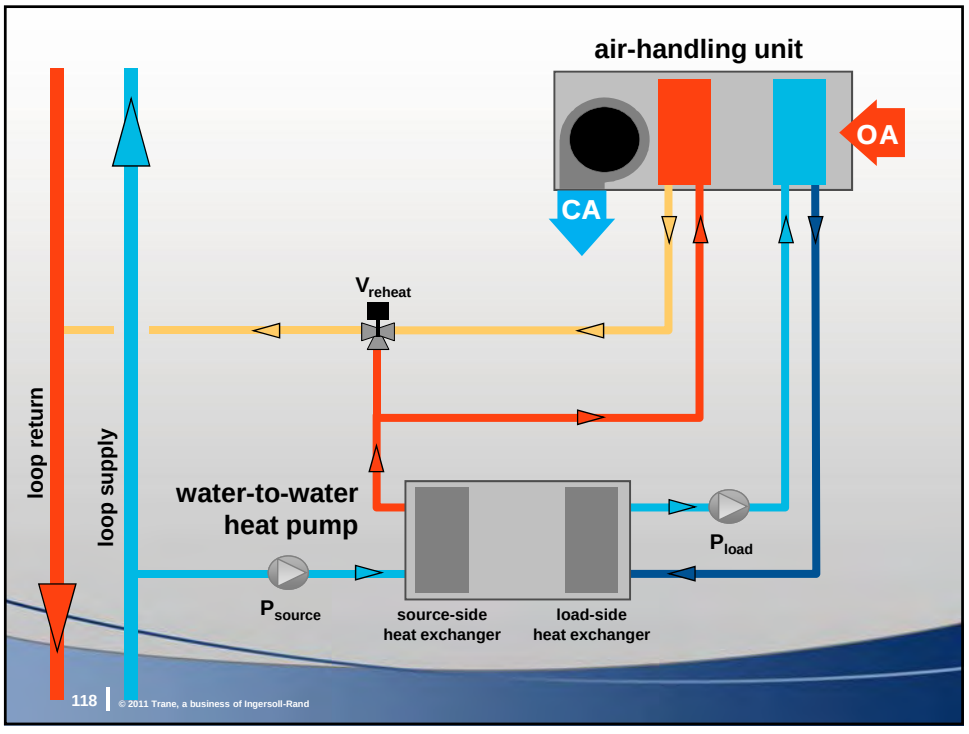

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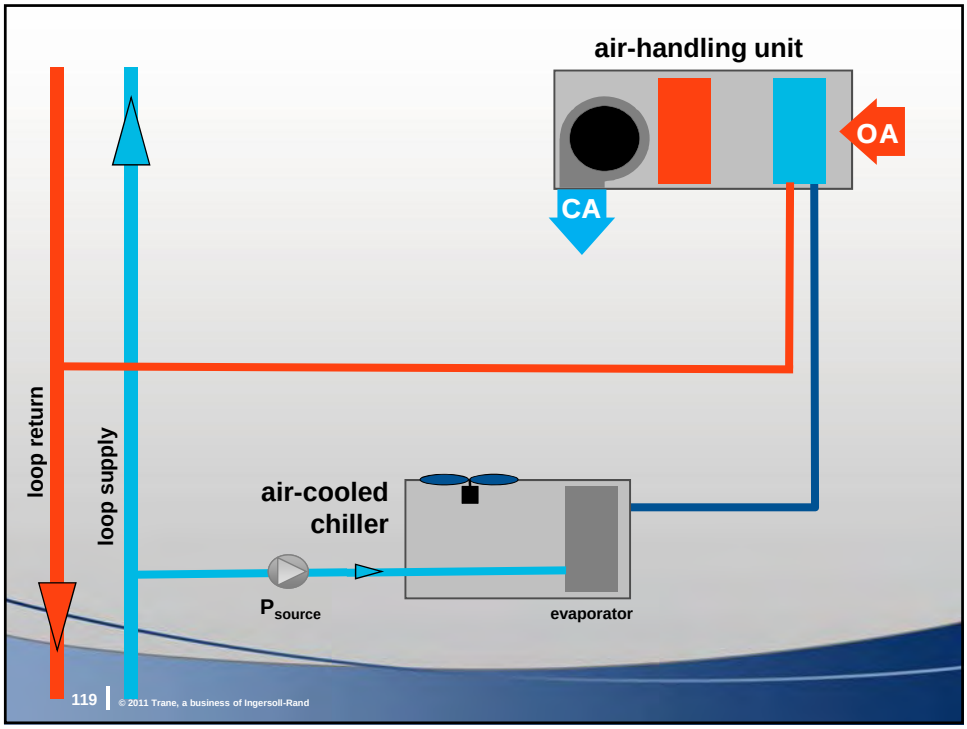
air-handling unit
OA
CA
loop return
loop supply
air-cooled
chiller
P source
evaporator
119
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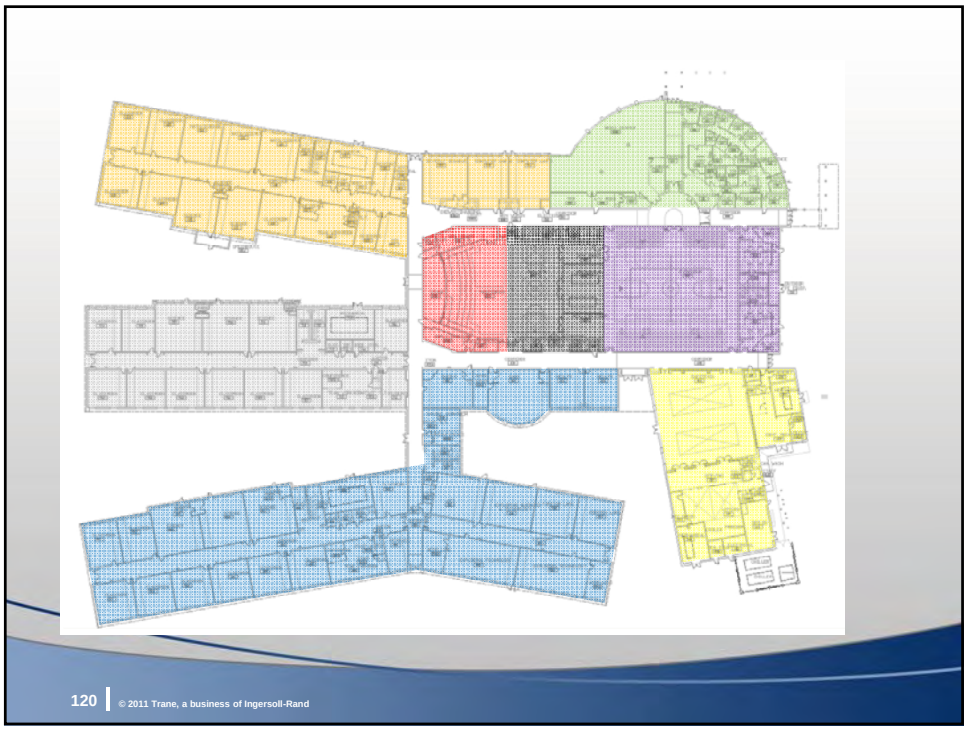
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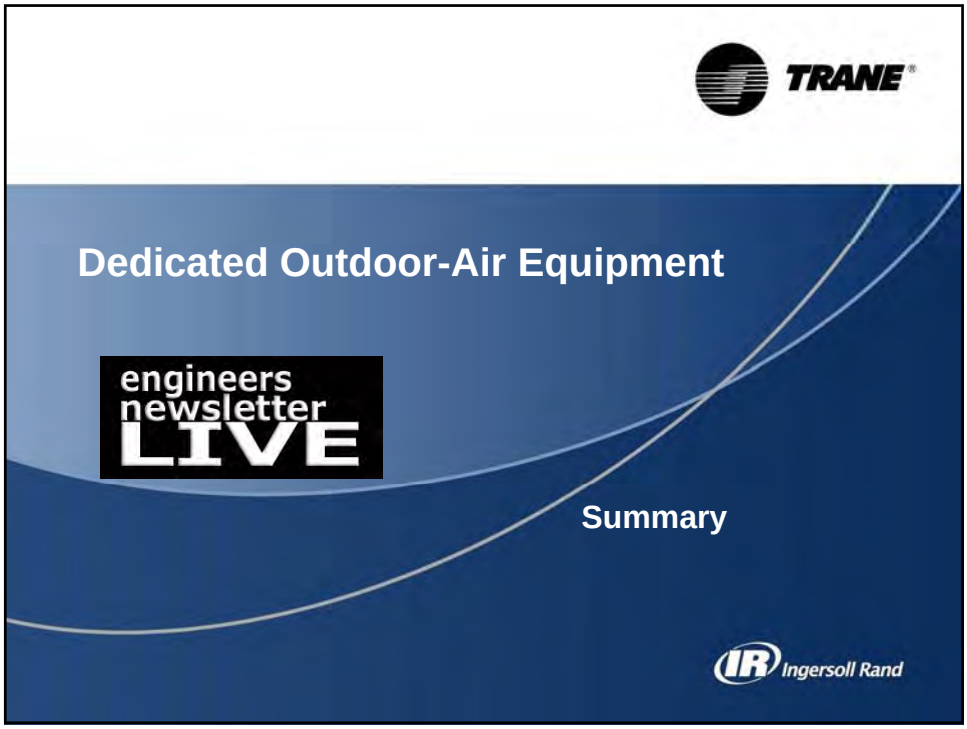
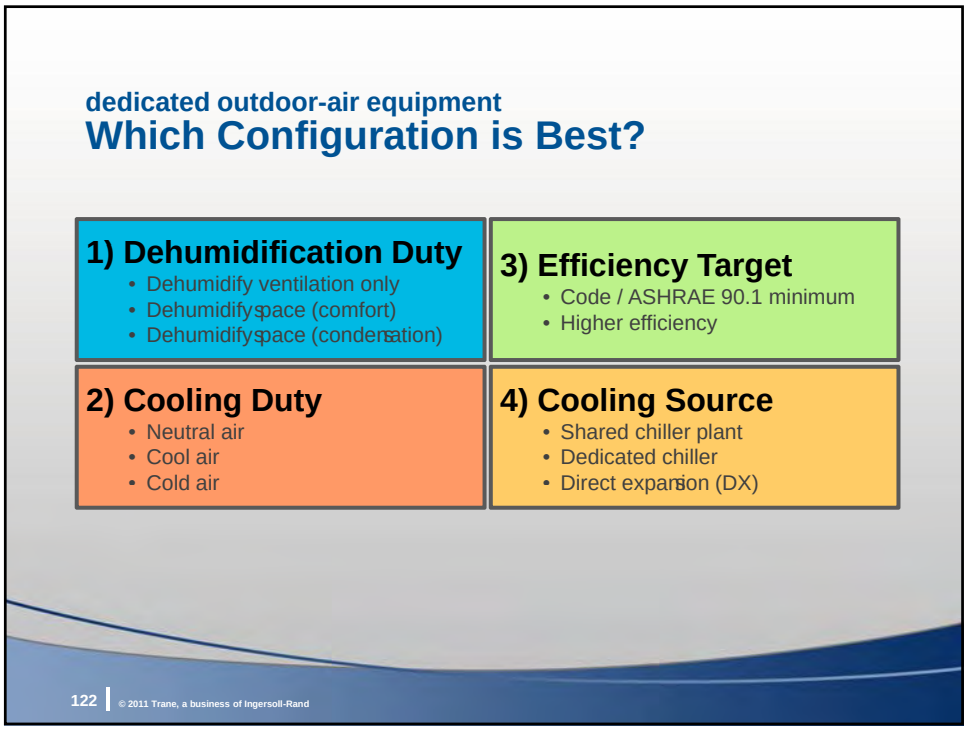


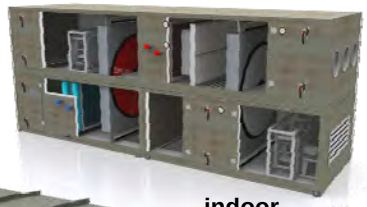


dedicated outdoor-air equipment

Which Configuration is Best?

1 + **2** + **3** + **4** = no silver bullet!

packaged DX
dedicated OA unit



indoor
air-handling unit

outdoor
air-handling unit

references for this broadcast

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- ASHRAE Standard 62.1: Ventilation Rate Procedure
- ASHRAE 90.1-2010
- Energy Saving Strategies for Rooftop VAV Systems
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Insightful topics on HVAC system design:

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- Refrigerant-to-air systems
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- Acoustics
- Ventilation
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- **March**
  High Performance Green Buildings: The Impact of ASHRAE Standard 189.1-2011
- **June**
  Heat Pump Systems
- **October**
  Air-to-Air Energy Recovery

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Dedicated Outdoor-Air Equipment

engineers newsletter LIVE

Supplemental Slides

Dedicated OA System Configurations

Conditioned OA delivered…

1. Directly to each zone
2. To intake of each local unit
3. To supply-side of each local unit
4. To ceiling plenum, near each local unit

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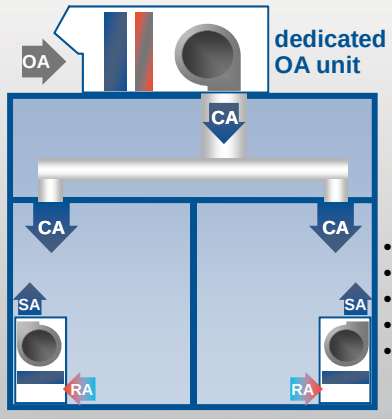
conditioned OA delivered

Directly to Each Zone



- fan-coil
- WSHP
- PTAC
- passive chilled beams
- radiant cooling panels

130

conditioned OA delivered
Directly to Each Zone

Advantages

- Easier to ensure required outdoor airflow reaches each zone (separate diffusers)
- Opportunity to cycle off local fan because OA is not distributed through it
- Allows dedicated OA system to operate during unoccupied periods without needing to operate local fans
- Opportunity to downsize local equipment (if OA delivered cold)

Drawbacks

- Requires installation of additional ductwork and separate diffusers
- May require multiple diffusers to ensure that outdoor air is adequately dispersed throughout the zone

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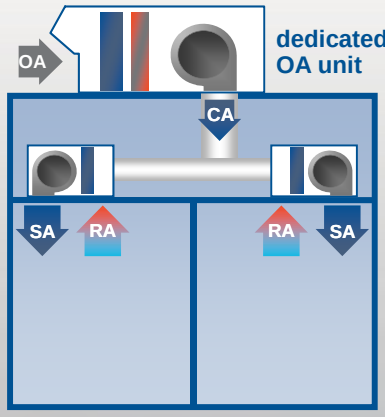
conditioned OA delivered
To Intake of Local HVAC Equipment



- fan-coil
- WSHP
- small RTU
- VRF

132

conditioned OA delivered
To Intake of Local HVAC Equipment

Advantages

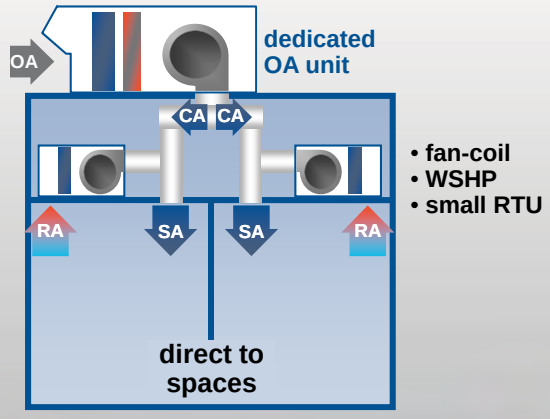
- Helps ensure required OA reaches each zone (ducted directly to each unit)
- Avoids cost and space to install additional ductwork and separate diffusers
- Easier to ensure that OA is adequately dispersed throughout zone because it is distributed by local fan

Drawbacks

- Measurement and balancing is more difficult than if OA delivered directly to zone
- Typically requires field-fabricated plenum to connect OA duct to mix with RA
- Local fan must operate continuously to provide OA during scheduled occupancy
- Local fan must operate if dedicated OA system operates during unoccupied period

133

conditioned OA delivered
To Supply-Side of Local HVAC Equipment



134

conditioned OA delivered

To Supply-Side of Local HVAC Equipment

Advantages

- Helps ensure required OA reaches each zone (ducted directly to each unit)
- Avoids cost and space to install additional ductwork and separate diffusers
- Easier to ensure that OA is adequately dispersed throughout zone because it is distributed by local fan
- Opportunity to downsize local equipment (if OA delivered cold)

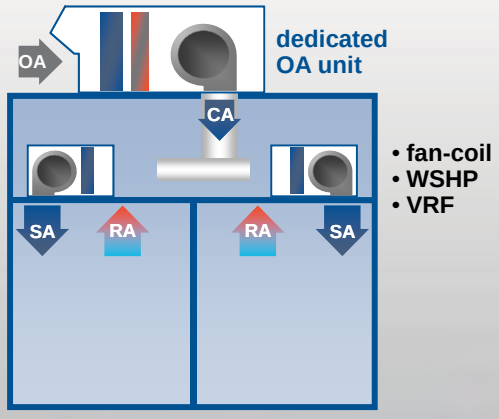
Drawbacks

- Measurement and balancing is more difficult than if OA delivered directly to zone
- Local fan typically must operate continuously to provide OA during scheduled occupancy (unless pressure-independent VAV terminal)

135

conditioned OA delivered

To Plenum, Near Local HVAC Equipment



136

conditioned OA delivered
To Plenum, Near Local HVAC Equipment

Advantages

- Avoids cost and space to install additional ductwork and separate diffusers

Drawbacks

- More difficult to ensure required OA reaches each zone (not ducted directly)
  - Refer to Figure 5-E and 5-F of *ASHRAE 62.1-2010 User's Manual*
- Local fan must operate continuously to provide OA during scheduled occupancy
- Conditioned OA not able to be delivered at a cold temperature due to concerns over condensation

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