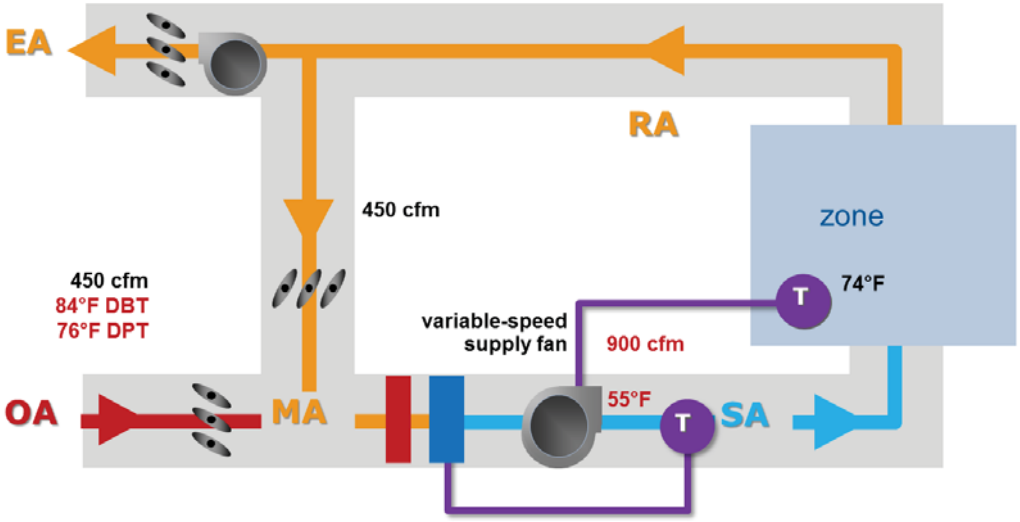
TRANE

Trane Engineers Newsletter Live

Single-Zone VAV Systems

Presenters: Eric Sturm, John Murphy, Walgreens, Jeanne Harshaw (host)



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Agenda

Trane Engineers Newsletter Live Series

Single-Zone VAV Systems

Abstract: Recent changes to ASHRAE Standard 90.1 require single-zone VAV in some applications. This ENL will review these new requirements, discuss the benefits of single-zone VAV systems (energy savings, better part-load dehumidification, and lower part-load sound levels), identify common applications for this system, and discuss ways to address application-related challenges (air distribution, ventilation, and building pressure control). In addition, we intend to review a case study of a retrofit project where a constant-volume rooftop unit was replaced with a single-zone VAV unit.

Presenters: Trane applications engineers John Murphy and Eric Sturm
Guest: Hakim Yala, Walgreen's and Nirmal Sekhri, Trane National Accounts

What you will learn:

- Summarize the potential benefits of a single-zone VAV system
- Identify recent changes to ASHRAE Standard 90.1 that require either two-speed or variable-speed fan control in many single-zone systems
- Summarize some common challenges of applying a single-zone VAV system
- Apply design and control strategies to address these challenges

Agenda

1) ASHRAE Standard 90.1 requirements
   a) Summary of requirements
   b) California Title 24
2) System operation
   a) Single zone versus Constant volume system
   b) Review of single-zone control sequences (variable speed, two-speed fans)
   c) Typical application
   d) Implementation in various system types of equipment (pkgd rooftop, AHUs, DX split, WSHP, fan coils)
3) Ventilation control strategies
   a) Demonstarte the need for OA damper control
   b) Two-position OA damper (for two-speed fan control)
   c) OA compensation (OA damper proportional to fan speed)
   d) Traq damper
   e) DOAS direct to zones (fan-coils, WSHPs)
   f) CO2-based DCV (control sequence and setpoints)
4) Benefits
   a) Part-load energy savings (fan, cooling?)
   b) Better part-load dehumidification
   c) Lower part-load sound levels
5) Challenges and solutions
6) Interview with Walgreens

Presenter biographies

Trane Engineers Newsletter Live Series

Single-Zone VAV Systems

Eric Sturm | applications engineer | Trane

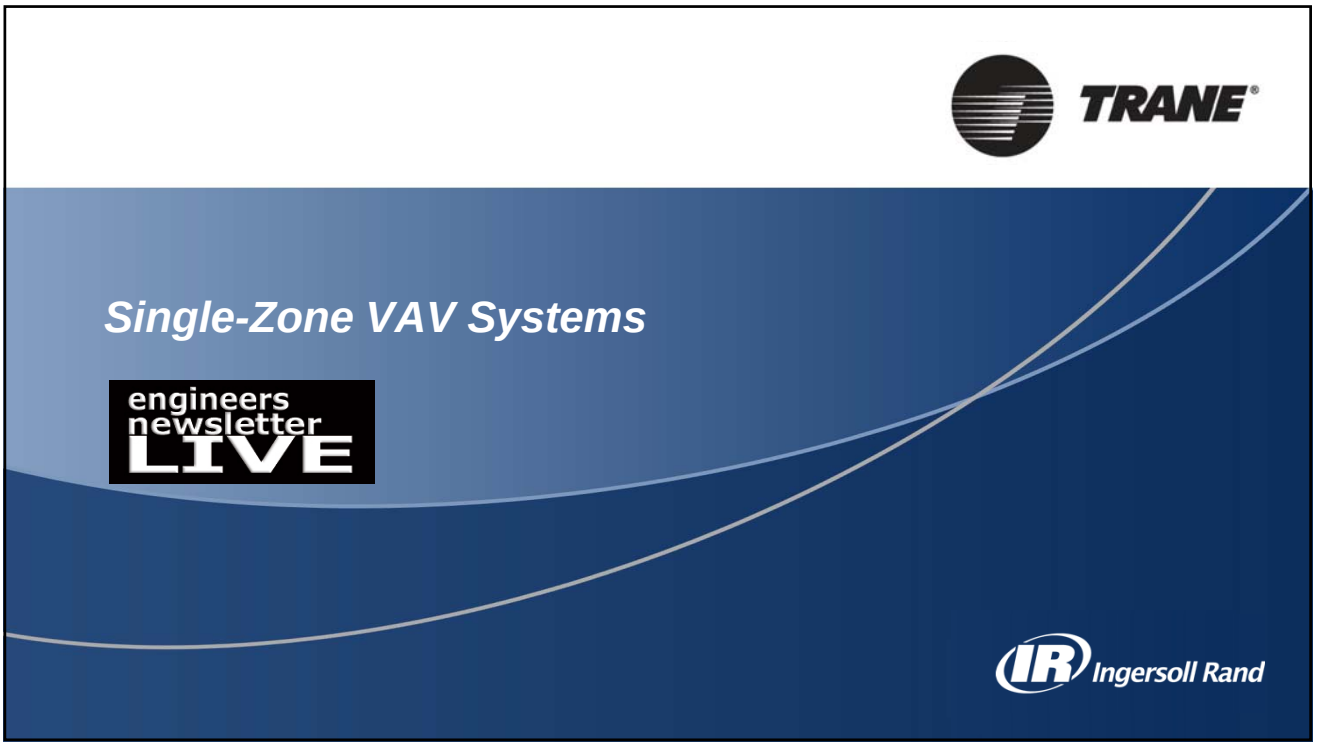
Eric joined Trane in 2006 after graduating from the University of Wisconsin-Platteville with a bachelor's of science degree in mechanical engineering. Prior to joining the applications engineering team, Eric worked in the Customer Direct Services (C.D.S.) department as a marketing engineering where he trained and supported computer applications provided by Trane. From 2007 to 2012, Eric managed the TRACE™ 700 application.

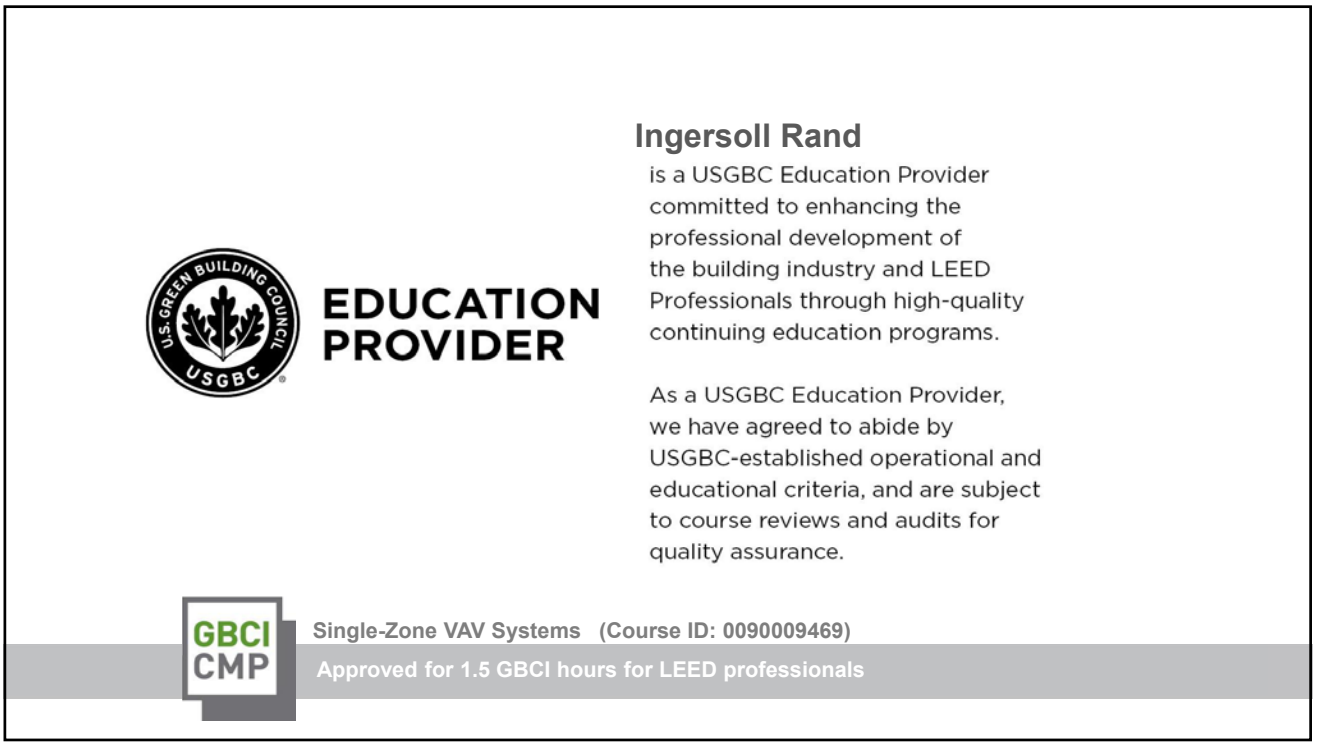
Eric is currently involved with ASHRAE at the local and national levels serving as a member of the Standard 140 and 205 committees.

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. He also is a member of ASHRAE, has authored several articles for the ASHRAE Journal, and has been 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, 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.





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learning objectives

After today's program you will be able to:

- Summarize the potential benefits of a single-zone VAV system
- Identify recent changes to ASHRAE Standard 90.1 that require either two-speed or variable-speed fan control in many single-zone systems
- Summarize some common challenges of applying a single-zone VAV system
- Apply design and control strategies to address these challenges

Today's Presenters

John Murphy
Applications Engineer

Eric Sturm
Applications Engineer

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Agenda

- ASHRAE Standard 90.1 requirements
- Single-zone VAV systems
  - System operation
  - Typical benefits
  - Application considerations
- Case study: Walgreens

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Agenda

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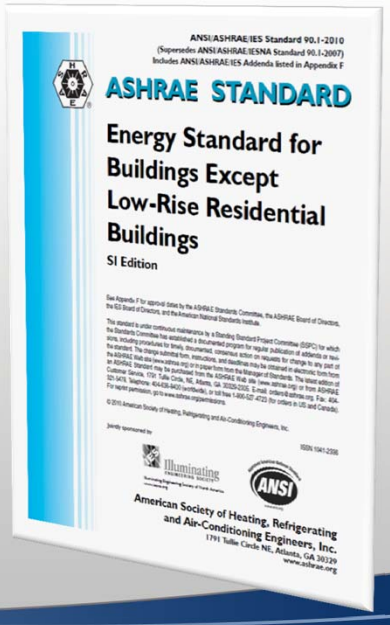
Single-zone VAV systems

- ASHRAE Standard 90.1 requirements
- System operation
- Typical benefits
- Application considerations
- Case study

ASHRAE Standard 90.1

- Requirements for single-zone VAV control added in 2010 edition
- U.S. DOE requires states to update their commercial energy codes to meet or exceed 90.1-2010 by October 18, 2013



heating, ventilating, and air conditioning

Section 6.0

6.1 General
6.2 Compliance Paths
6.3 Simplified Approach Option for HVAC Systems
6.4 Mandatory Provisions
6.5 Prescriptive Path

ASHRAE 90.1-2010, Section 6.4.3.10

Single Zone Variable-Air-Volume Controls

HVAC systems shall have variable airflow controls as follows:

a. Air-handling and fan-coil units with chilled-water cooling coils and supply fans with motors greater than or equal to 5 hp shall have their supply fans controlled by two-speed motors or variable-speed drives. At cooling demands less than or equal to 50%, the supply fan controls shall be able to reduce the airflow to no greater than the larger of the following:
    1. One half of the full fan speed, or
    2. The volume of outdoor air required to meet the ventilation requirements of Standard 62.1

ASHRAE 90.1-2010, Section 6.4.3.10
Single Zone Variable-Air-Volume Controls

b. Effective January 1, 2012, all air-conditioning equipment and air-handling units with direct expansion cooling and a cooling capacity at AHRI conditions greater than or equal to 110,000 Btu/h that serve single zones shall have their supply fans controlled by two-speed motors or variable-speed drives.
At cooling demands less than or equal to 50%, the supply fan controls shall be able to reduce the airflow to no greater than the larger of the following:
   1. Two-thirds of the full fan speed, or
   2. The volume of outdoor air required to meet the ventilation requirements of Standard 62.1.

ASHRAE 90.1-2010, Section 6.4.3.10
Single Zone Variable-Air-Volume Controls

- Chilled-water cooling coils
  - Two-speed or variable-speed motor control required for fans ≥ 5 hp
  - At cooling demands ≤ 50%, reduce airflow to:
    - One-half of airflow delivered at full fan speed
    - Minimum outdoor air per ASHRAE Standard 62.1 ventilation requirement

Standard 90.1-2010 User's Manual

"In this section of the Standard, the term 'cooling demand' refers to the zone sensible cooling load. That is, when the zone sensible cooling load decreases to 50% of the design sensible cooling load for the zone, the supply fan controls shall have reduced airflow to the threshold described above." (page 6-37)

ASHRAE 90.1-2010, Section 6.4.3.10
Single Zone Variable-Air-Volume Controls

- Direct expansion cooling coils
  - Required when capacity ≥ 110,000 Btu/h (9.17 tons)
  - Two-speed or variable-speed motor control required
  - At cooling demands ≤ 50%, reduce airflow to:
    - Two-thirds of airflow delivered at full fan speed
    - Minimum outdoor air per ASHRAE Standard 62.1 ventilation requirement

2008 California Energy Code, Section 144 (L)
VAV Control for Single Zone Systems

- Unitary and air-handling units
  - Required when capacity ≥ 110,000 Btu/h (9.17 tons)
  - Two-speed or variable-speed motor control required
  - At low cooling demands, reduce speed to:
    - Two-thirds fan speed, or lower

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2010 California Energy Code, Section 144 (L)
VAV Control for Single Zone Systems

(L) Variable air volume control for single zone systems. Effective January 1, 2012 all unitary air conditioning equipment and air-handling units with mechanical cooling capacity at ARI conditions greater than or equal to 110,000 Btu/h that serve single zones shall be designed for variable supply air volume with their supply fans controlled by two-speed motors, variable speed drives, or equipment that has been demonstrated to the Executive Director to use no more energy. The supply fan controls shall modulate down to a minimum of ⅔ of the full fan speed or lower at low cooling demand.

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Single-zone VAV systems

- ASHRAE Standard 90.1 requirements
- System operation
- Typical benefits
- Application considerations
- Case study

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What is Single-Zone VAV?

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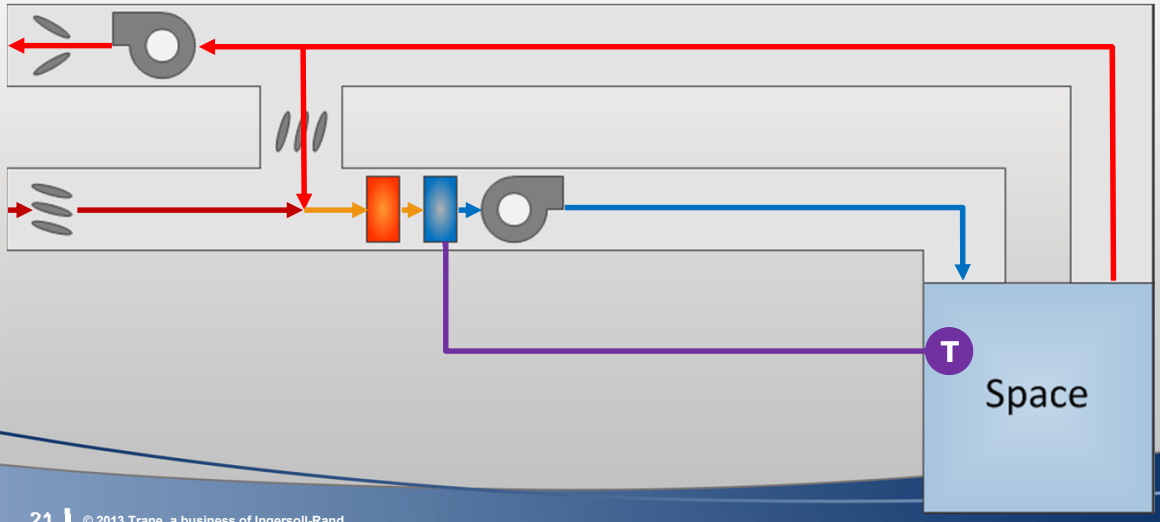
Simple Single-Zone CV System Diagram



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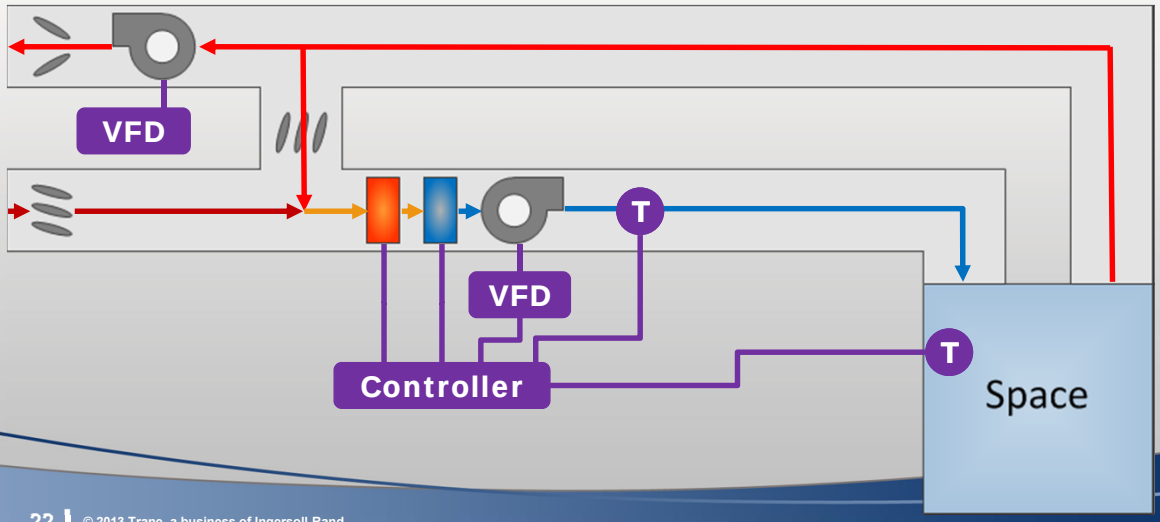
Single-Zone VAV System Diagram



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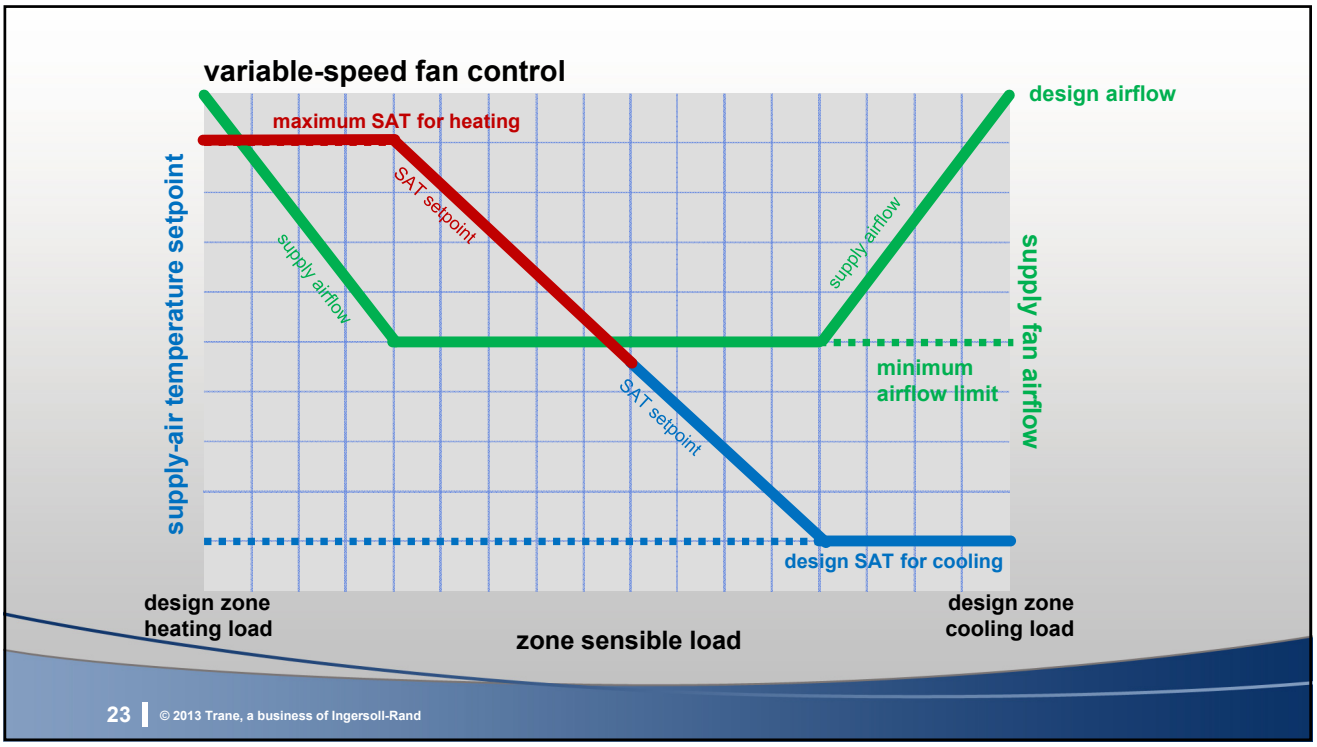
variable-speed fan control
maximum SAT for heating
SAT setpoint
supply airflow
supply airflow
SAT setpoint
design airflow
supply airflow
minimum
airflow limit
supply fan airflow
design SAT for cooling
supply-air temperature setpoint
design zone
heating load
zone sensible load
design zone
cooling load
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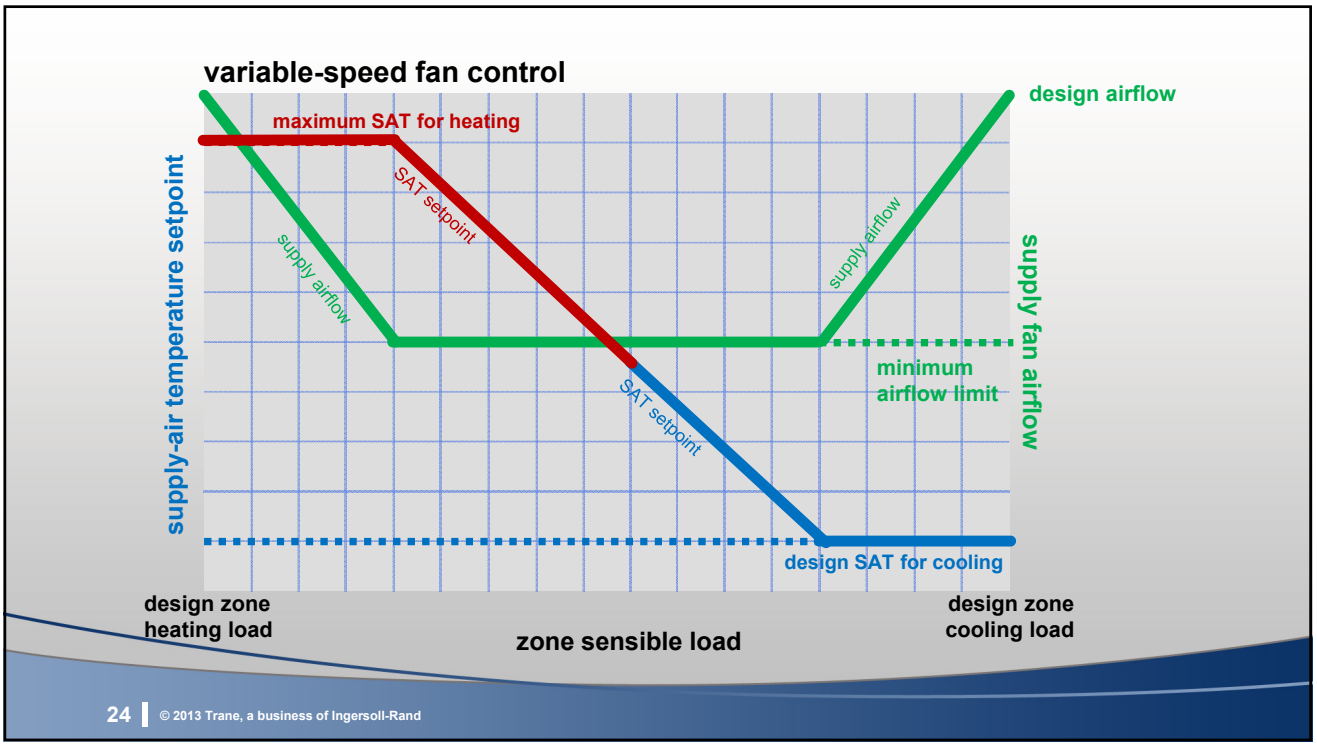
variable-speed fan control
maximum SAT for heating
SAT setpoint
supply airflow
supply airflow
SAT setpoint
design airflow
supply airflow
minimum
airflow limit
supply fan airflow
design SAT for cooling
supply-air temperature setpoint
design zone
heating load
zone sensible load
design zone
cooling load
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SZVAV with variable-speed fan

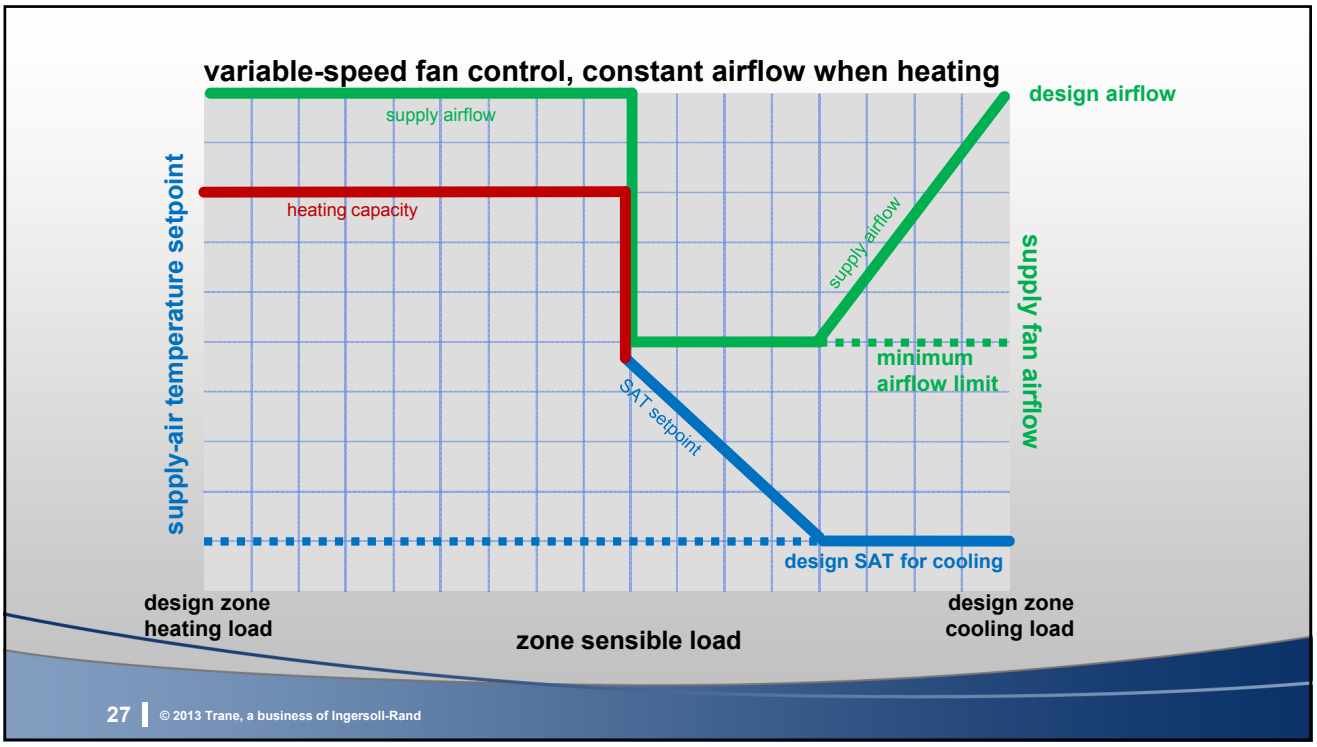
Minimum Airflow Limit

- Might be determined by
  - How far VFD or ECM can be turned down
  - Other air distribution or ventilation requirement
- To comply with ASHRAE Standard 90.1
  - Must be ≤ one half of design airflow for chilled-water cooling
  - Must be ≤ two-thirds of design airflow for DX cooling
  - Equal to outdoor airflow required by ASHRAE 62.1, if higher

SZVAV with variable-speed fan

Maximum SAT for Heating

- Might be determined by
  - Equipment manufacturer, for safety or reliability reasons
  - Desire to limit stratification when supplying hot air from overhead diffusers with overhead return grilles
- Requires a discharge-air temperature sensor


variable-speed fan control, constant airflow when heating
supply airflow
heating capacity
supply airflow
minimum airflow limit
SAT setpoint
design SAT for cooling
design airflow
supply fan airflow
supply-air temperature setpoint
design zone heating load
zone sensible load
design zone cooling load
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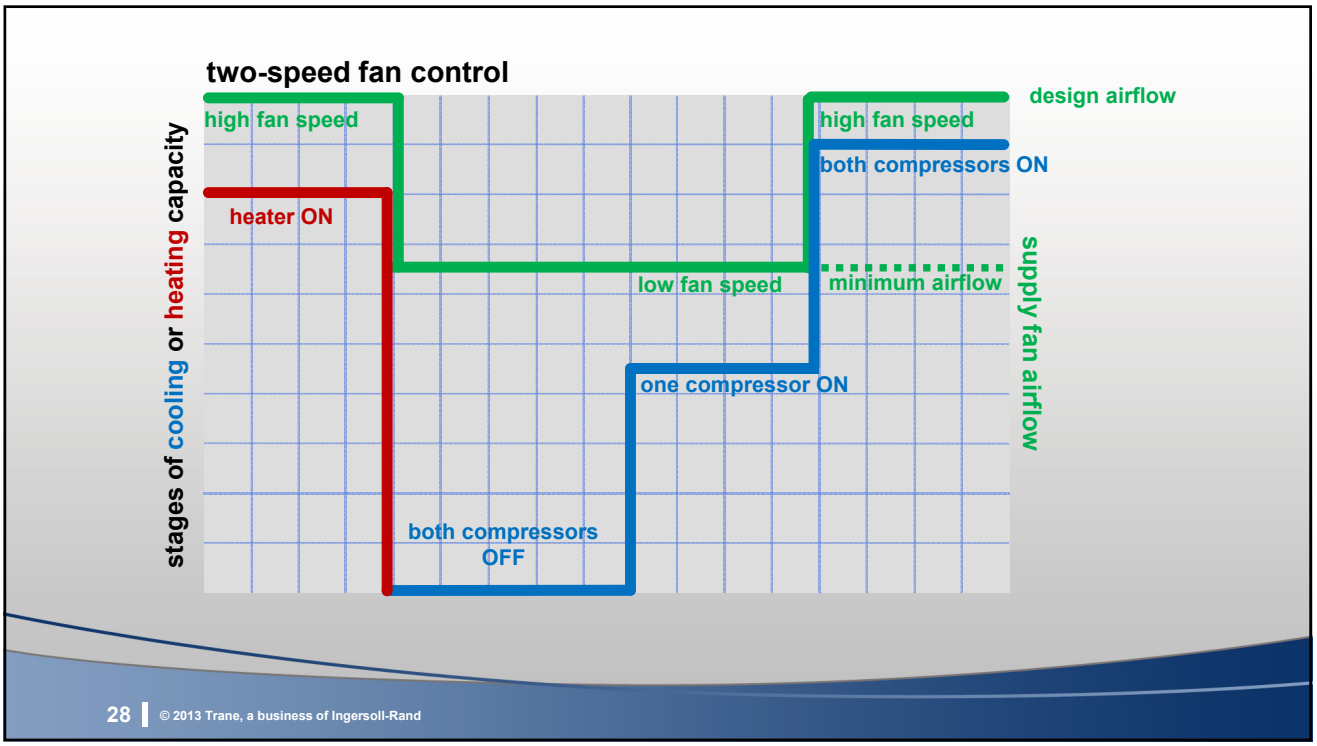
two-speed fan control
high fan speed
heater ON
high fan speed
both compressors ON
low fan speed
minimum airflow
one compressor ON
both compressors OFF
design airflow
supply fan airflow
stages of cooling or heating capacity
28
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SZVAV with two-speed fan
Minimum Airflow at Low Fan Speed

- Might be determined by
  - Equipment manufacturer, for safety or reliability reason
  - Other air distribution or ventilation requirement
- To comply with ASHRAE 90.1
  - Must be ≤ one half of design airflow for chilled-water cooling
  - Must be ≤ two-thirds of design airflow for DX cooling
  - Equal to outdoor airflow required by ASHRAE 62.1, if higher

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Typical Applications for SZVAV

Traditional
- Gymnasiums
- Cafeterias
- Lecture halls
- Auditoriums
- Meeting rooms
- Churches
- Arenas

More recently
- K-12 classrooms
- Retail stores
- Dormitories or barracks
- Offices

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Types of SZVAV Equipment

Traditional

- Air-handling units
- Large packaged rooftops

More recently

- Small packaged rooftops
- DX split systems
- Fan-coil units
- Classroom unit ventilators
- Water-source heat pumps

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Agenda

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Single-zone VAV systems

- ASHRAE Standard 90.1 requirements
- System operation
  - Ventilation control
- Typical benefits
- Application considerations
- Case study

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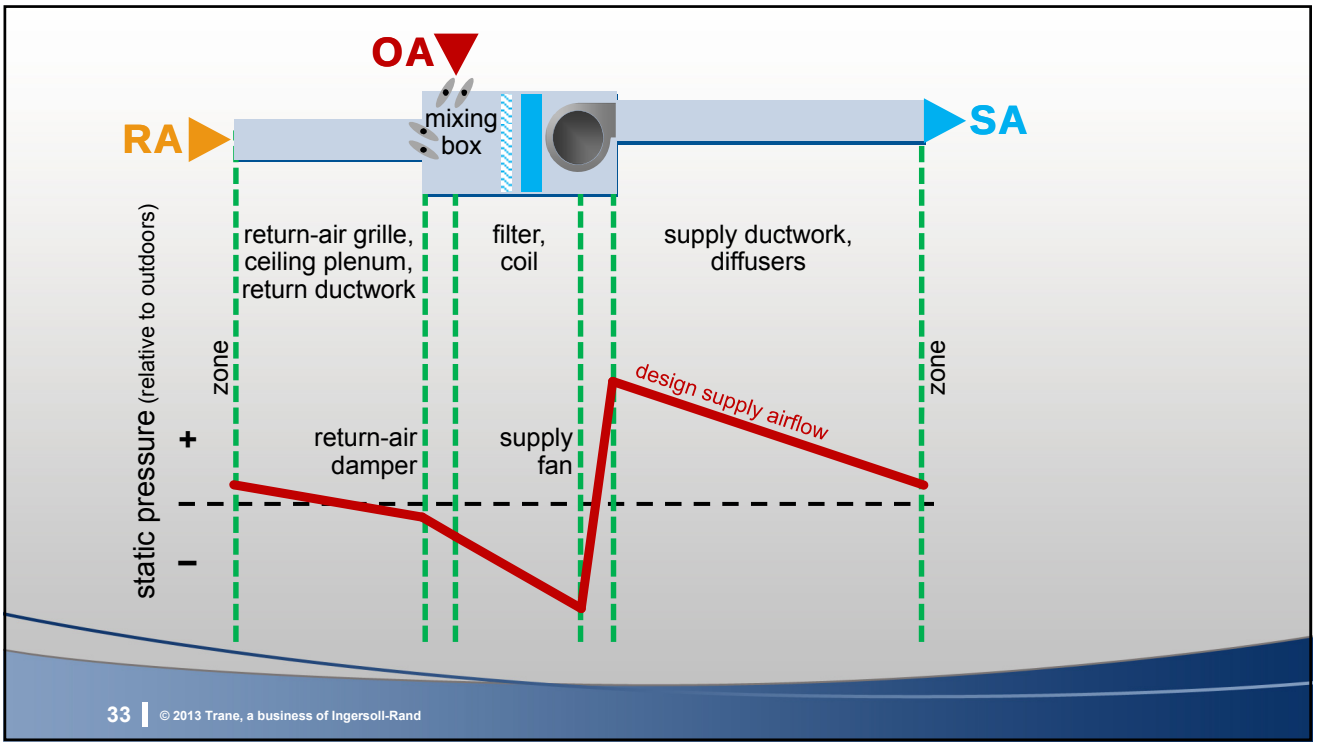
OA
RA
SA
mixing box
return-air grille, ceiling plenum, return ductwork
filter, coil
supply ductwork, diffusers
static pressure (relative to outdoors)
zone
zone
+
–
return-air damper
supply fan
design supply airflow
33
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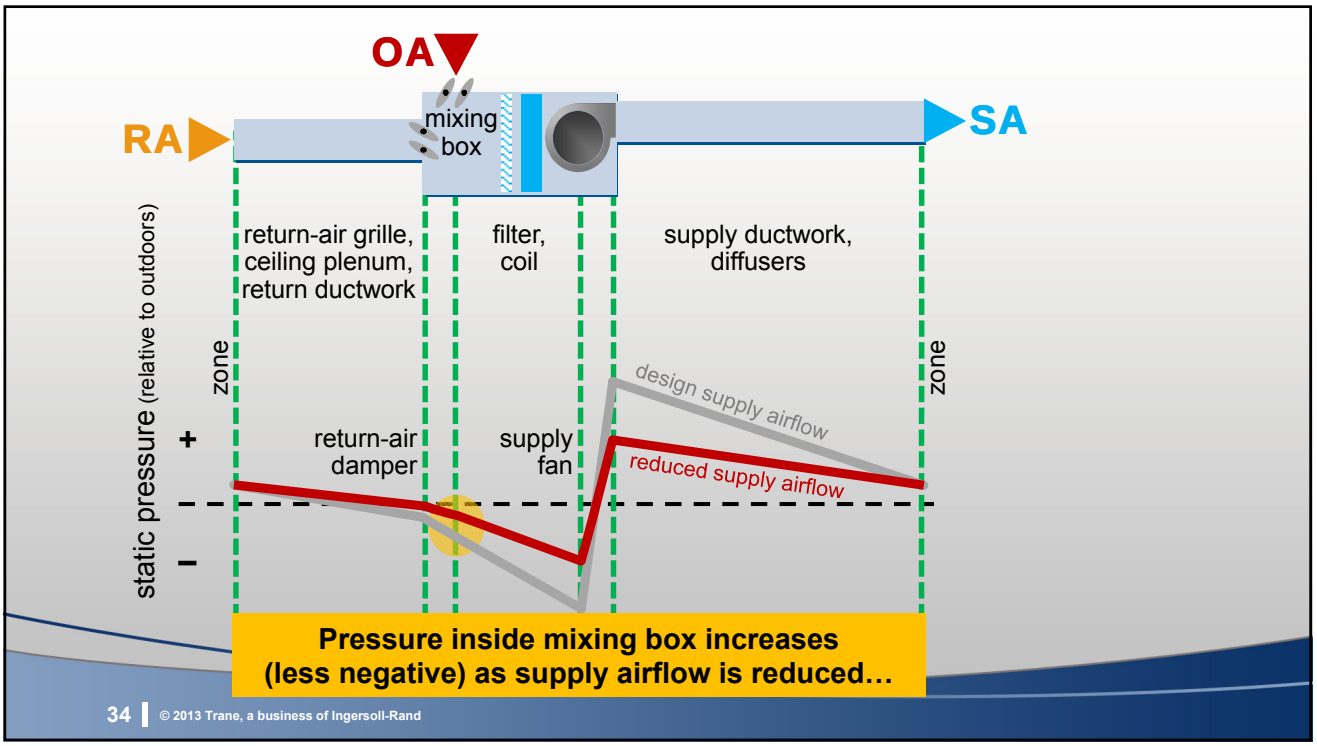
OA
RA
SA
mixing box
return-air grille, ceiling plenum, return ductwork
filter, coil
supply ductwork, diffusers
static pressure (relative to outdoors)
zone
zone
+
–
return-air damper
supply fan
design supply airflow
reduced supply airflow
Pressure inside mixing box increases (less negative) as supply airflow is reduced…
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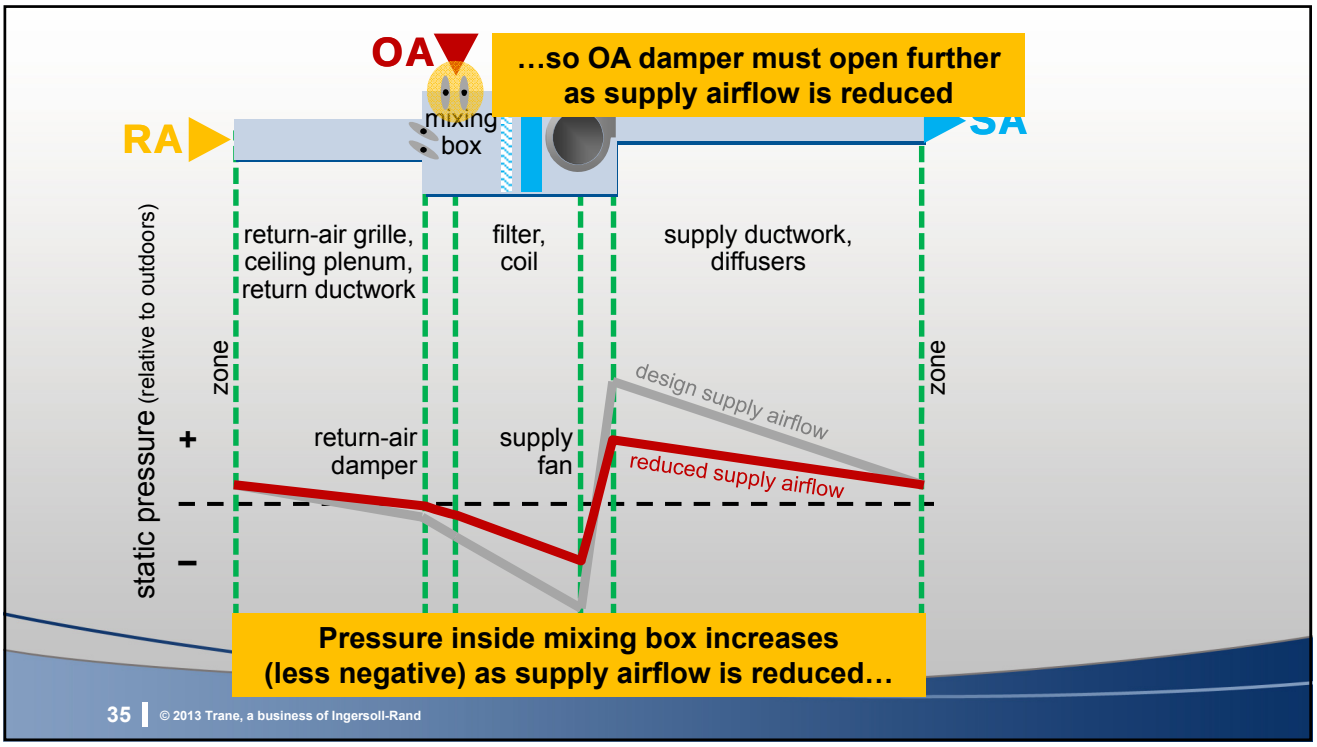
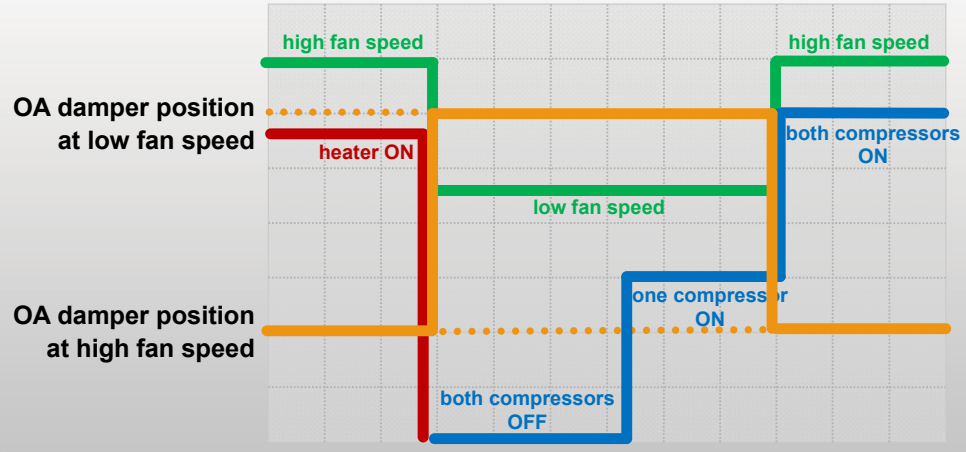


single-zone VAV
Ventilation Control Strategies

- Two-position OA damper for two-speed fan control

Two-Position Control of OA Damper



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single-zone VAV
Ventilation Control Strategies

- Two-position OA damper for two-speed fan control
- Modulate OA damper position proportional to fan speed

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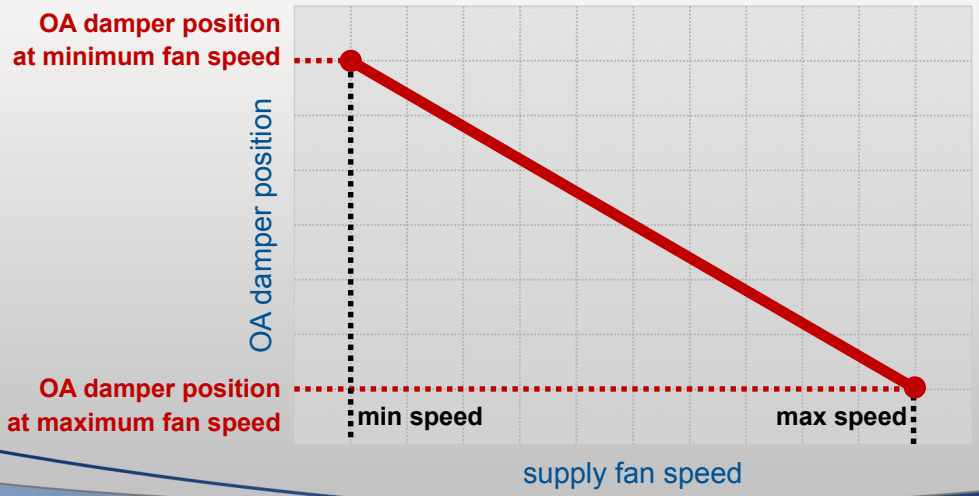
Proportional Control of OA Damper



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ASHRAE Standard 62.1-2010

"The system shall be designed to maintain no less than the minimum outdoor airflow as required by Section 6 under any load condition.

***Note:** Variable Air Volume (VAV) systems with fixed outdoor air damper positions must comply with this requirement at minimum system primary airflow."*

Section 5.3

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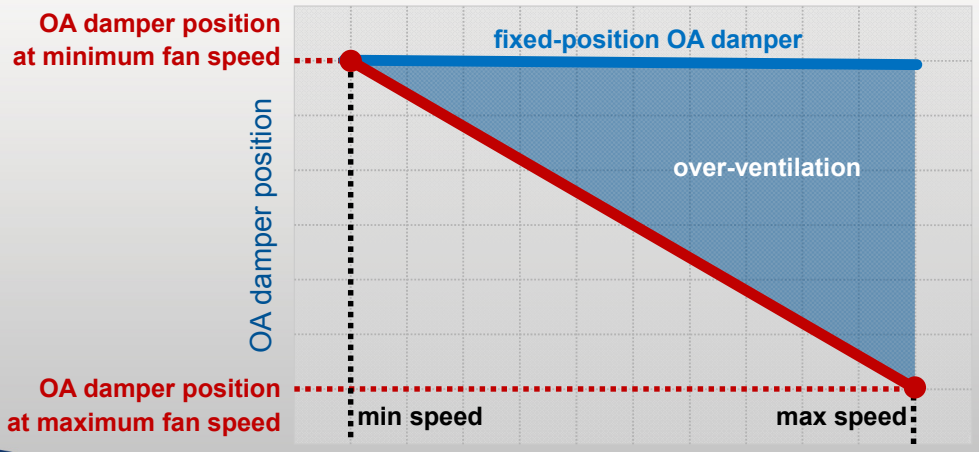
Proportional Control of OA Damper



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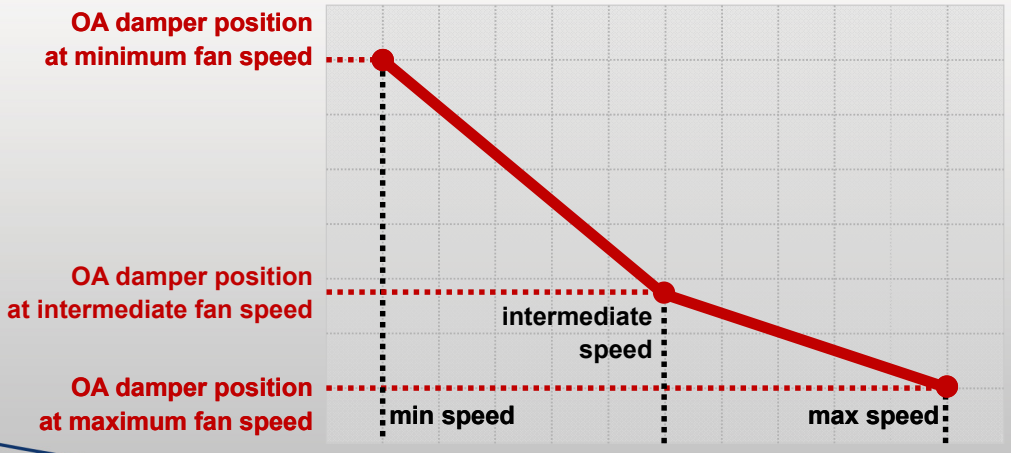
Proportional Control of OA Damper



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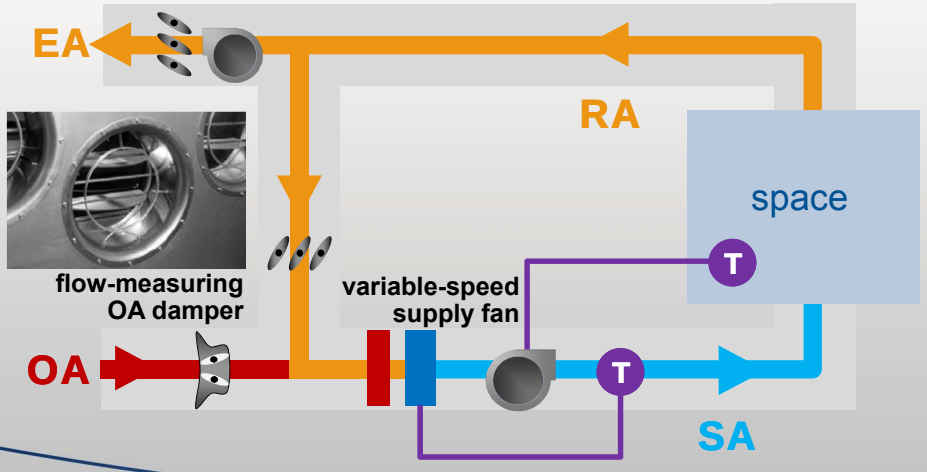
single-zone VAV

Ventilation Control Strategies

- Two-position OA damper for two-speed fan control
- Modulate OA damper position proportional to fan speed
- Flow-measuring OA damper

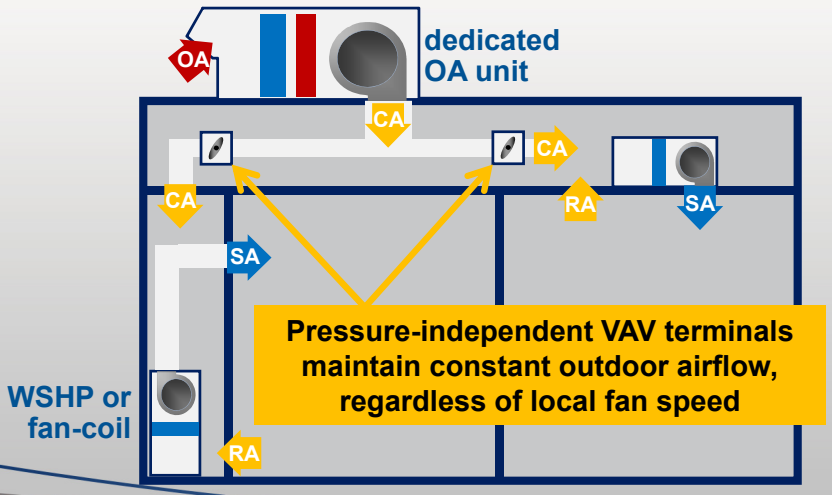
Flow-Measuring OA Damper



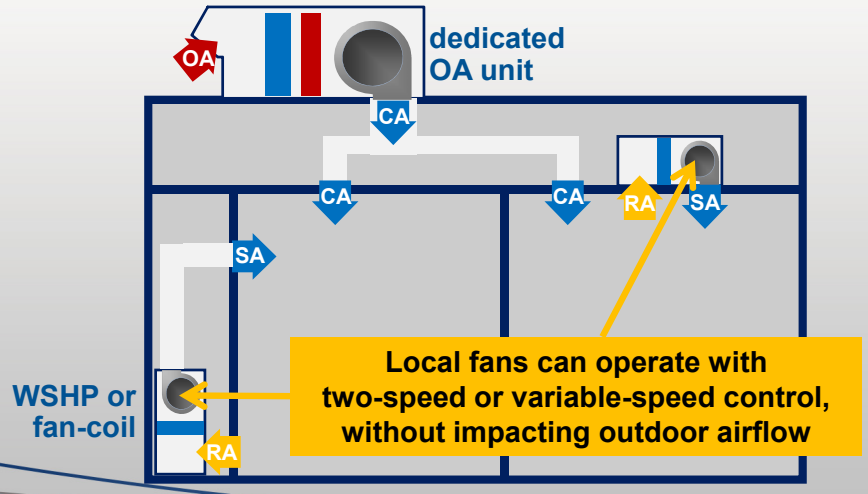
single-zone VAV
Ventilation Control Strategies

- Two-position OA damper for two-speed fan control
- Modulate OA damper position proportional to fan speed
- Flow-measuring OA damper

conditioned OA delivered
To Inlet of Each Local Unit



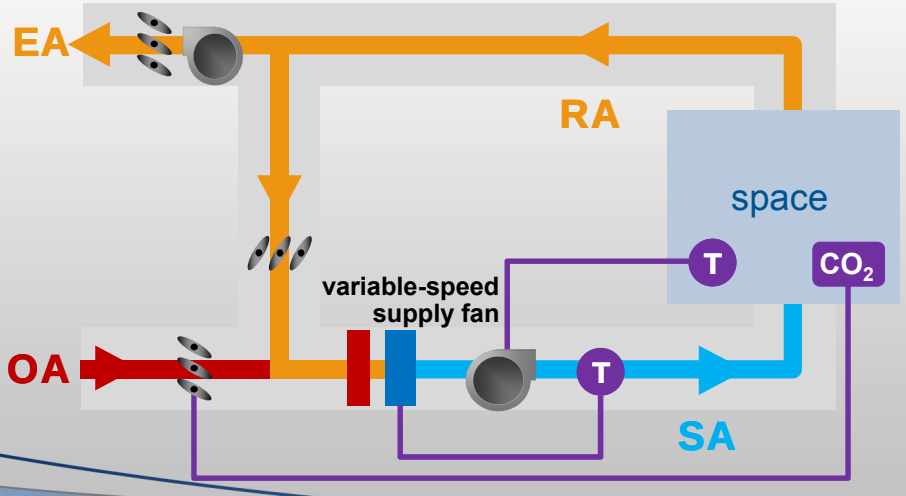
conditioned OA delivered
Directly to Each Zone



single-zone VAV
Ventilation Control Strategies

- Two-position OA damper for two-speed fan control
- Modulate OA damper position proportional to fan speed
- Flow-measuring OA damper
- Deliver conditioned OA directly to each zone, if using a dedicated OA system

CO_2-based DCV



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ASHRAE Standard 62.1-2010

"The breathing zone outdoor airflow shall be reset in response to current occupancy and shall be no less than the building component ($R_a \times A_z$) of the zone."

Section 6.2.7.1

"Systems shall be operated such that spaces are ventilated in accordance with Section 6 when they are expected to be occupied."

Section 8.3

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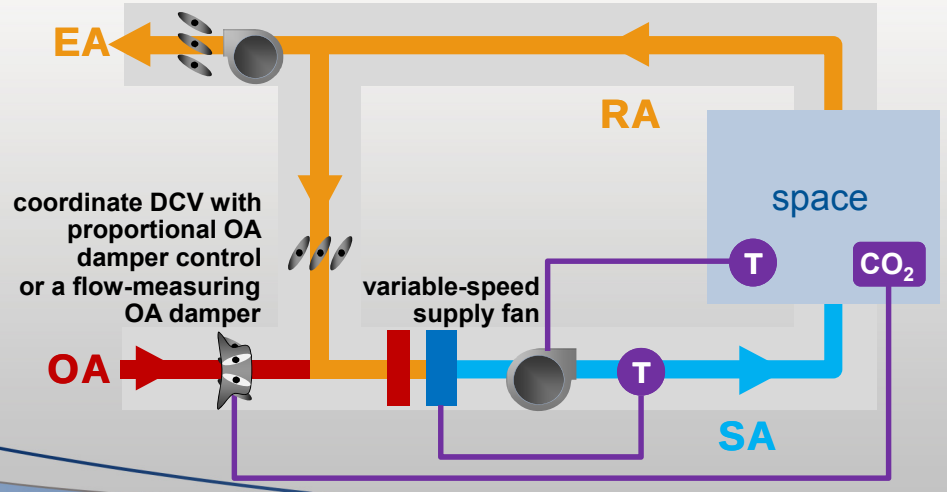
CO_2-based DCV



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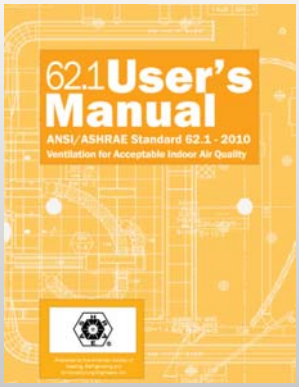
implementing DCV in single-zone systems
ASHRAE 62.1 User's Manual



Example: University lecture classroom

- Floor area (A_z) = 1000 ft^2
- Peak population (P_z) = 65 people
- CO_2 generation rate (N) = 0.0105 cfm/person (light office work)

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implementing DCV in single-zone systems
ASHRAE 62.1 User's Manual

1) Calculate breathing-zone outdoor airflow (V_{bz}) for both design population, and with zero people

V_{bz} $= R_p \times P_z + R_a \times A_z$

$V_{bz\text{-}design}$ $= 7.5 \times \mathbf{65} + 0.06 \times 1000 = 550$ cfm

$V_{bz\text{-}zero}$ $= 7.5 \times \mathbf{0} + 0.06 \times 1000 = 60$ cfm

implementing DCV in single-zone systems
ASHRAE 62.1 User's Manual

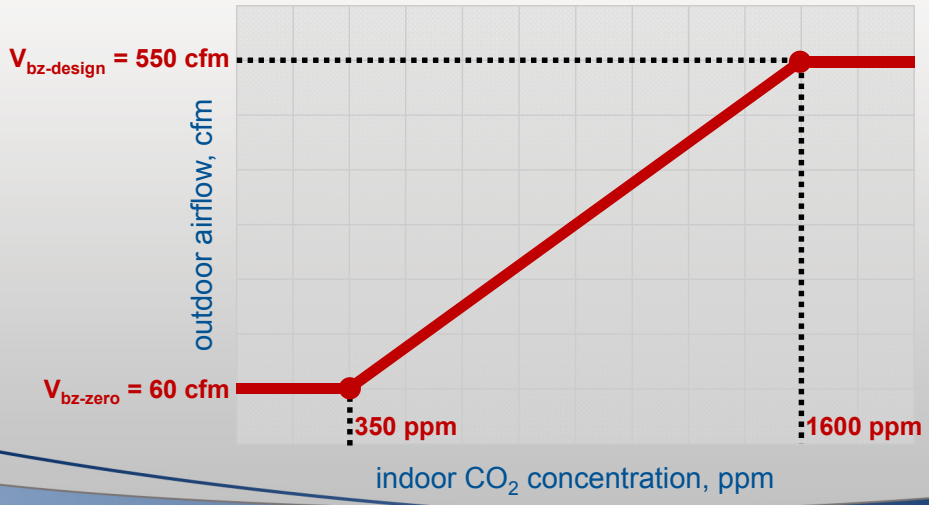
2) Calculate steady-state indoor CO_2 concentration (C_{bz}) for both design population, and with zero people

C_{bz} $= C_{oa} + N \times P_z / V_{bz}$

$C_{bz\text{-}design}$ $= 350 + 0.0105 \times \mathbf{65}$ people / 550 cfm $= 1600$ ppm

$C_{bz\text{-}zero}$ $= 350 + 0.0105 \times \mathbf{0}$ people / 60 cfm $= 350$ ppm

implementing DCV in single-zone systems
ASHRAE 62.1 User's Manual



Agenda

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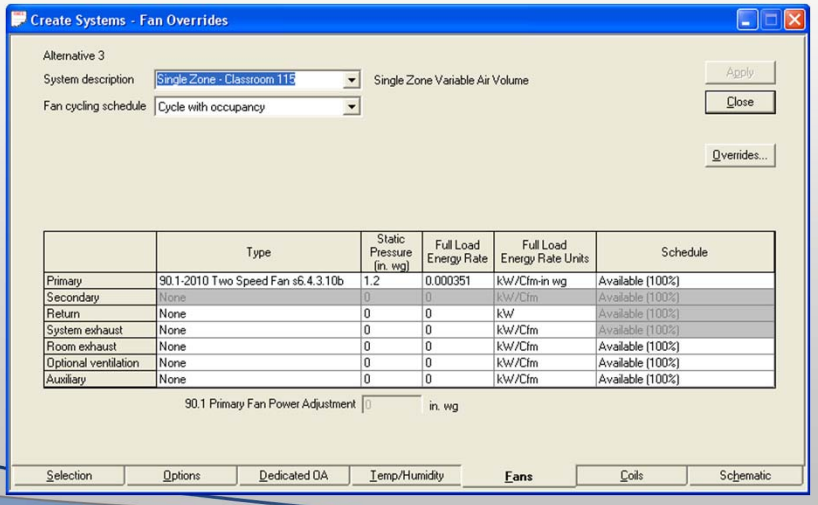
Single-zone VAV systems
- ASHRAE Standard 90.1 requirements
- System operation
- Typical benefits
- Application considerations
- Case study

Part-Load Energy Savings

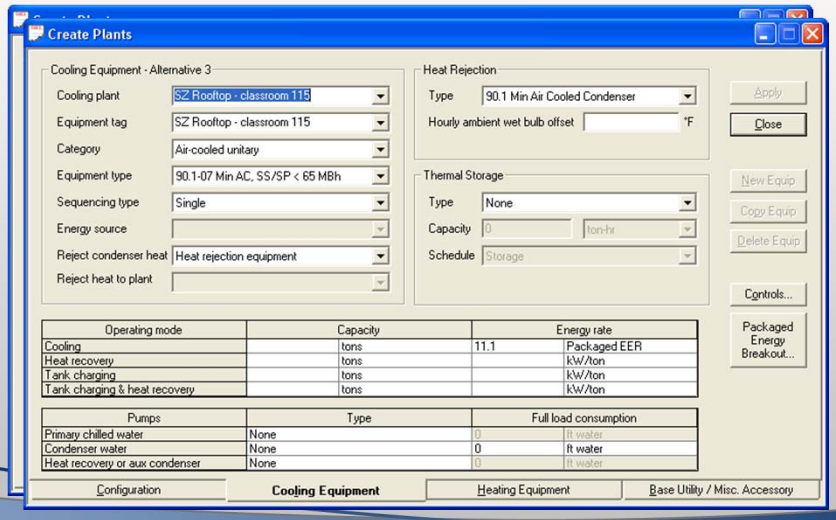
- Supply fans
- Exhaust/relief fans
- Compressors

example TRACE™ 700 analysis

Input Screenshots – Create Systems



example TRACE™ 700 analysis
Input Screenshots – Create Plants

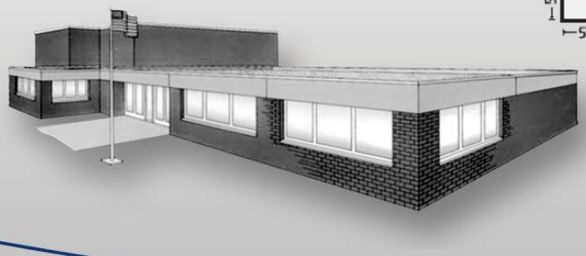


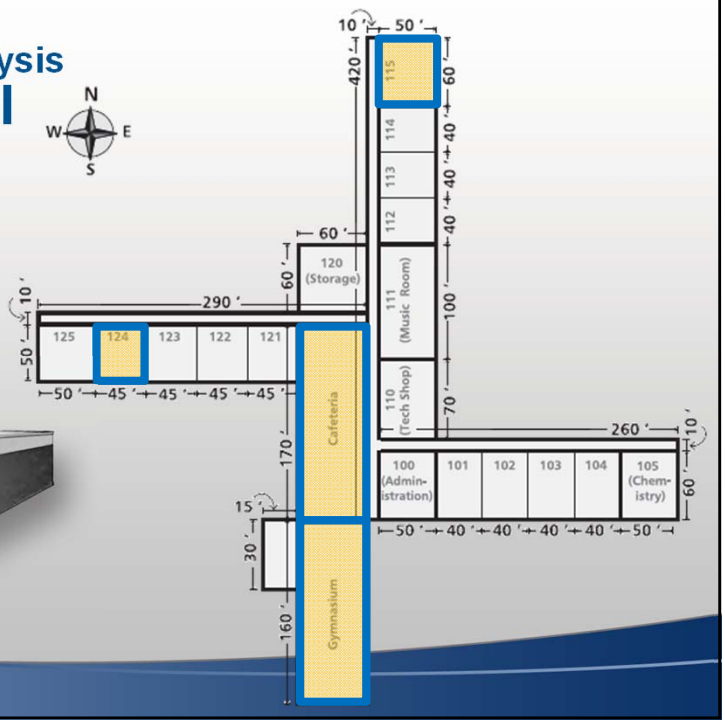
Example TRACE™ 700 Analysis

- Locations
  - Atlanta, Georgia
  - Minneapolis, Minnesota
  - St. Louis, Missouri
- Standard 90.1-2007 baseline
- SZVAV with two speed fans
- SZVAV with variable speed fans

example TRACE™ 700 analysis

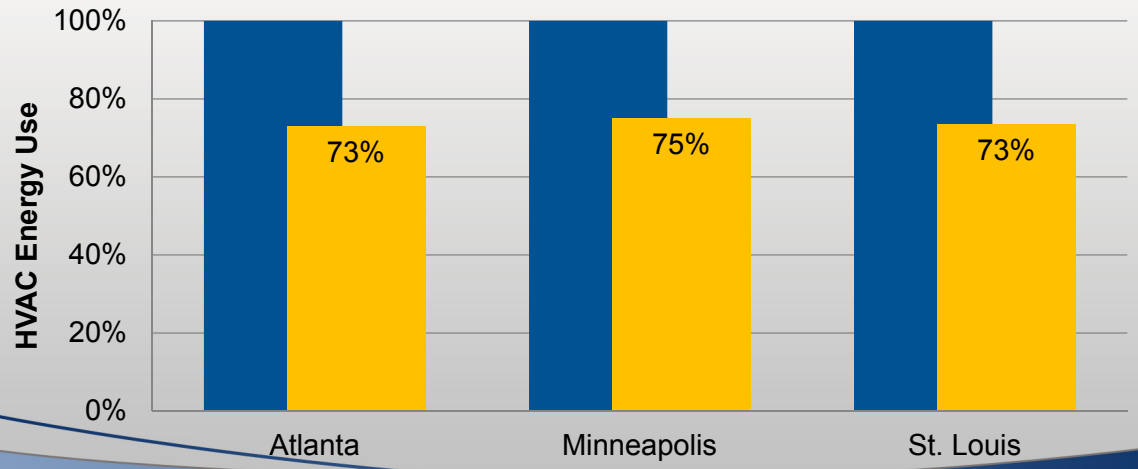
Elementary School



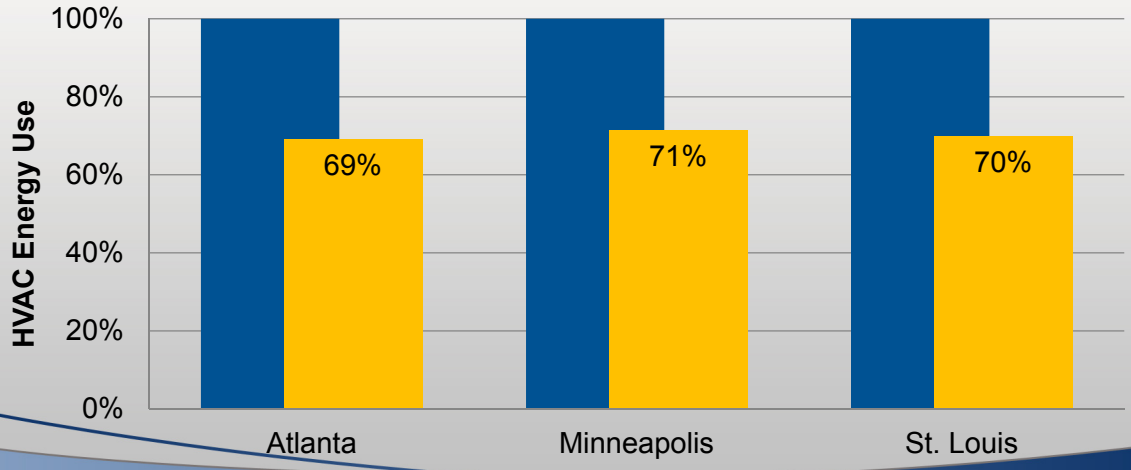


example TRACE™ 700 analysis

Energy Reduction: Two-Speed Fans



example TRACE™ 700 analysis
Energy Reduction: Variable-Speed Fans



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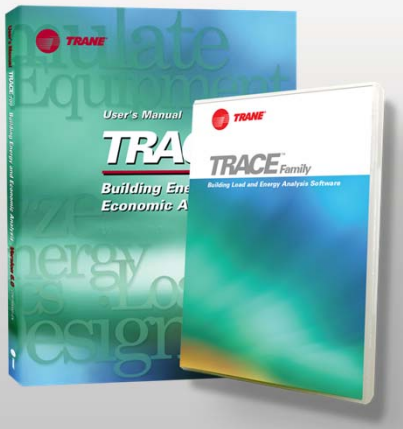
example TRACE™ 700 analysis
System Optimization

- Comparative enthalpy economizers
- Demand-controlled ventilation
- Optimum start controls
- Optimum stop controls



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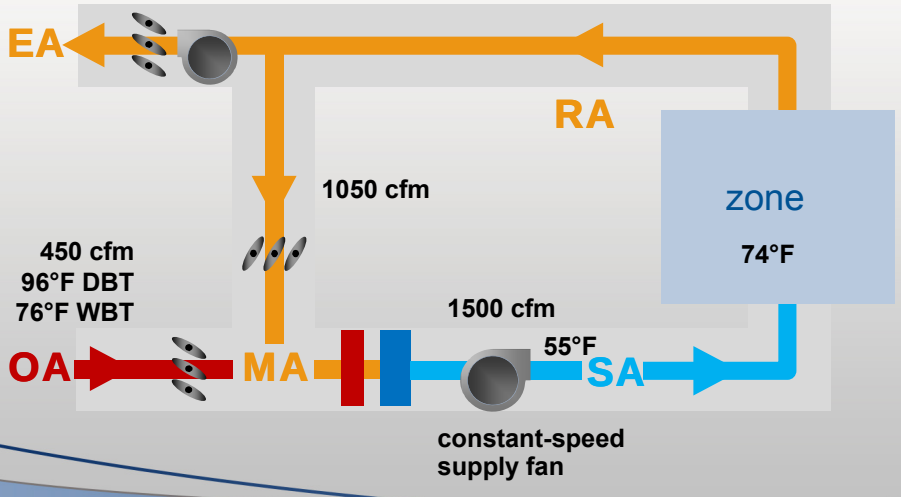
Typical Benefits of SZVAV

- Lower energy consumption by reducing fan speed at part load
- Improved dehumidification since the system continues to supply cool, dry air at part load

dehumidification performance
Full Load



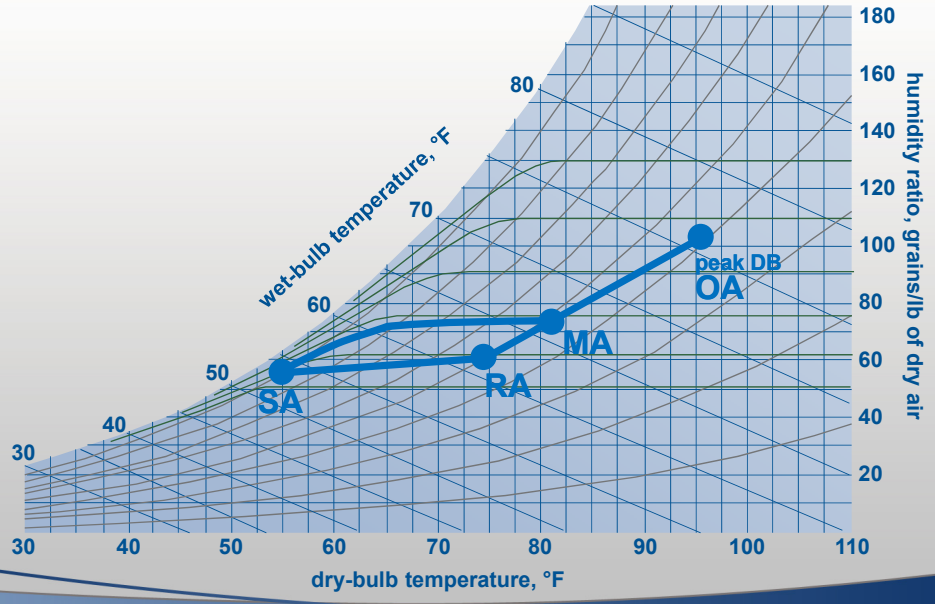
peak DB

OA 96°F DB, 76°F WB (450 cfm)

RA 74°F DB, 52% RH

MA 81°F DB

SA 55°F DB (1500 cfm)



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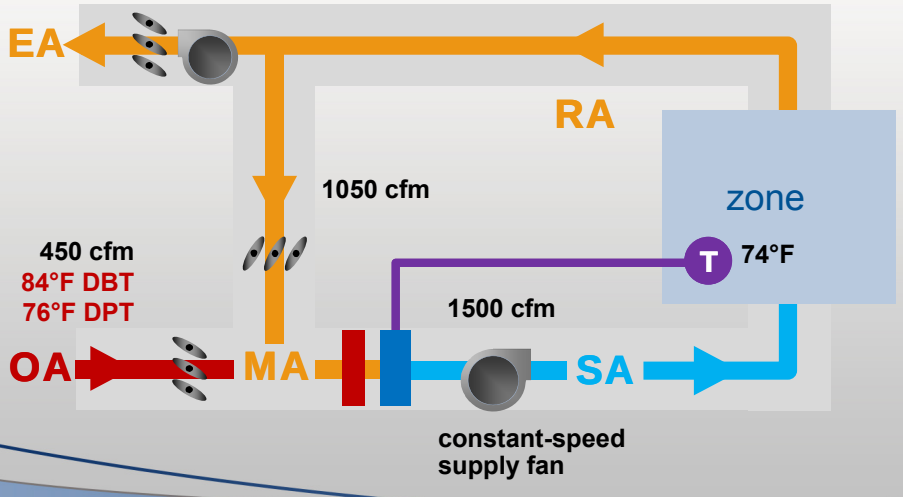
dehumidification performance

Part Load: Constant-Speed Fan



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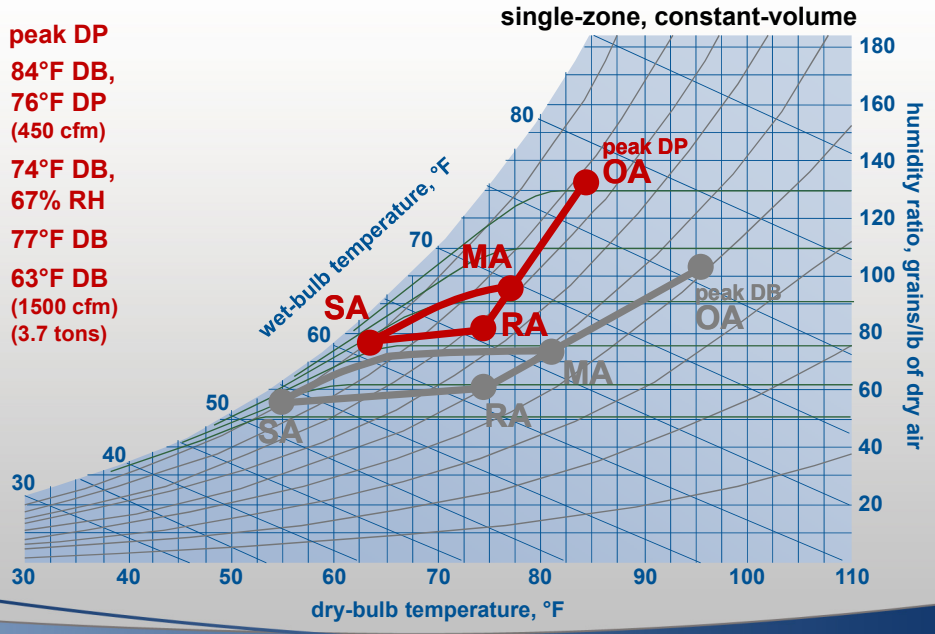
	peak DB	peak DP
OA	96°F DB, 76°F WB (450 cfm)	84°F DB, 76°F DP (450 cfm)
RA	74°F DB, 52% RH	74°F DB, 67% RH
MA	81°F DB	77°F DB
SA	55°F DB (1500 cfm) (4.8 tons)	63°F DB (1500 cfm) (3.7 tons)



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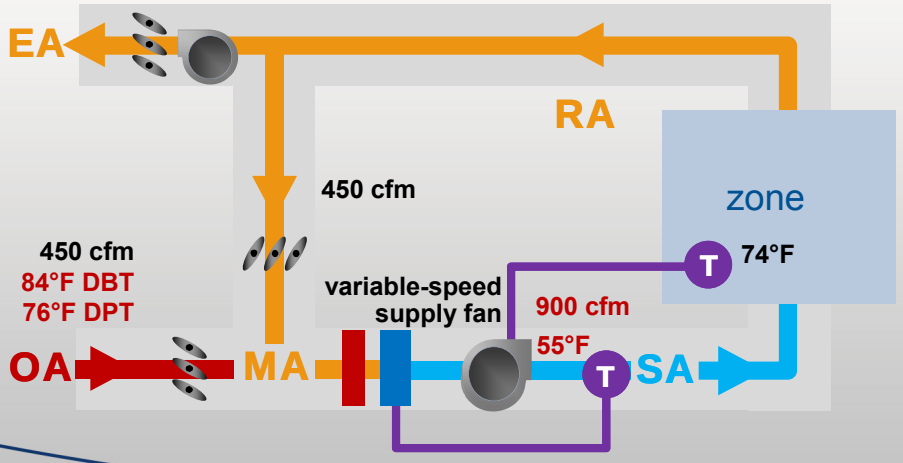
dehumidification performance
Part Load: Variable-Speed Fan



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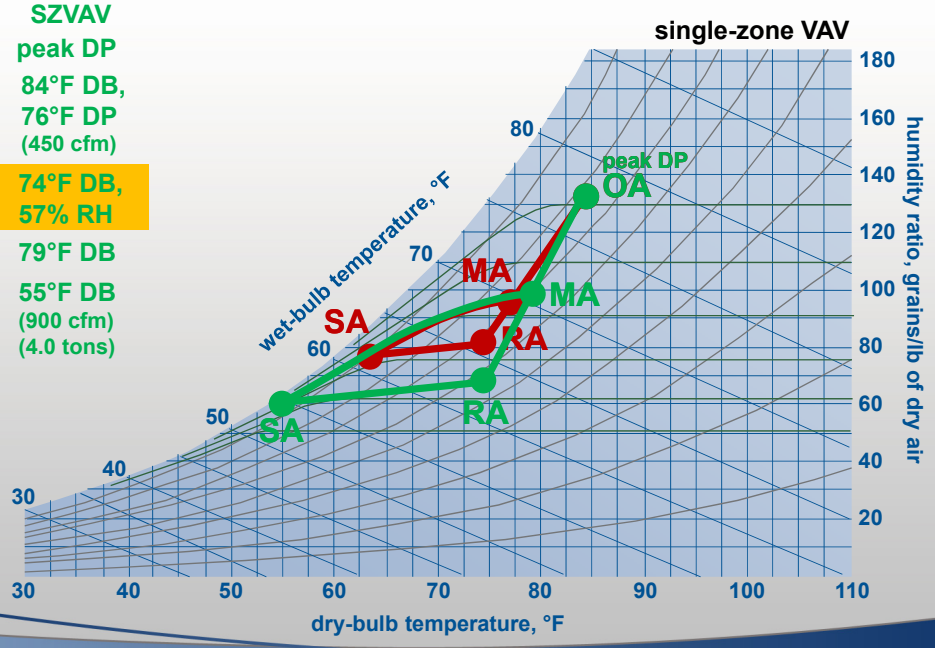
	CV peak DP	SZVAV peak DP
OA	84°F DB, 76°F DP (450 cfm)	84°F DB, 76°F DP (450 cfm)
RA	74°F DB, 67% RH	74°F DB, 57% RH
MA	77°F DB	79°F DB
SA	63°F DB (1500 cfm) (3.7 tons)	55°F DB (900 cfm) (4.0 tons)



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	constant-speed fan	variable-speed fan	constant-speed fan with HGRH
peak DPT			
zone humidity, %RH	67%	57%	
cooling load, tons	3.7	4.0	
fan airflow, cfm	1500	900	
mild/rainy			
zone humidity, %RH	73%	60%	60%
cooling load, tons	1.6	1.9	2.4
fan airflow, cfm	1500	750	1500

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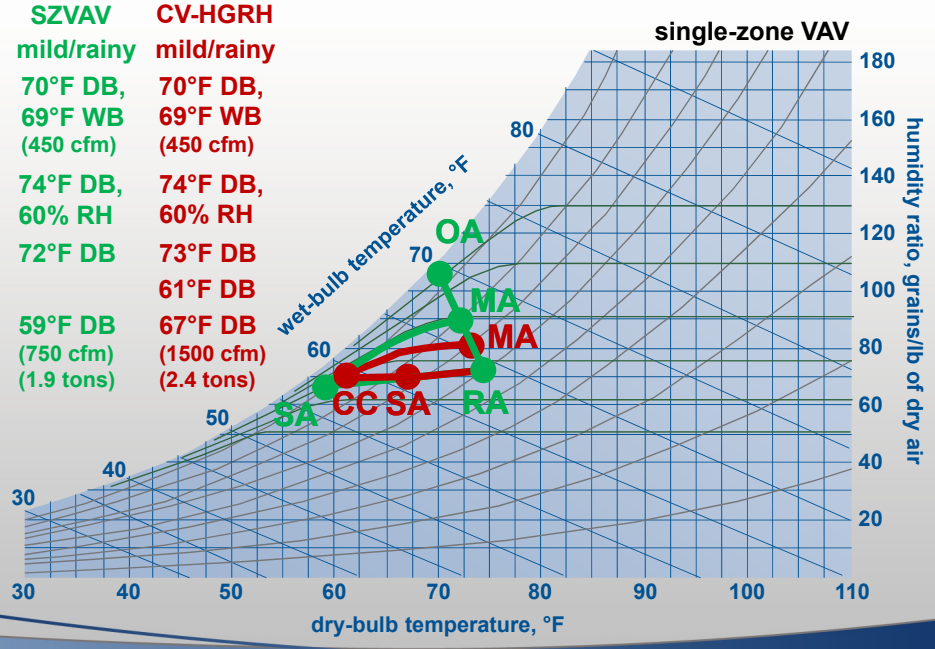
	CV mild/rainy	SZVAV mild/rainy	CV-HGRH mild/rainy
OA	70°F DB, 69°F WB (450 cfm)	70°F DB, 69°F WB (450 cfm)	70°F DB, 69°F WB (450 cfm)
RA	74°F DB, 73% RH	74°F DB, 60% RH	74°F DB, 60% RH
MA	73°F DB	72°F DB	73°F DB
CC			61°F DB
SA	67°F DB (1500 cfm) (1.6 tons)	59°F DB (750 cfm) (1.9 tons)	67°F DB (1500 cfm) (2.4 tons)



example TRACE™ 700 analysis report

Space Humidity Comparison

All hours - Alternative 1

System/Room Description	---- Maximum---- %Rh	Mo	Hr	Day	---------- Number of Hours at each Percentage Range ---------- >70%	70-66	66-62	62-58	58-54	54-50	50-46	46-42	42-38	38-34	34-30	<30 %	---- Minimum ---- %Rh	Mo	Hr	Day
Single Zone - Gymnasium																				
Gymnasium	88	12	7	Thur	254	289	461	653	638	658	502	540	619	1,125	1,461	1,620	9	1	17	Sun
Single Zone - Cafeteria																				
Cafeteria	83	11	7	Mon	1,316	894	638	631	455	357	381	444	599	668	505	1,902	9	1	17	Thur
Single Zone - Classroom 115																				
Classroom 115 used	95	12	7	Thur	359	386	566	940	718	618	540	453	527	558	1,378	1,701	9	2	13	Thur
Single Zone - Classroom 124																				
Classroom 124 used	90	12	7	Thur	551	579	795	729	445	497	447	449	487	586	1,383	1,912	8	2	16	Sat

Occupied hours only - Alternative 1

System/Room Description	---- Maximum---- %Rh	Mo	Hr	Day	---------- Number of Hours at each Percentage Range ---------- >70%	70-66	66-62	62-58	58-54	54-50	50-46	46-42	42-38	38-34	34-30	<30 %	---- Minimum ---- %Rh	Mo	Hr	Day
Single Zone - Gymnasium																				
Gymnasium	77	10	8	Wed	62	127	294	373	392	314	207	192	194	161	575	343	11	1	19	Thur
Single Zone - Cafeteria																				
Cafeteria	78	9	8	Tues	157	249	274	241	180	137	152	167	174	205	586	654	9	1	17	Thur
Single Zone - Classroom 115																				
Classroom 115 used	83	7	8	Wed	96	117	252	409	279	288	157	178	182	160	555	511	9	2	13	Thur
Single Zone - Classroom 124																				
Classroom 124 used	86	7	8	Wed	187	243	312	231	206	236	146	176	172	161	559	533	9	2	13	Thur

Space Humidity: Constant-Volume System

Occupied hours only - Alternative 1

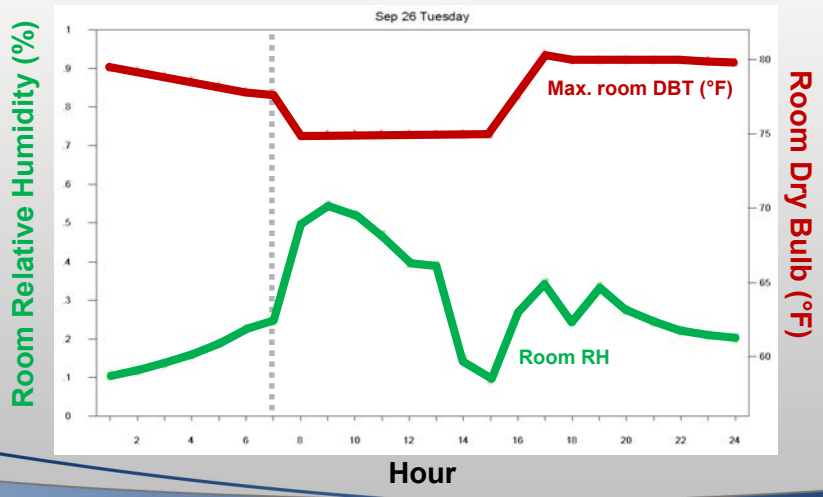
System/Room Description	Number of Hours at each Percentage Range											
	>70%	70-66	66-62	62-58	58-54	54-50	50-46	46-42	42-38	38-34	34-30	<30 %
Single Zone - Gymnasium												
Gymnasium	62	127	256	373	392	314	207	192	154	181	175	343
Single Zone - Cafeteria												
Cafeteria	157	249	274	241	180	137	152	167	174	205	186	654
Single Zone - Classroom 115												
Classroom 115 used	86	117	252	409	279	280	157	178	192	160	155	511
Single Zone - Classroom 124												
Classroom 124 used	197	243	312	231	206	238	148	176	172	161	159	533

Space Humidity: Single-Zone VAV

Occupied hours only - Alternative 4

System/Room Description	---------- Number of Hours at each Percentage Range ----------											
	>70%	70-66	66-62	62-58	58-54	54-50	50-46	46-42	42-38	38-34	34-30	<30 %
Single Zone - Gymnasium												
Gymnasium	9	8	43	75	153	284	639	421	175	190	176	603
Single Zone - Cafeteria												
Cafeteria	4	48	125	284	352	189	191	181	185	239	209	769
Single Zone - Classroom 115												
Classroom 115 used	20	23	27	74	109	428	628	263	188	183	183	650
Single Zone - Classroom 124												
Classroom 124 used	29	39	79	194	242	351	390	240	182	163	176	691

Space Humidity: Constant-Volume System



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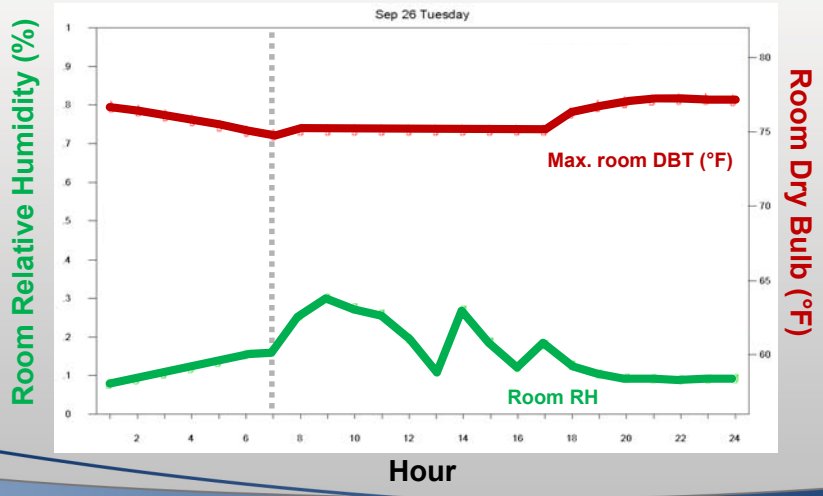
Space Humidity: Single-Zone VAV



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Typical Benefits of SZVAV

- Lower energy consumption by reducing fan speed at part load
- Improved dehumidification since the system continues to supply cool, dry air at part load
- Less fan-generated noise at reduced fan speeds

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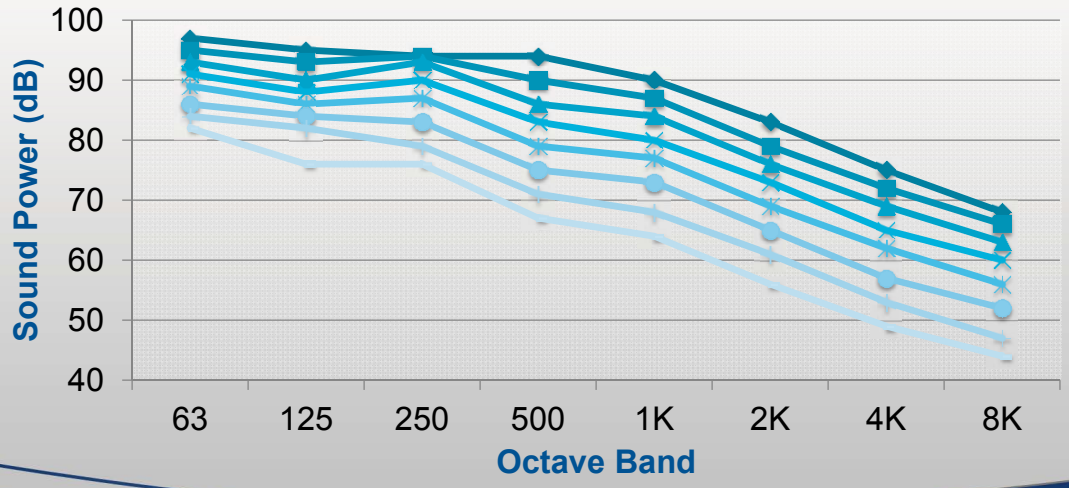
Fan Acoustics



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Agenda

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Single-zone VAV systems

- ASHRAE Standard 90.1 requirements
- System operation
- Typical benefits
- Application considerations
- Case study

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Application Considerations

- Large zones should have uniform loads
- Design air distribution system for variable airflow
  - Use diffusers that provide proper air distribution at reduced airflows
  - Layout duct runs as symmetric as possible

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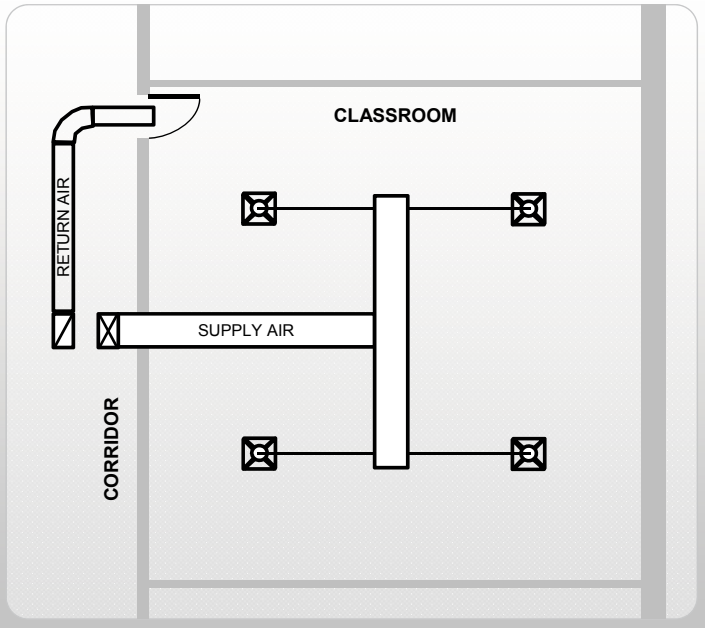
Example of symmetric ductwork



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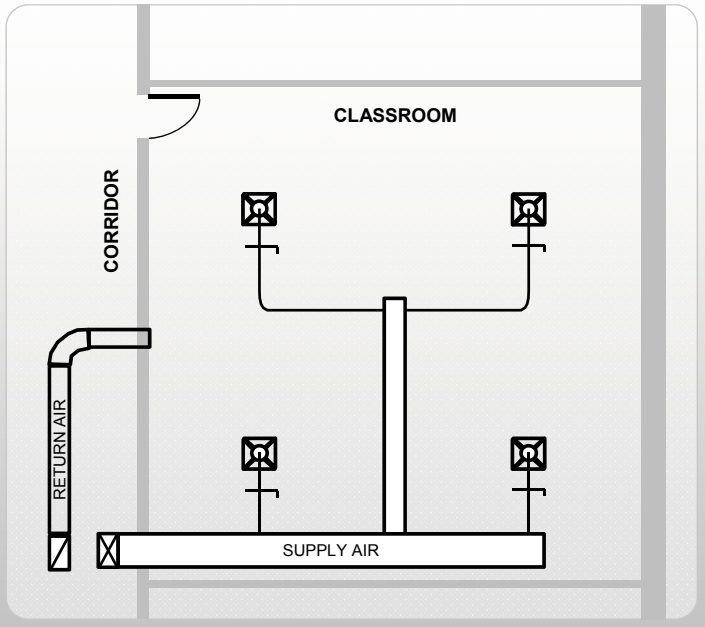
Example of asymmetric ductwork



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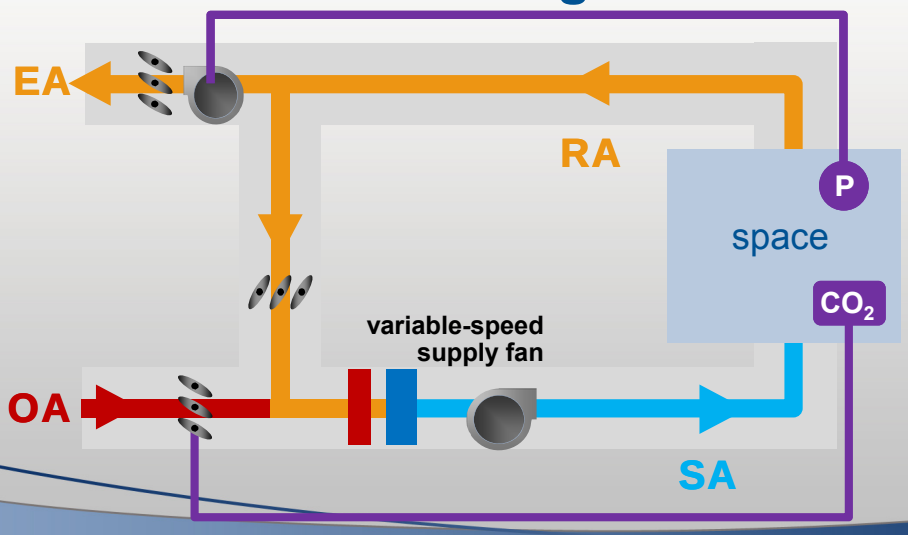
Application Considerations

- Large zones should have uniform loads
- Design air distribution system for variable airflow
- Ensure proper ventilation as supply airflow changes

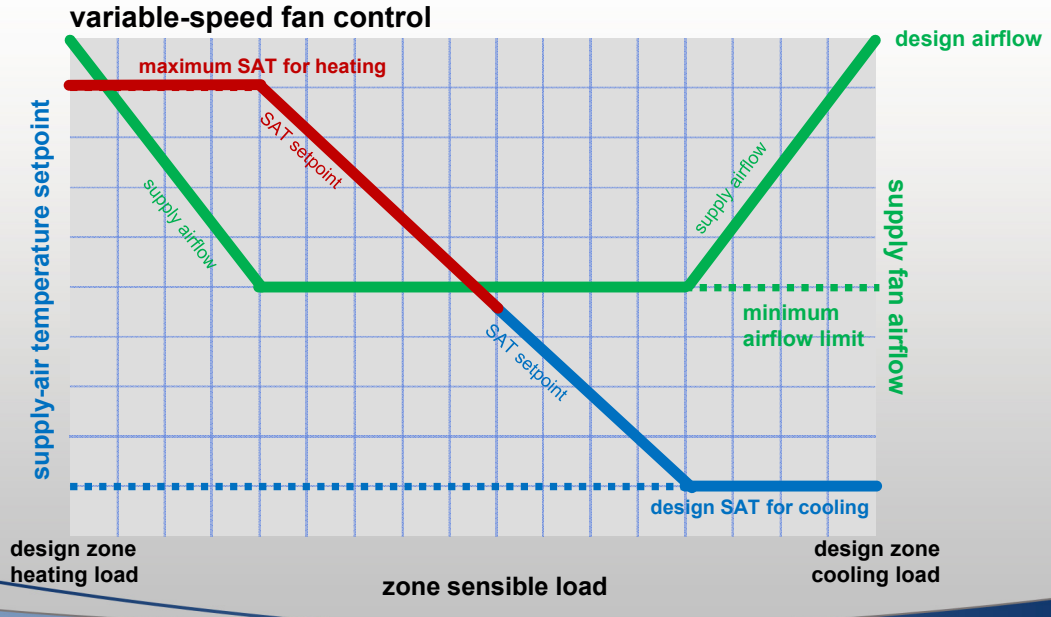
when using DCV Remember Building Pressure Control



Application Considerations

- Large zones should have uniform loads
- Design air distribution system for variable airflow
- Ensure proper ventilation as supply airflow changes
- Select modulating heat if varying airflow during heating is desired

87



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Application Considerations

- Variable-speed fan control requires a zone temperature sensor
  - Conventional thermostats are suitable for two-speed fan control
  - Consider wireless zone sensors for difficult-to-wire projects

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Agenda

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Single-zone VAV systems

- ASHRAE Standard 90.1 requirements
- System operation
- Typical benefits
- Application considerations
- Case study

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examples of
Walgreens Sustainability Initiatives

- Doors added to refrigerated coolers
- LED lighting
- Solar energy
- Charging stations for electric vehicles
- New rooftop units

Walgreens
Rooftop Unit Replacement Program

- Began in 2010
- Equipment replaced at 1400 locations so far
- Replacing older rooftop units, before failure
  - Energy savings
  - Less downtime
  - Reduced maintenance expense

Walgreens
Rooftop Unit Replacement Program

- Initially focused on replacing equipment > 13 years old
- Prioritized stores with highest energy costs
- Considered available utility rebates
- "Right-size" HVAC equipment during replacement
- Site survey to grade current condition of equipment and gather accurate information for replacement

Walgreens
Rooftop Unit Replacement Program

- Currently replacing constant-volume units with new units that have two-speed fan control
  - Improved comfort, lower indoor humidity levels
  - 20% to 30% predicted energy savings
  - 35% to 37% actual energy savings
  - Reduced maintenance expenses
- Next step: variable-speed fan control

Replacement Considerations

- Size and weight of replacement equipment (new refrigerant?)
  - Compatibility with existing roof curb
- Compatibility with existing controls
  - Integration with automation system
  - Thermostat vs. zone sensor
  - Setup of ventilation control

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Total Cost of Ownership

- Initial cost of replacement unit
- Energy savings
- Reduced maintenance expense

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references for this broadcast
Where to Learn More

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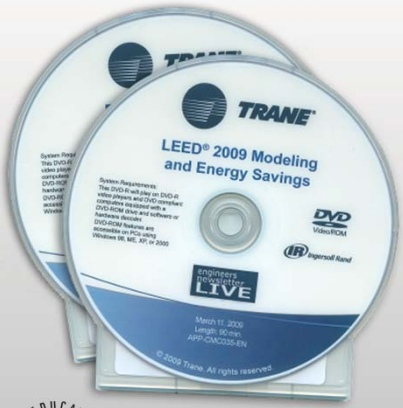

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- Variable-speed Chiller Plant Operation

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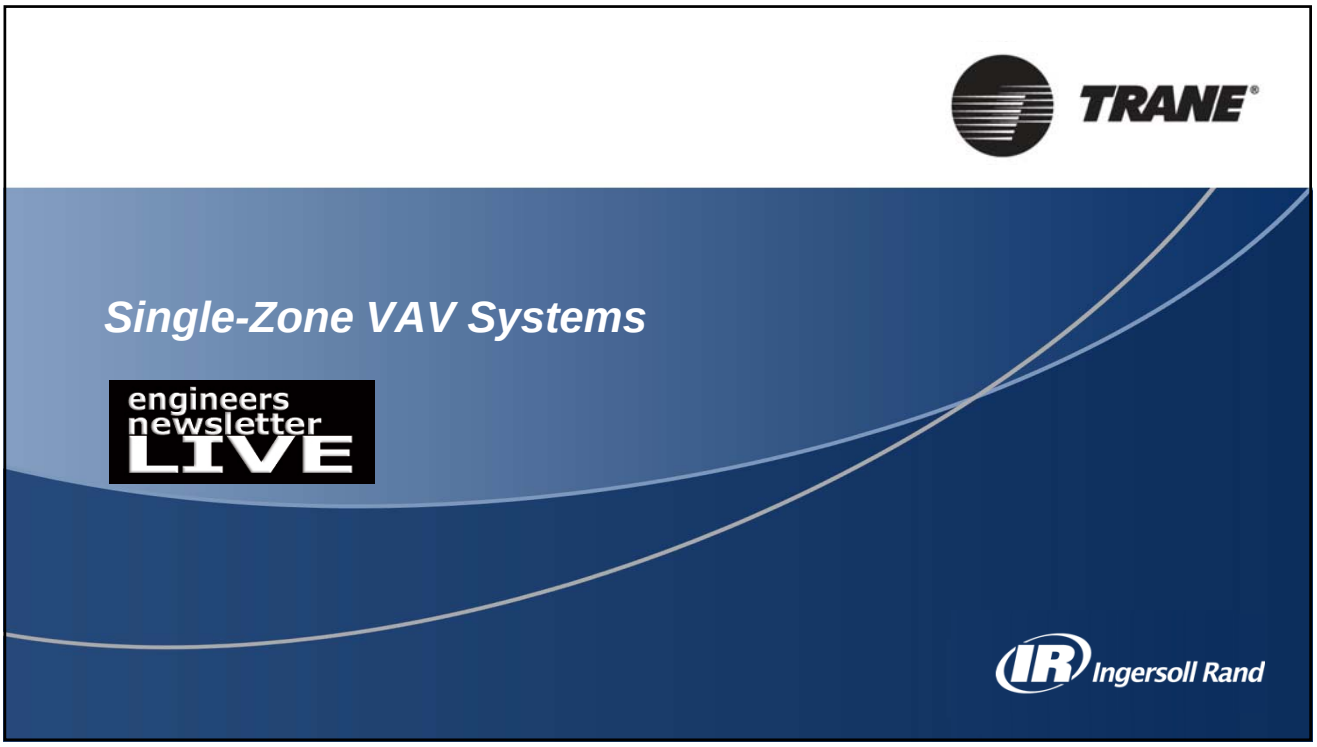

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April 2013

Single-Zone VAV Systems

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Single-Zone VAV Systems

1. True or False: ASHRAE Standard 90.1-2010 allows either two-speed or variable-speed fan control in order to meet the new single-zone VAV requirements.

2. True or False: The new single-zone VAV requirements are included in the "Mandatory Provisions" section of ASHRAE Standard 90.1-2010.

3. Which of the following might impact the minimum airflow limit (minimum fan speed) in a single-zone VAV system? Select all that apply.
    a) ASHRAE Standard 90.1-2010 requirement for turndown (minimum airflow)
    b) Limitation set by the manufacturer for safety or reliability reasons
    c) Minimum outdoor airflow required by ASHRAE Standard 62.1

4. As supply airflow (fan speed) is reduced in a single-zone VAV system, the static pressure inside mixing box (or at the inlet of the unit) _____.
    a) increases (becomes less negative than outside the building)
    b) decreases (becomes more negative than outside the building)

5. As supply airflow (fan speed) is reduced in a single-zone VAV system, the outdoor-air damper must _____ further to ensure that the same quantity (cfm) of outdoor air enters the system.
    a) open
    b) close

6. True or False. With a dedicated outdoor-air system, delivering the conditioned outdoor air directly to each zone allows the fan inside the local fan-coil or heat pump to operate with a two-speed or variable-speed motor, without impacting how much outdoor air is delivered to the zone.

7. Which of the following are potential benefits of using a single-zone VAV system? Select all that apply.
    a) Less fan-generated noise at reduced fan speeds
    b) Simpler control of ventilation
    c) Lower energy use due to reducing fan speed at part load
    d) Better dehumidification at part-load conditions

8. True or False. Variable-speed fan control typically requires a zone temperature sensor, while two-speed fan control may be able to re-use a conventional thermostat with COOL1/COOL2 control.

9. True or False. A single-zone VAV system typically result in lower indoor humidity levels at part-load conditions than a conventional constant-volume system, because the SZVAV system continue to deliver cooler, and therefore drier, air at part-load conditions.

10. Which of the following are issues to be aware of when replacing older, constant-volume rooftop units with new, single-zone VAV units? Select all that apply.
    a) Differences in unit dimensions and/or weight (especially if a different refrigerant is to be used)
    b) Compatibility with the existing roof curb, or need for an adaptor curb
    c) Compatibility with the existing zone thermostat or temperature sensor

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