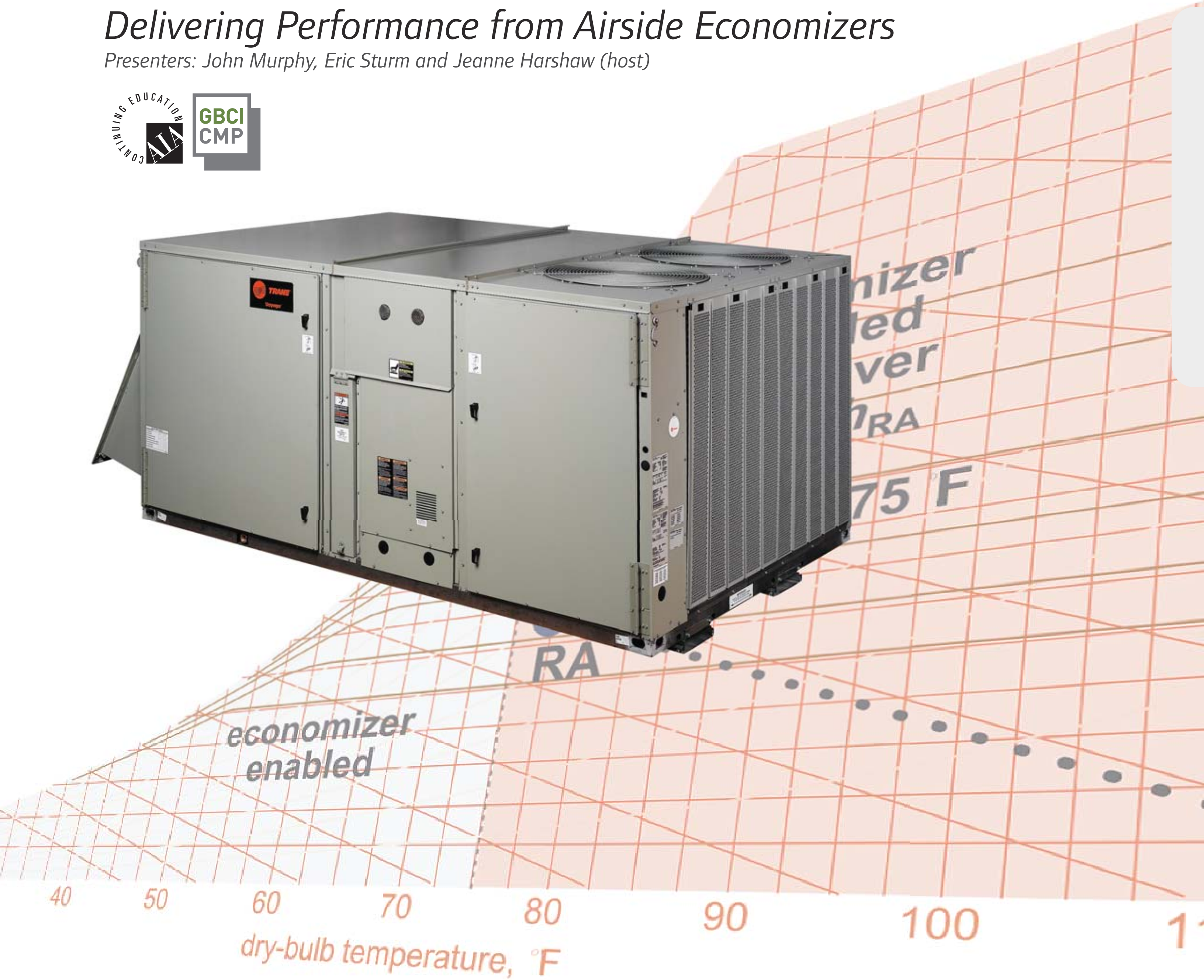
Trane Engineers Newsletter Live

Delivering Performance from Airside Economizers

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



Ingersoll Rand

TRANE

Agenda

Trane *Engineers Newsletter Live* Series

Delivering Performance from Airside Economizers

Abstract
Airside economizers are an effective way to save energy and operational cost in many unitary and air handling systems. In some instances, the promise of energy savings hasn't been fully realized. This ENL will discuss the current energy code requirements related to economizers, how economizers can be used to save energy, common problems, and how modern design and technology can be used to ensure that the expected energy savings are realized.

Presenters: Trane engineers John Murphy and Eric Sturm

After viewing attendees will be able to:
1. Summarize airside economizer energy code and standard requirements.
2. Identify common issues that affect correct and reliable economizer operation.
3. Incorporate new technologies (e.g. fault detection and damper design) to maximize the energy benefit of economizers.
4. Summarize how to use economizers in different types of equipment.

Agenda
- What are airside economizers?
- Energy code and standards requirements
- How can economizers save energy?
- Comon problems with economizers
- Situational issues
- How to implement economizers in different equipment types

Ingersoll Rand

Presenter biographies

Delivering Performance from Airside Economizers

John Murphy | applications engineer | Trane

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

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

Eric Sturm | applications engineer | Trane

Eric joined Trane in 2006 after graduating from the University of Wisconsin – Platteville with a Bachelor of Science degree in mechanical engineering. Prior to joining the applications engineering team, he worked in the Customer Direct Services (C.D.S.) department as a marketing engineer and product manager for the TRACE™ 700 load design and energy simulation software application. As a C.D.S. marketing engineer he supported and trained customers globally. In his current role as an applications engineer, Eric's areas of expertise include acoustics, airside systems, and standards and codes.

Eric is currently involved with ASHRAE at the local chapter as president-elect and nationally as member of the "Global Climate Change" and "Sound and Vibration" technical committees. In 2015, Eric was named recipient of the Young Engineers in ASHRAE Award of Individual Excellence for service to the la Crosse Area Chapter of ASHRAE.

.

"Trane" is a Registered Provider with The American Institute of Architects Continuing Education System. Credit earned on completion of this program will be reported to CES Records for AIA members. Certificates of Completion are available on request.

This program is registered with the AIA/CES for continuing professional education. As such, it does not include content that may be deemed or construed to be an approval or endorsement by the AIA of any material of construction or any method or manner of handling, using, distributing, or dealing in any material or product.

Credit for viewing today's program can be applied toward LEED credential maintenance requirements .

www.USGBC.org

Visit the Registered Continuing Education Programs (RCEP) Website for individual state continuing education requirements for Professional Engineers.

www.RCEP.net

Learning objectives

- Summarize airside economizer energy code and standard requirements.
- Identify common issues that affect correct and reliable economizer operation.
- Incorporate new technologies (e.g. fault detection and damper design) to maximize the energy benefit of economizers.
- Summarize how to use economizer control types in different climates.
- Apply economizers in different system types.


AGENDA
• What is an airside economizer?
• Energy standard and code requirements
• How economizers can save energy
• Common problems with economizers
• Situational issues
• Summary

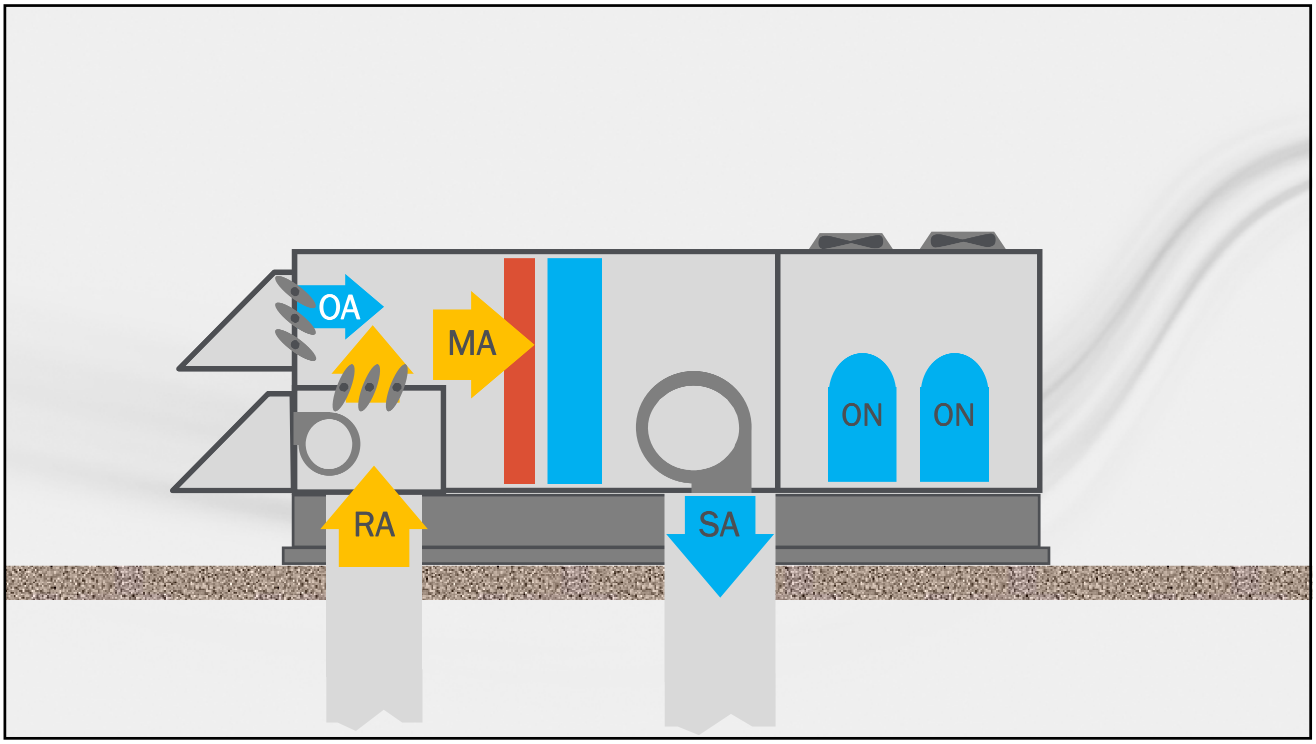

Today's Presenters
John Murphy
Applications Engineer
Eric Sturm
Applications Engineer

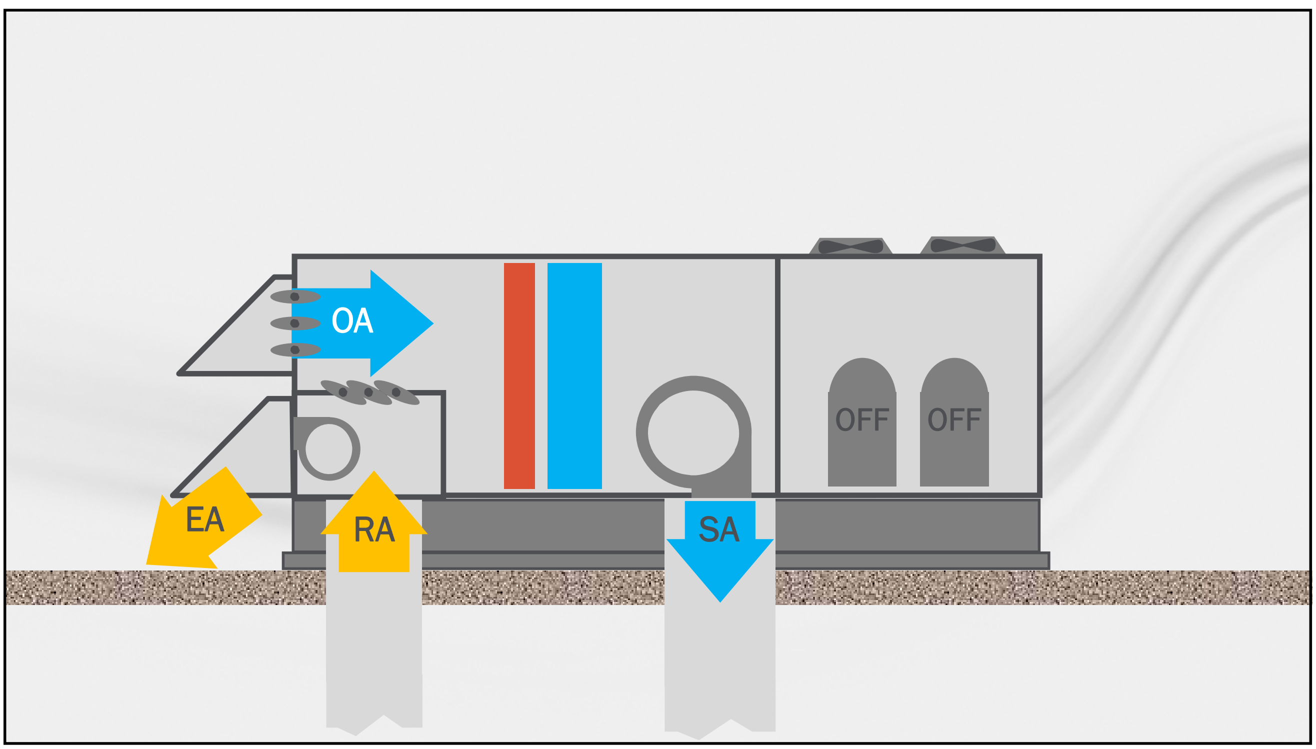
definition

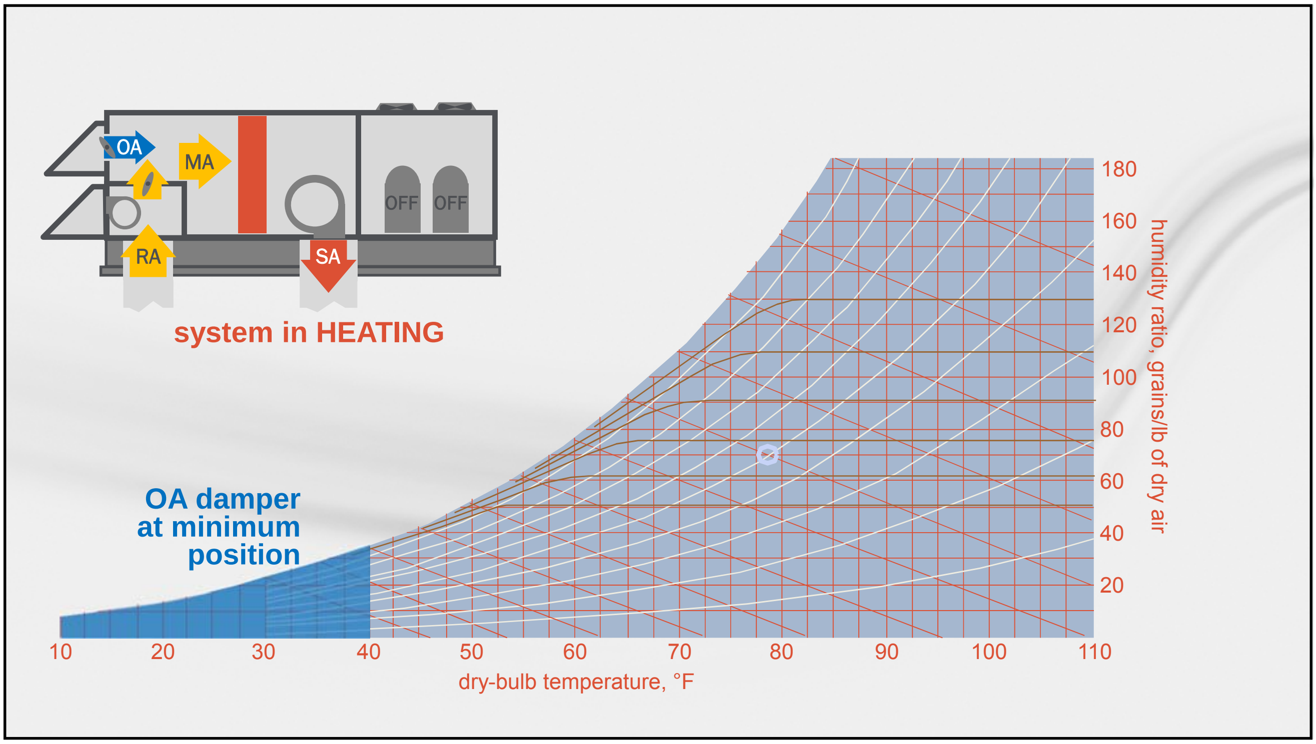
Air Economizer

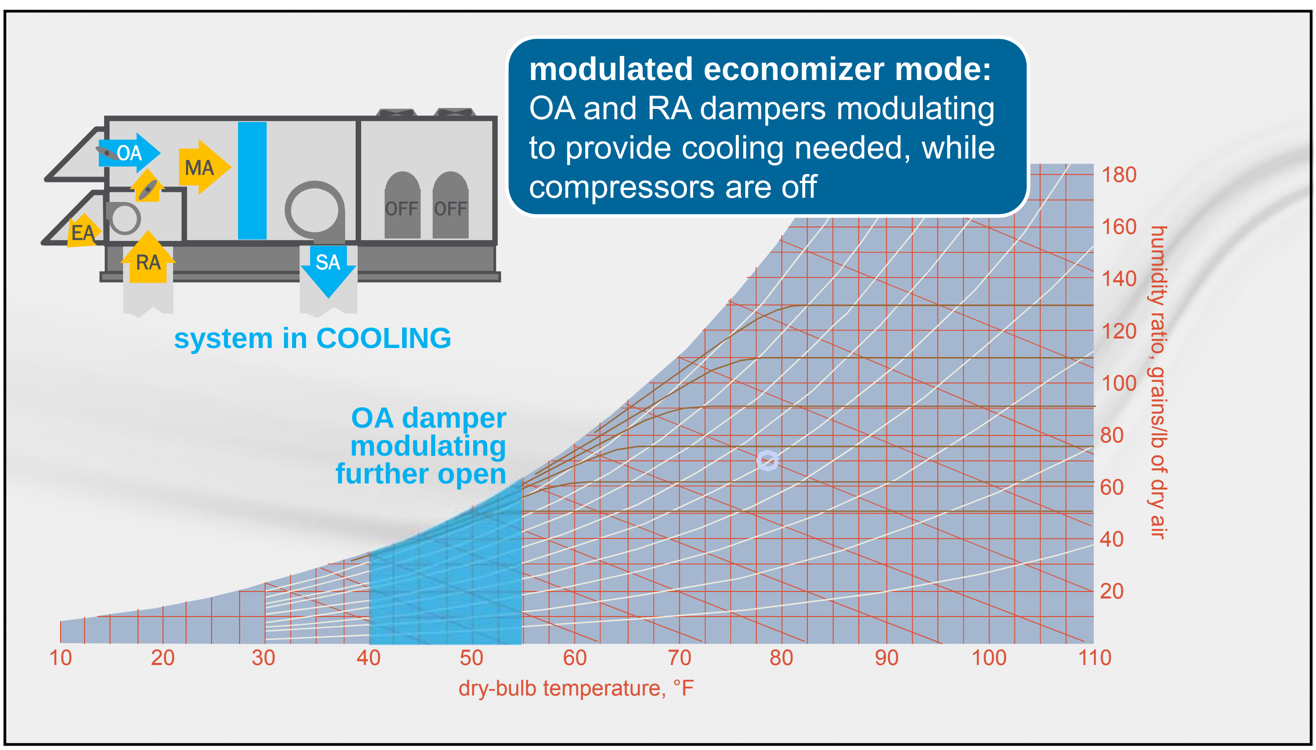
"A duct and damper arrangement, and automatic control system, that together allow a cooling system to supply outdoor air to reduce or eliminate the need for mechanical cooling during mild or cold weather."

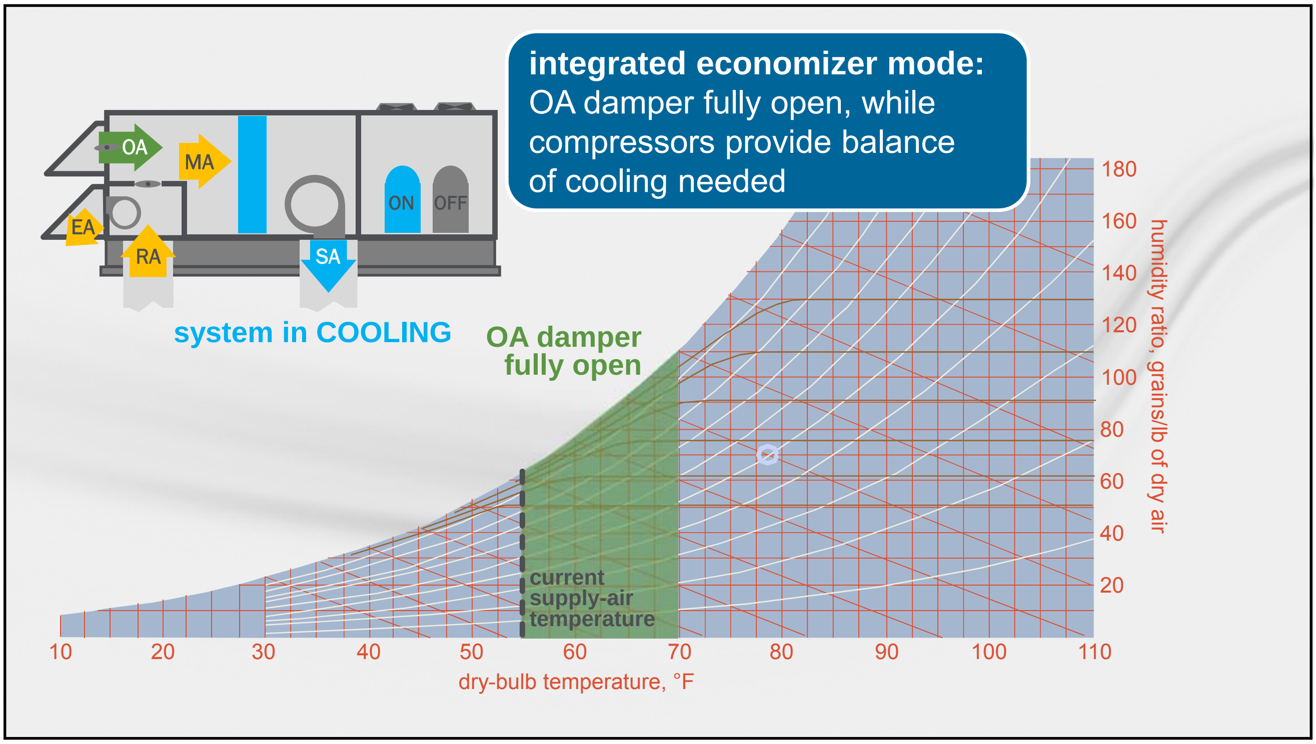
ANSI/ASHRAE/IES Standard 90.1-2013 (Section 3)

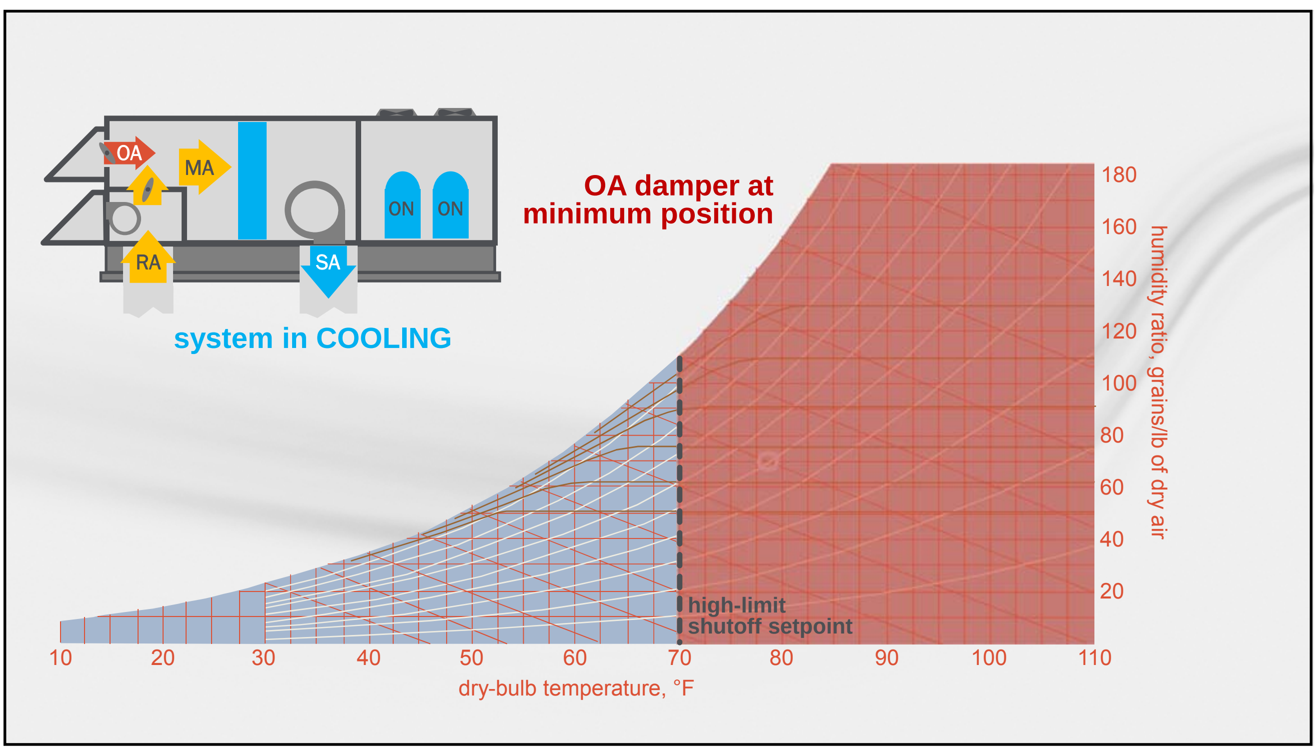

OA
MA
RA
SA
ON
ON

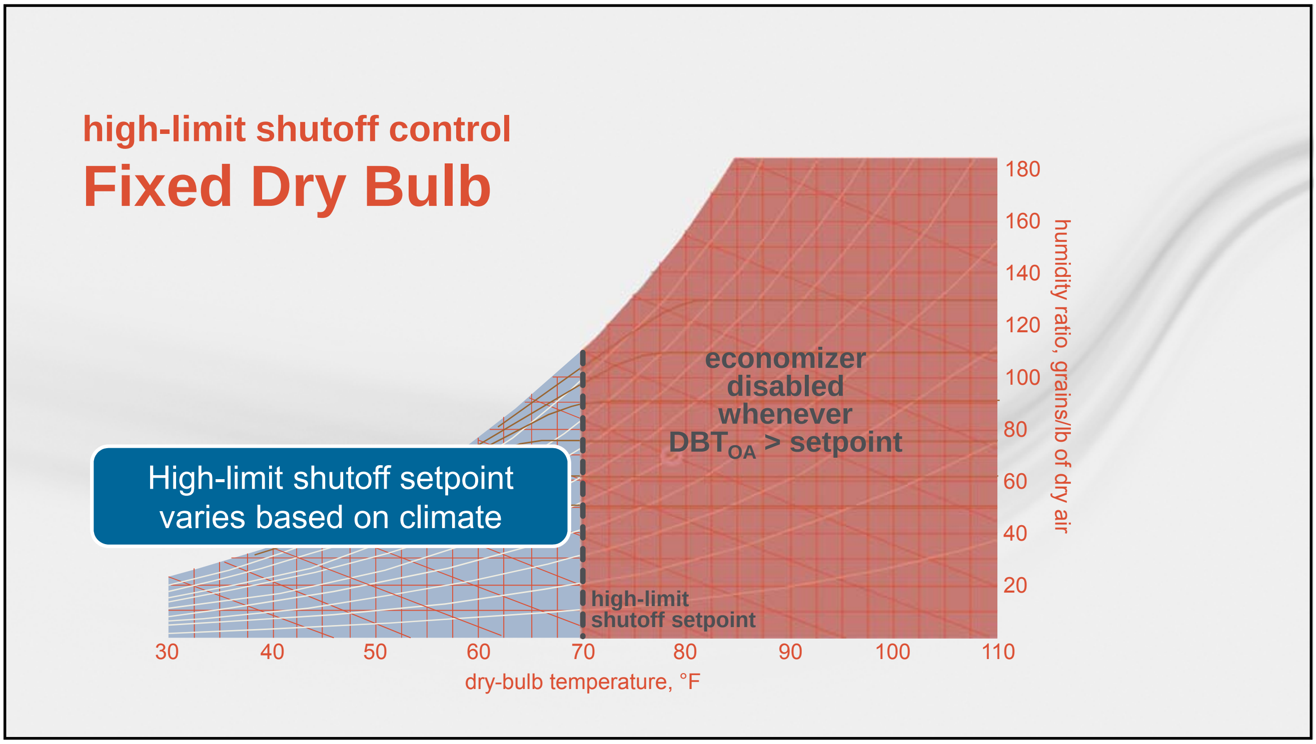

OA
EA
RA
SA
OFF
OFF

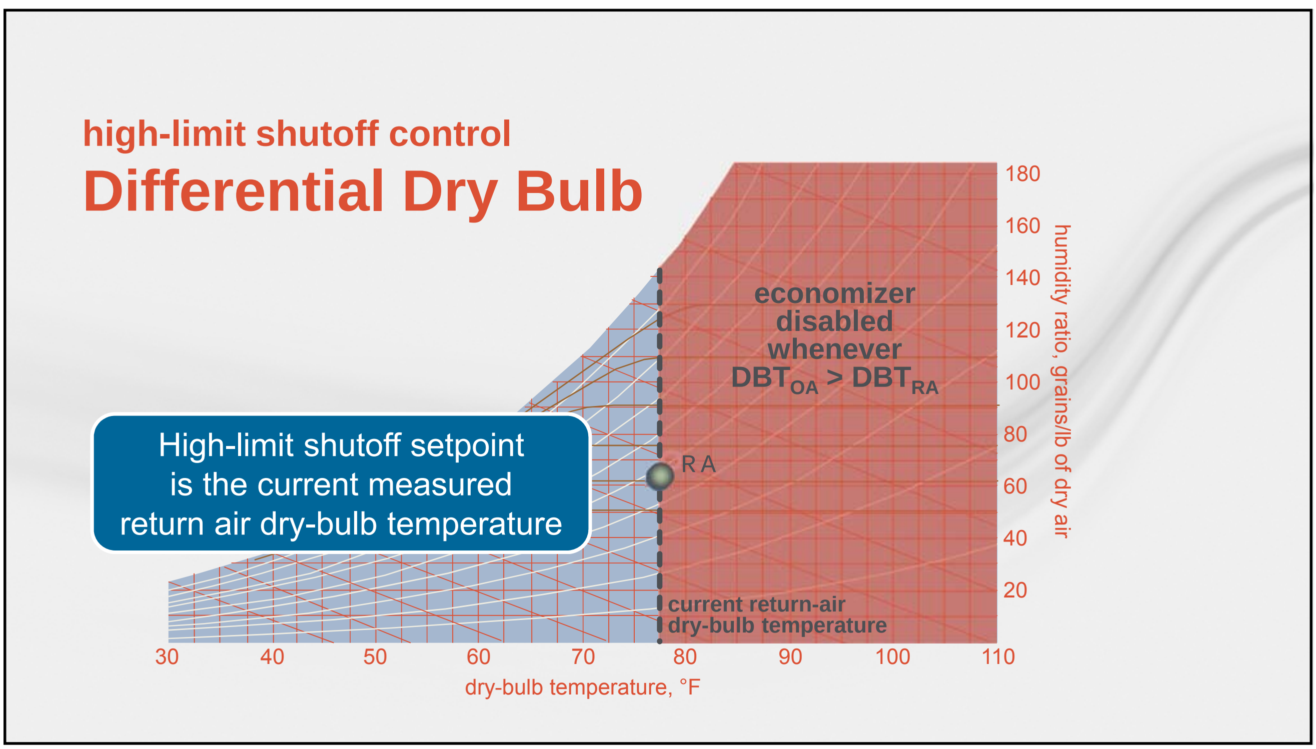

OA
MA
RA
SA
OFF
OFF
system in HEATING
OA damper
at minimum
position
180
160
140
120
100
80
60
40
20
humidity ratio, grains/lb of dry air
10
20
30
40
50
60
70
80
90
100
110
dry-bulb temperature, °F

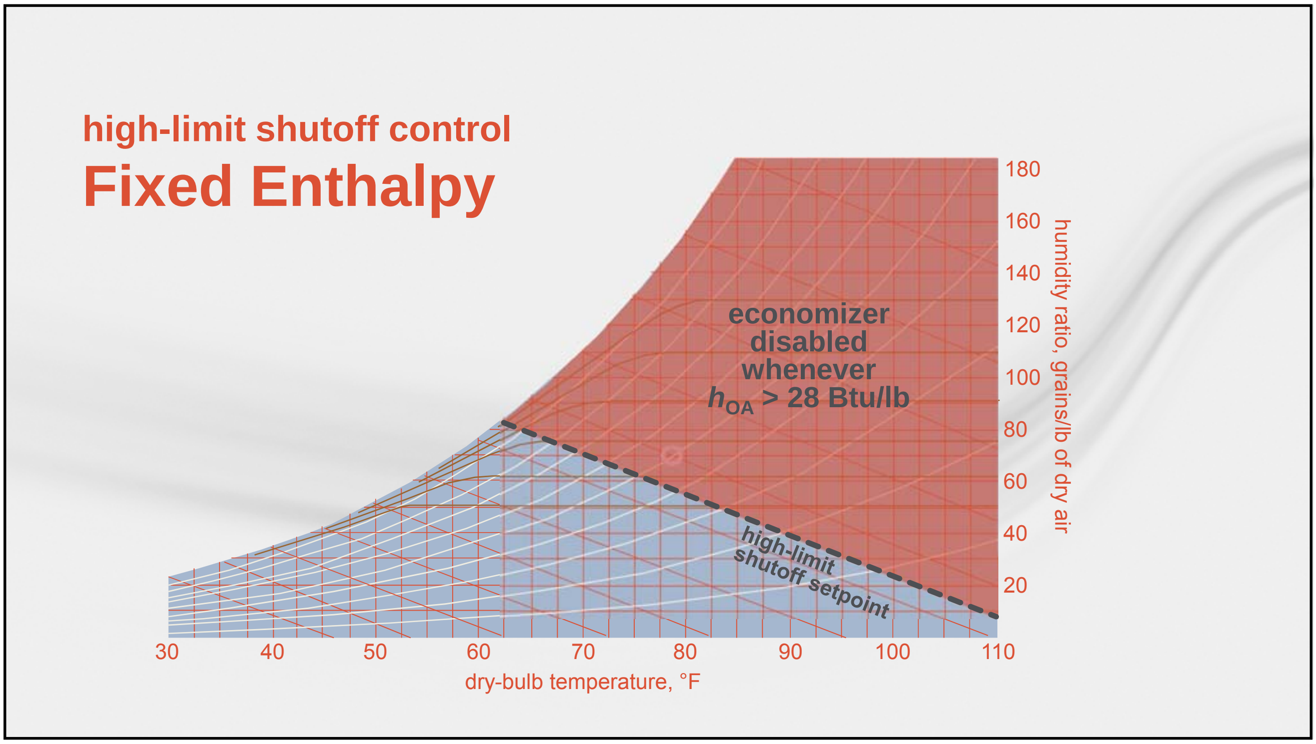

modulated economizer mode:
OA and RA dampers modulating
to provide cooling needed, while
compressors are off
OA
MA
EA
RA
SA
OFF
OFF
system in COOLING
OA damper
modulating
further open
180
160
140
120
100
80
60
40
20
humidity ratio, grains/lb of dry air
10
20
30
40
50
60
70
80
90
100
110
dry-bulb temperature, °F

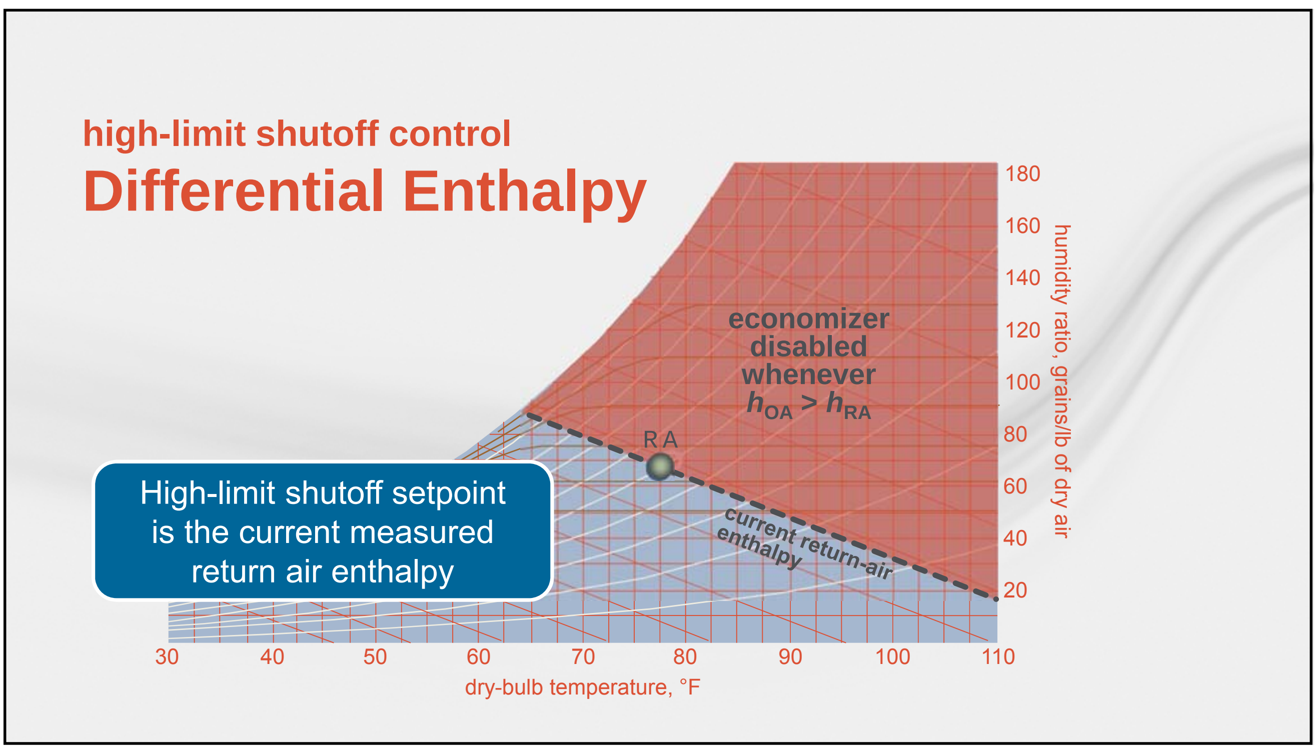

integrated economizer mode:
OA damper fully open, while compressors provide balance of cooling needed
OA
MA
EA
RA
SA
ON
OFF
system in COOLING
OA damper fully open
current supply-air temperature
10 20 30 40 50 60 70 80 90 100 110
dry-bulb temperature, °F
180 160 140 120 100 80 60 40 20
humidity ratio, grains/lb of dry air


OA
MA
RA
SA
ON
ON
system in COOLING
OA damper at minimum position
high-limit shutoff setpoint
10 20 30 40 50 60 70 80 90 100 110
dry-bulb temperature, °F
180 160 140 120 100 80 60 40 20
humidity ratio, grains/lb of dry air


high-limit shutoff control
Fixed Dry Bulb
economizer disabled whenever DBT$_{OA}$ > setpoint
High-limit shutoff setpoint varies based on climate
high-limit shutoff setpoint
180
160
140
120
100
80
60
40
20
humidity ratio, grains/lb of dry air
30
40
50
60
70
80
90
100
110
dry-bulb temperature, °F


high-limit shutoff control
Differential Dry Bulb
economizer disabled whenever DBT$_{OA}$ > DBT$_{RA}$
RA
High-limit shutoff setpoint is the current measured return air dry-bulb temperature
current return-air dry-bulb temperature
180
160
140
120
100
80
60
40
20
humidity ratio, grains/lb of dry air
30
40
50
60
70
80
90
100
110
dry-bulb temperature, °F


high-limit shutoff control
Fixed Enthalpy
economizer disabled whenever
h_{OA} > 28 Btu/lb
high-limit shutoff setpoint
180
160
140
120
100
80
60
40
20
humidity ratio, grains/lb of dry air
30 40 50 60 70 80 90 100 110
dry-bulb temperature, °F


high-limit shutoff control
Differential Enthalpy
economizer disabled whenever
$h_{OA} > h_{RA}$
RA
current return-air enthalpy
High-limit shutoff setpoint is the current measured return air enthalpy
180
160
140
120
100
80
60
40
20
humidity ratio, grains/lb of dry air
30 40 50 60 70 80 90 100 110
dry-bulb temperature, °F

Airside Economizers in Standards and Codes

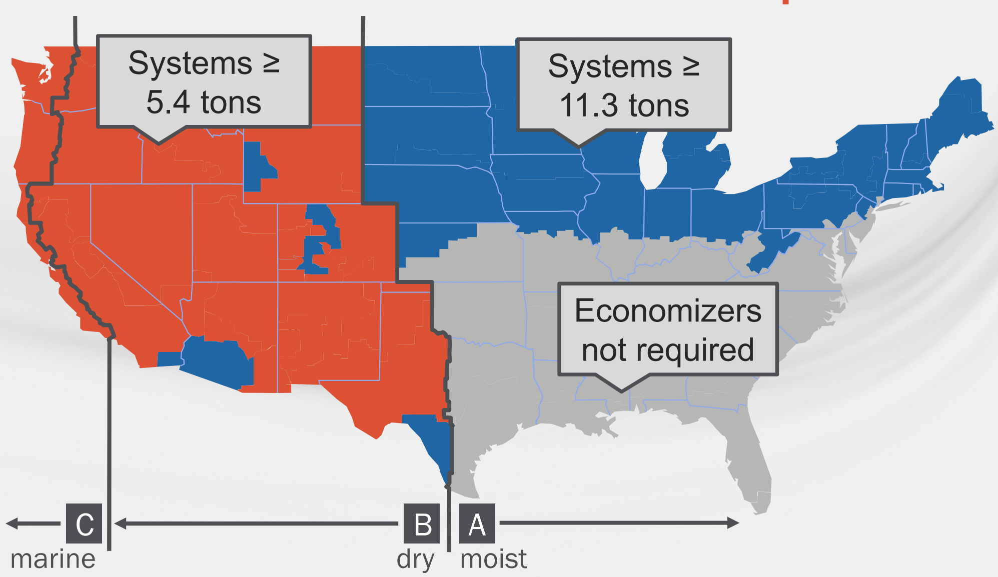
- ANSI/ASHRAE/IES Standard 90.1
- International Code Council's International Energy Conservation Code (IECC)

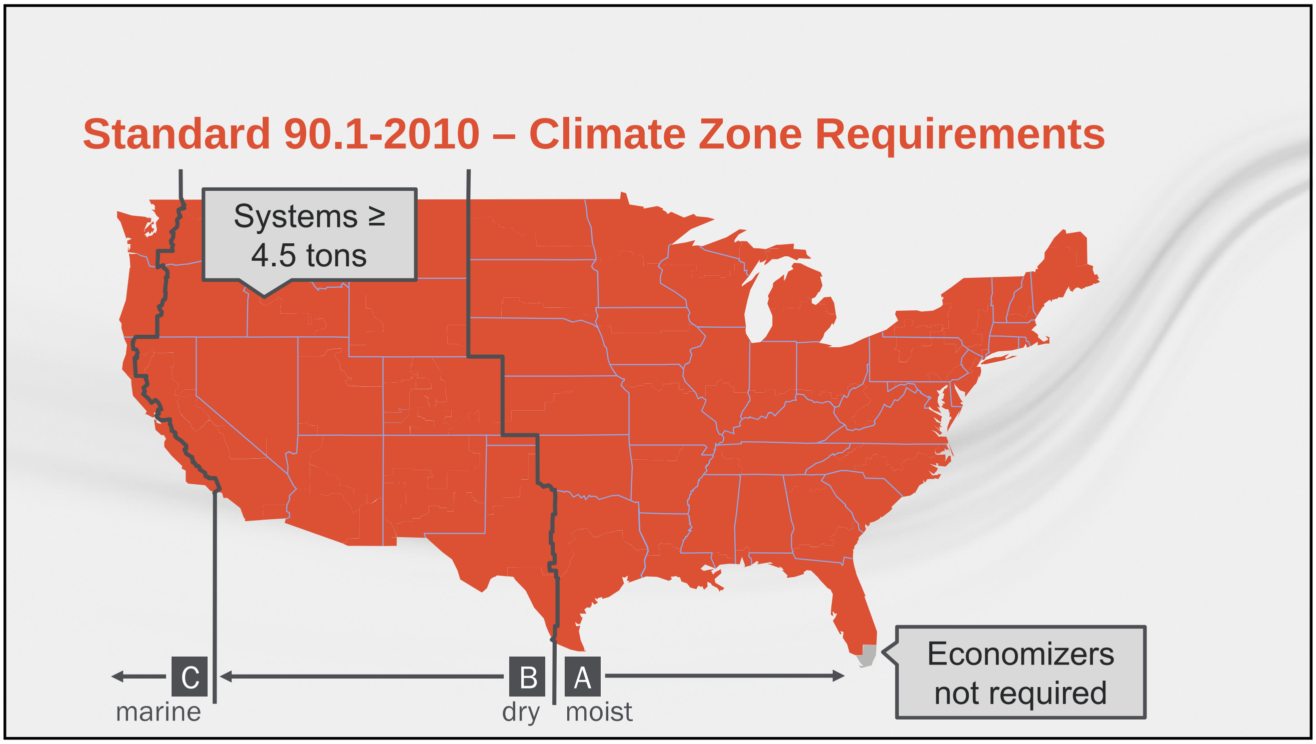
Air Economizer Design Capacity

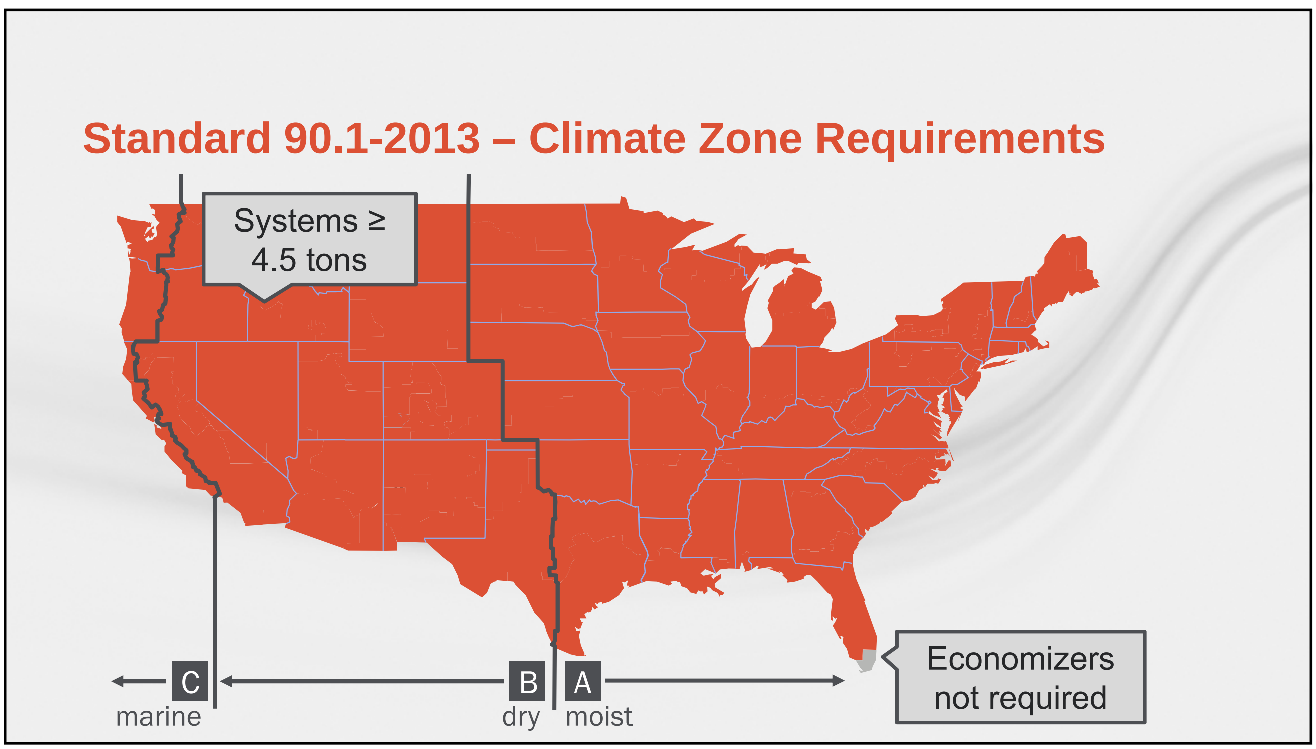
Design Capacity. Air economizer systems shall be capable of modulating outdoor air and return air dampers to provide up to 100% of the design supply air quantity as outdoor air for cooling.

Control Signal. Economizer dampers shall be capable of being sequenced with the mechanical cooling equipment and shall not be controlled by only mixed-air temperature.

Standard 90.1-2007 – Climate Zone Requirements




Standard 90.1-2010 – Climate Zone Requirements
Systems ≥ 4.5 tons
Economizers not required
C
B
A
marine
dry
moist


Standard 90.1-2013 – Climate Zone Requirements
Systems ≥ 4.5 tons
Economizers not required
C
B
A
marine
dry
moist

Standard 90.1-2013 Table 6.5.1-1 – Comfort Cooling Applications

Climate Zone	Economizer required when…
1A, 1B	No economizer requirement
2A, 2B, 3A, 4A, 5A, 6A 3B, 3C, 4B, 4C, 5B, 5C, 6B, 7, 8	≥ 54,000 Btu/h (4.5 tons)

Standard 90.1-2013 Table 6.5.1-1 – Computer Room Applications

Climate Zone	Economizer required when…
1A, 1B, 2A, 3A, 4A	No economizer requirement
2B, 5A, 6A, 7, 8	≥ 135,000 Btu/h (11.3 tons)
3B, 3C, 4B, 4C, 5B, 5C, 6B	≥ 65,000 Btu/h (5.4 tons)

Standard 90.1-2007 – High-Limit Shutoff Setpoints

Control Type	Allowed in Climate Zone	Shutoff When…
	1B, 2B, 3B, 3C, 4B, 4C, 5B, 5C, 6B, 7, 8	T_{OA} > 75°F
Fixed Dry-bulb	5A, 6A	T_{OA} > 70°F
	All other climate zones	T_{OA} > 65°F
Differential Dry-bulb	1B, 2B, 3B, 3C, 4B, 4C, 5A, 5B, 5C, 6A, 6B, 7, 8	$T_{OA} > T_{RA}$
Fixed Enthalpy	1A, 2A, 3A, 4A, 5A, 6A	h_{OA} > 28 Btu/lb
Electronic Enthalpy	All	(T_{OA}, RH_{OA}) > A curve
Differential Enthalpy	All	$h_{OA} > h_{RA}$
Dew-point and Dry-bulb Temperatures	All	DP_{OA} > 55°F or T_{OA} > 75°F

Standard 90.1-2010 – High-Limit Shutoff Setpoints

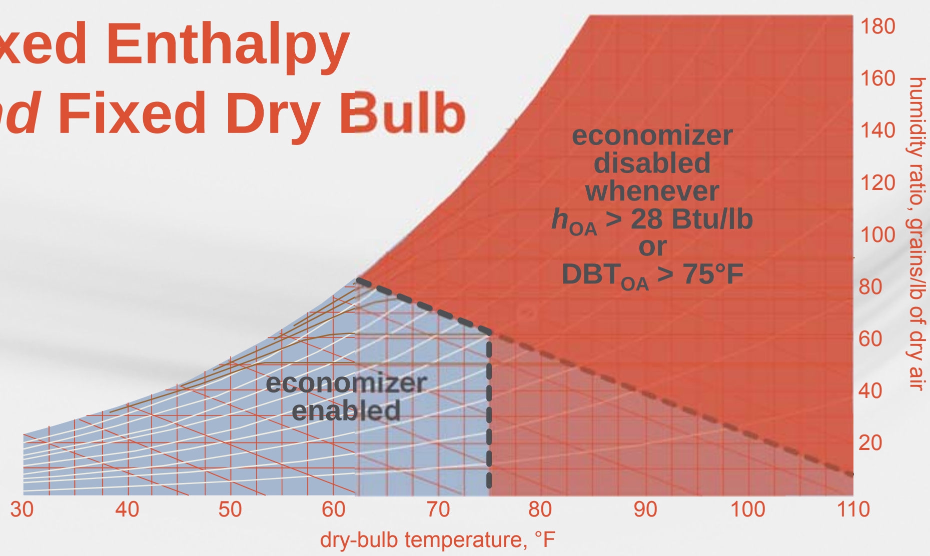
Control Type	Allowed in Climate Zone	Shutoff When…
Fixed Dry-bulb	1B, 2B, 3B, 3C, 4B, 4C, 5B, 5C, 6B, 7, 8	T_{OA} > 75°F
	5A, 6A	T_{OA} > 70°F
	~~All other climate zones~~	~~T_{OA} > 65°F~~
Differential Dry-bulb	1B, 2B, 3B, 3C, 4B, 4C, 5A, 5B, 5C, 6A, 6B, 7, 8	$T_{OA} > T_{RA}$
Fixed Enthalpy	1A, 2A, 3A, 4A, 5A, 6A	h_{OA} > 28 Btu/lb
Electronic Enthalpy	All	(T_{OA}, RH_{OA}) > A curve
Differential Enthalpy	All	$h_{OA} > h_{RA}$
Dew-point and Dry-bulb Temperatures	All	DP_{OA} > 55°F or T_{OA} > 75°F

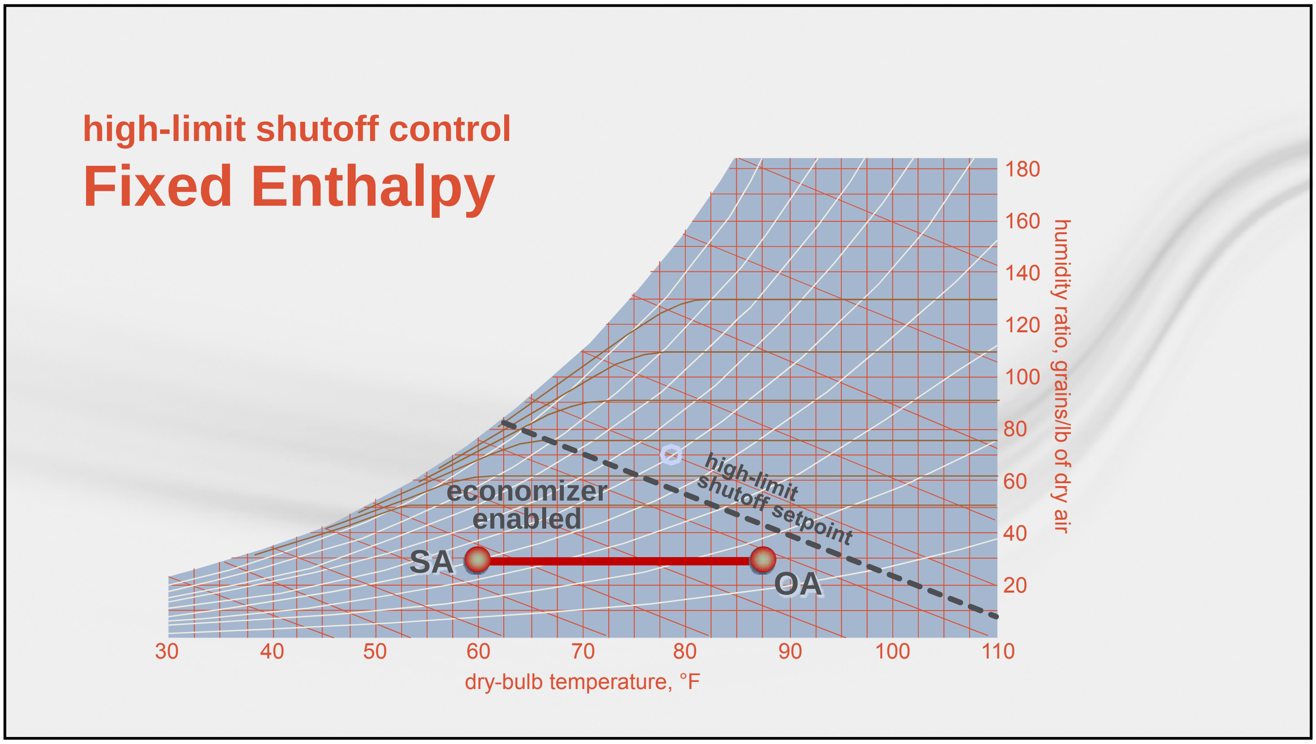
Standard 90.1-2013 – High-Limit Shutoff Setpoints

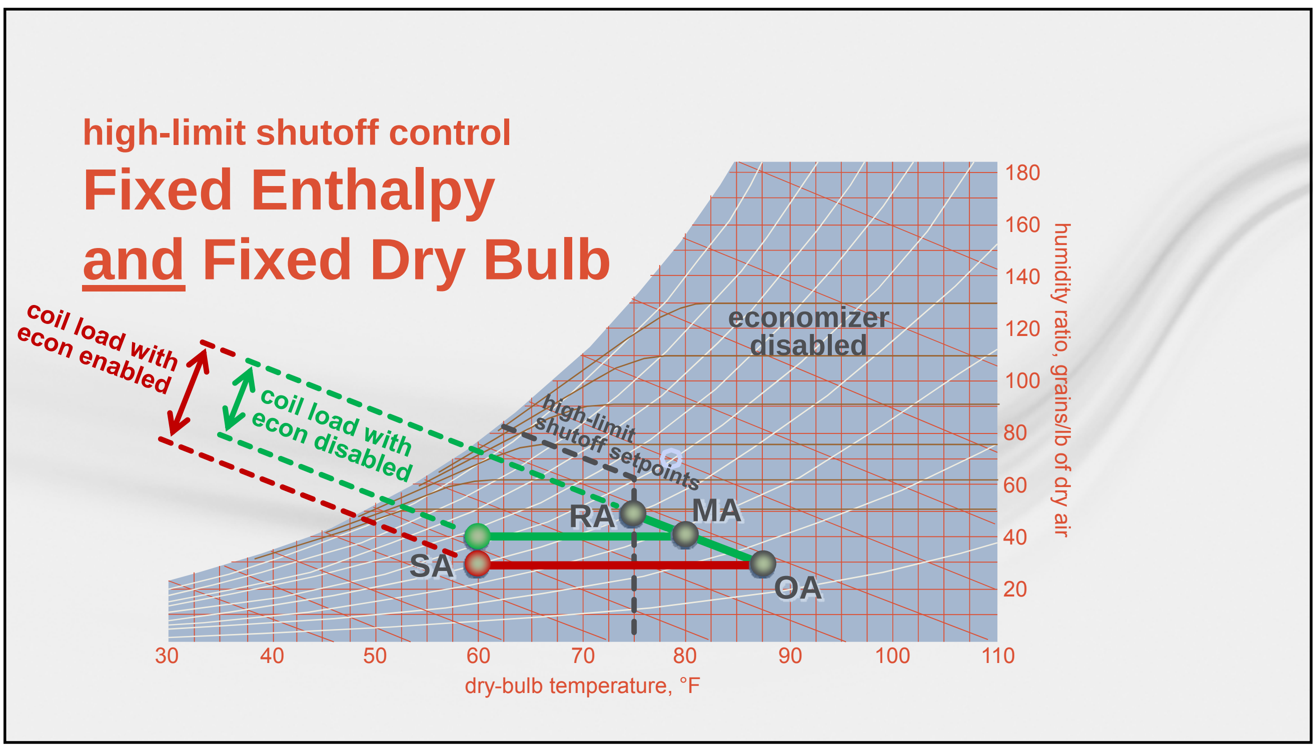
Control Type	Allowed in Climate Zone	Shutoff When…
Fixed Dry-bulb	1B, 2B, 3B, 3C, 4B, 4C, 5B, 5C, 6B, 7, 8	T_{OA} > 75°F
	5A, 6A	T_{OA} > 70°F
	1A, 2A, 3A, 4A	T_{OA} > 65°F
Differential Dry-bulb	1B, 2B, 3B, 3C, 4B, 4C, 5A, 5B, 5C, 6A, 6B, 7, 8	$T_{OA} > T_{RA}$
Fixed enthalpy with fixed dry-bulb temperature	1A, 2A, 3A, 4A, 5A, 6A	h_{OA} > 28 Btu/lb -or- T_{OA} > 75°F
Differential enthalpy with fixed dry-bulb temperature	All	$h_{OA} > h_{RA}$ -or- T_{OA} > 75°F

high-limit shutoff control

Fixed Enthalpy *and* Fixed Dry Bulb

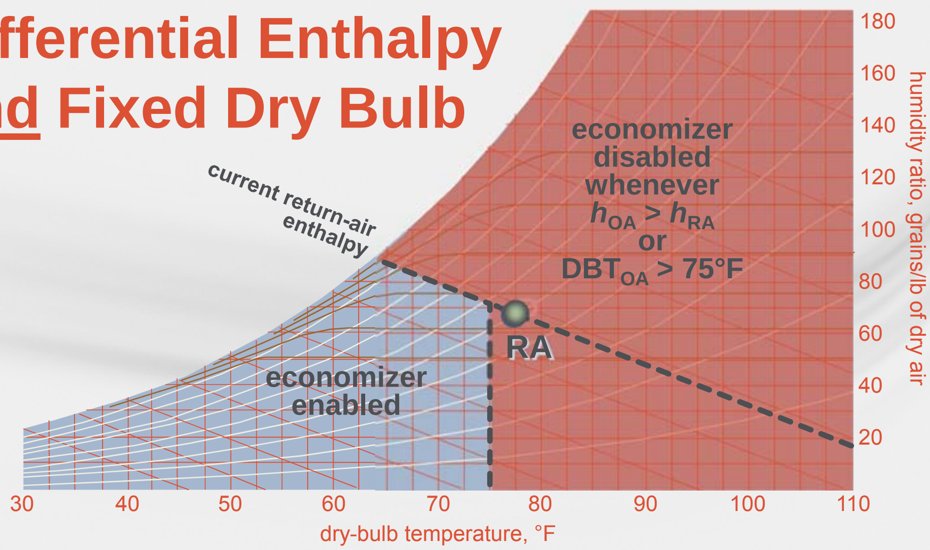



high-limit shutoff control
Fixed Enthalpy
economizer enabled
high-limit shutoff setpoint
SA
OA
180
160
140
120
100
80
60
40
20
humidity ratio, grains/lb of dry air
30
40
50
60
70
80
90
100
110
dry-bulb temperature, °F


high-limit shutoff control
Fixed Enthalpy
and Fixed Dry Bulb
coil load with econ enabled
coil load with econ disabled
economizer disabled
high-limit shutoff setpoints
RA
MA
SA
OA
180
160
140
120
100
80
60
40
20
humidity ratio, grains/lb of dry air
30
40
50
60
70
80
90
100
110
dry-bulb temperature, °F

high-limit shutoff control

Differential Enthalpy and Fixed Dry Bulb



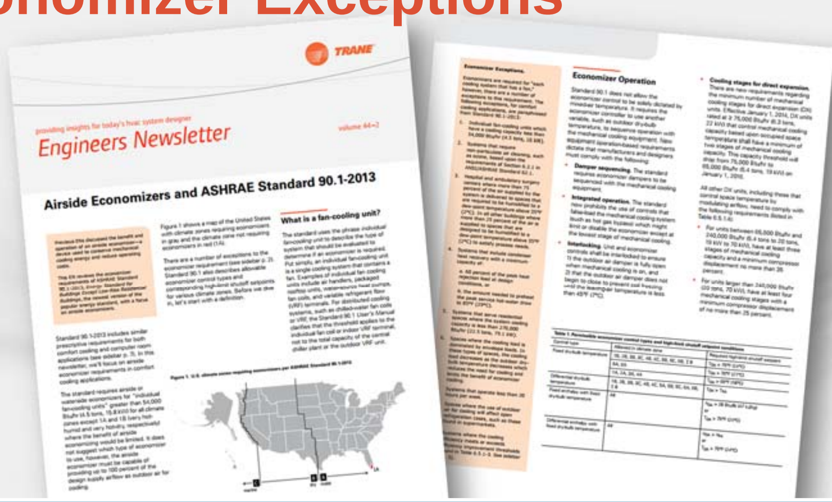
Sensor Accuracy

Sensor Type	Accuracy Threshold	Range
Dry-bulb, wet-bulb	±2 °F	40 to 80°F
Enthalpy, sensors computing differential enthalpy	±3 Btu/lb	20 to 36 Btu/lb
Relative humidity	±5% RH	20 to 80% RH

Economizer Exceptions

- Ten exceptions
- Building- or space-specific (e.g. hospitals, supermarkets)
- Condenser heat recovery
- Better-than-minimum energy efficiency
- Computer room exceptions

Economizer Exceptions



"Airside Economizers and ASHRAE Standard 90.1-2013" – www.trane.com/EN

Economizer Exceptions

1. Individual fan cooling units with a cooling capacity less than 54,000 Btu/hr (4.5 tons).
2. Systems that require non-particulate air cleaning based upon section 6.2.1 of ASHRAE Standard 62.1.
3. Hospitals and ambulatory surgery centers where more than 75% of supplied air must be humidified. In other buildings where humidification is needed for process loads.
4. Systems with condenser heat recovery with a minimum capacity of:
   a. 60% of the peak heat rejection load at design.
   b. The amount needed to preheat the peak service water draw to 85F.
5. Systems that serve residential spaces.
6. Envelope-cooling load dominated spaces.
7. Systems that operate less than 20 hours per week.
8. Spaces where outdoor air cooling will affect refrigerated cases.
9. Systems where the cooling efficiency meets or exceeds efficiency improvement thresholds found in Table 6.5.1-3.

Economizer Exceptions, continued

10. Systems primarily serving computer rooms where:
    a. Total computer room design cooling load less than 3,000,000 Btu/hr;
    b. Room total design cooling load is less than 600,000 Btu/hr and served by central chilled water;
    c. The local water authority doesn’t allow cooling towers; or
    d. Less than 600,000 Btu/hr of computer room equipment is added to an existing building.

Model Codes – 2015 IECC

- International Energy Conservation Code (IECC)
- Developed as a model code to be adopted or modified and adopted by jurisdictions
- Section C403 Building Mechanical Systems of Chapter 4 details HVAC system requirements
- Requirements similar to Standard 90.1, except:
  - C403.2.4.7 Economizer Fault Detection and Diagnostics

Notable Differences in the 2015 IECC

Economizer Exceptions

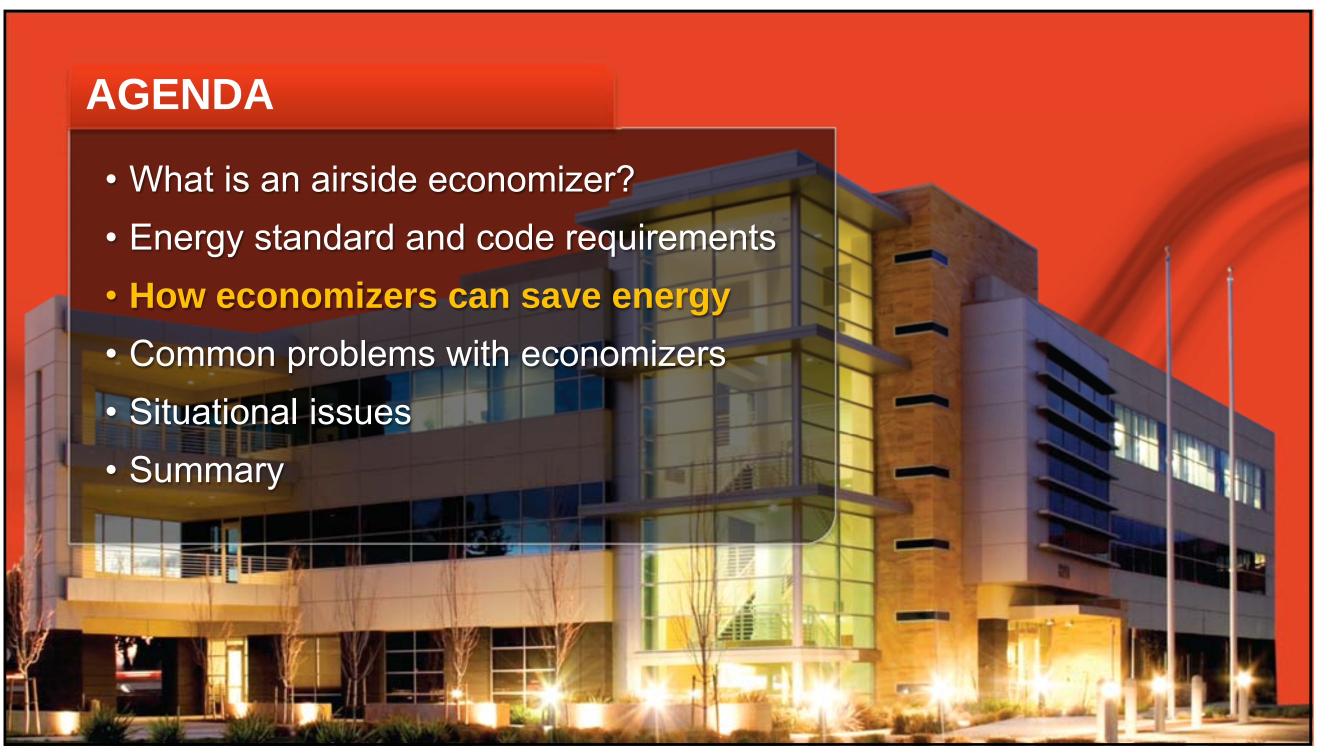
- Units < 4.5 tons exempted if:
  - System uses DX coil, or
  - Total chilled-water capacity less than Table C403.3(1)
- Exempted if cooling equipment efficiency exceeds climate-zone-dependent requirement

Fault Detection and Diagnostics

2015 IECC Compliance Paths – Chapter 4

C401.2 Application

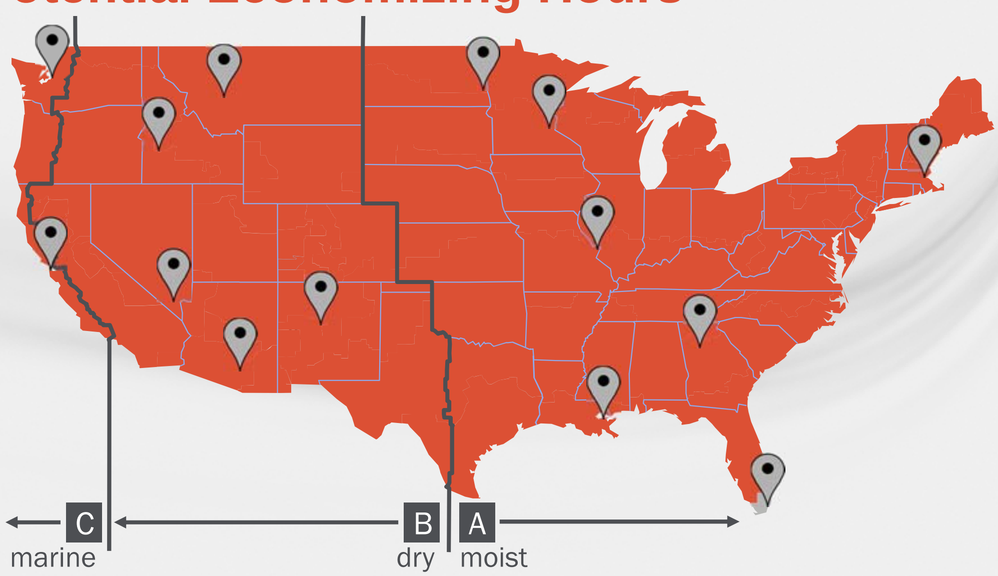
1. Requirements of ASHRAE 90.1.
2. Requirements of C402 through C405. Commercial buildings should comply with C406 and tenant spaces comply with C406.1.1.
3. Requirements of: C402.5, C403.2, C404, C405.4, C405.6, C407. Building energy cost must be less than 85% of standard reference design building.

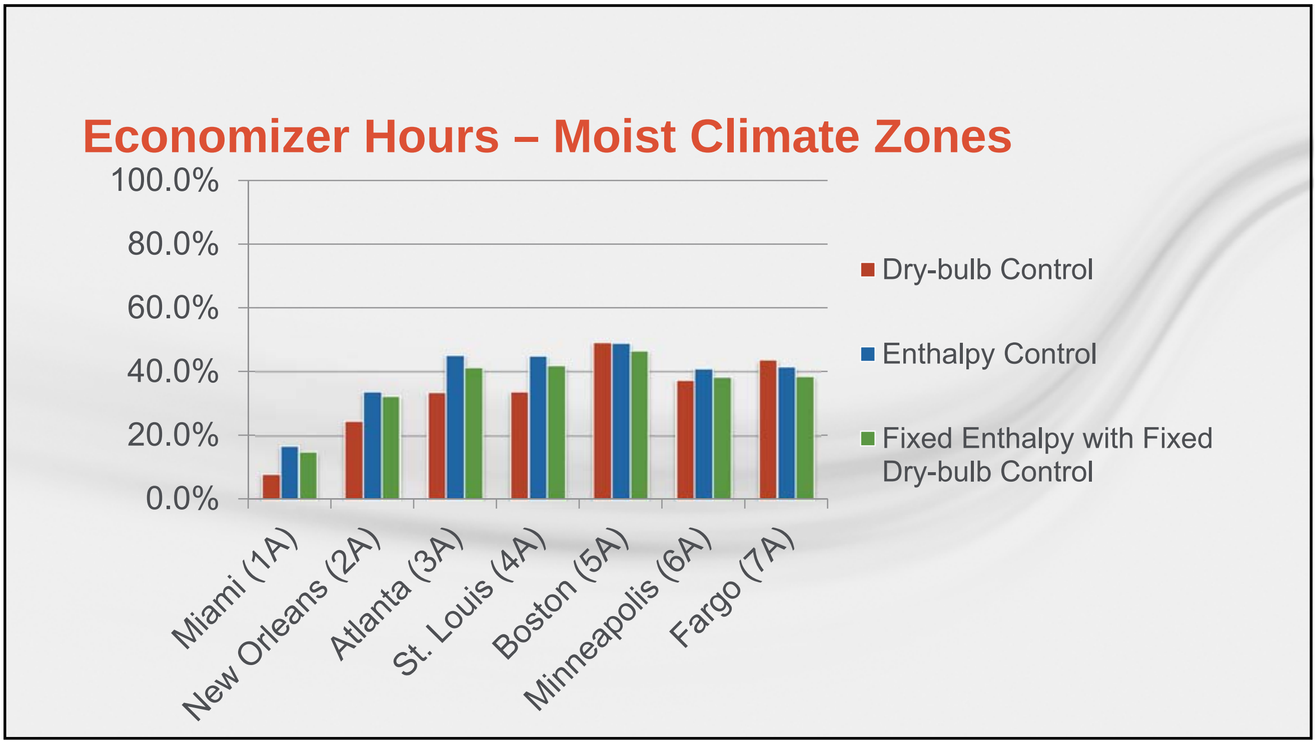


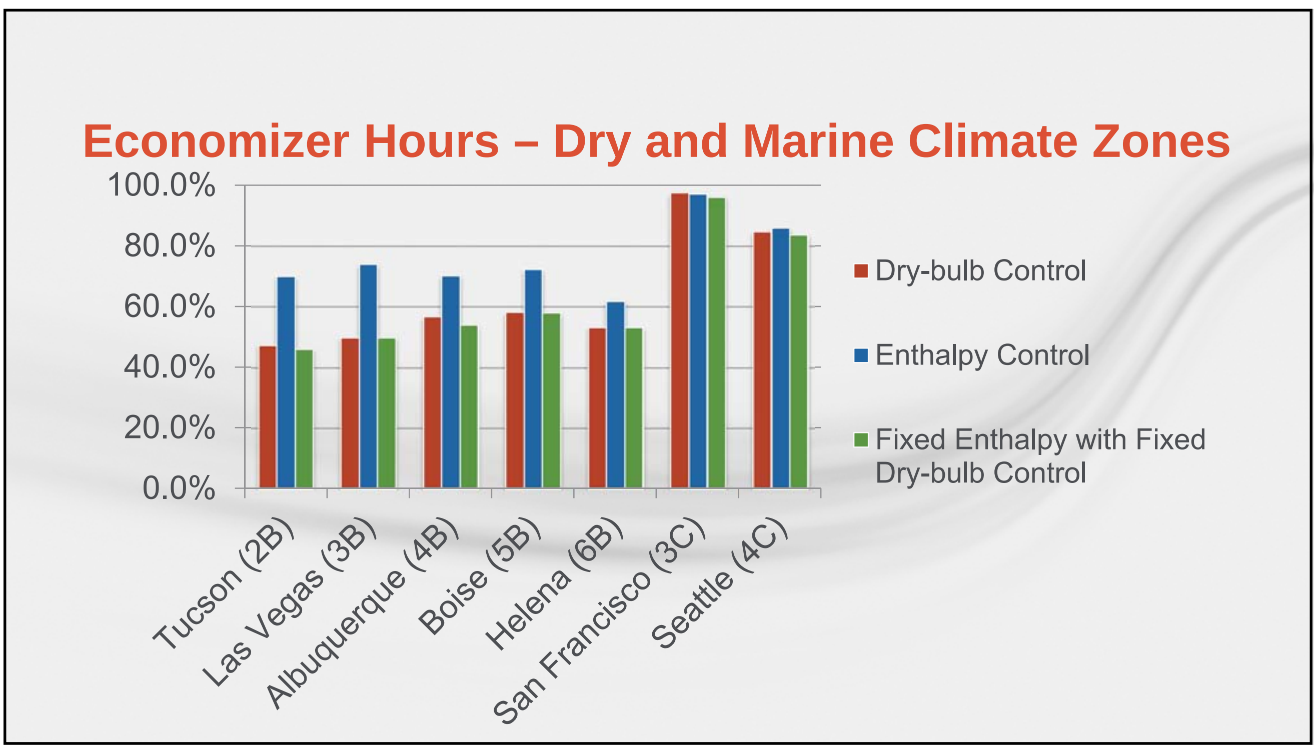
Economizer Hours Analysis

- Analysis based upon TMY3 weather data
- 2013 calendar applied
- Building is operational from 7:00 a.m. to 7:00 p.m. on weekdays; non-operational on weekends and holidays
- 3,024 operational hours
- Economizer disabled when OADB < 40°F

Potential Economizing Hours



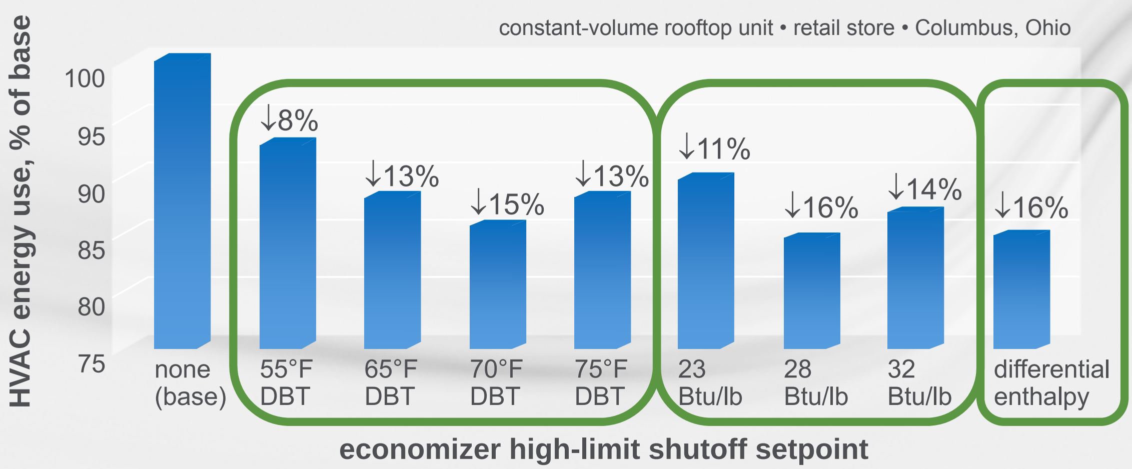

Economizer Hours – Moist Climate Zones
100.0%
80.0%
60.0%
40.0%
20.0%
0.0%
Miami (1A)
New Orleans (2A)
Atlanta (3A)
St. Louis (4A)
Boston (5A)
Minneapolis (6A)
Fargo (7A)
Dry-bulb Control
Enthalpy Control
Fixed Enthalpy with Fixed Dry-bulb Control


Economizer Hours – Dry and Marine Climate Zones
100.0%
80.0%
60.0%
40.0%
20.0%
0.0%
Tucson (2B)
Las Vegas (3B)
Albuquerque (4B)
Boise (5B)
Helena (6B)
San Francisco (3C)
Seattle (4C)
Dry-bulb Control
Enthalpy Control
Fixed Enthalpy with Fixed Dry-bulb Control

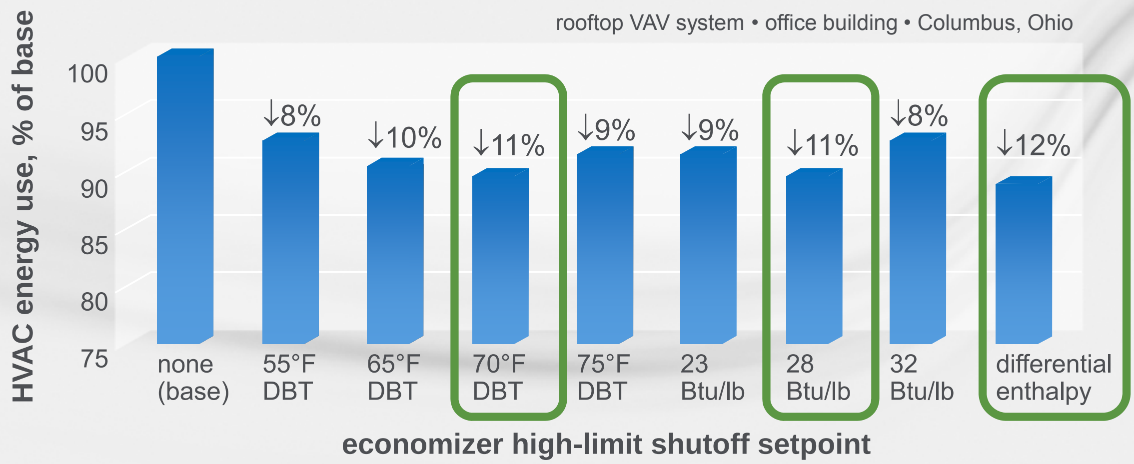
Example TRACE™ 700 Analysis

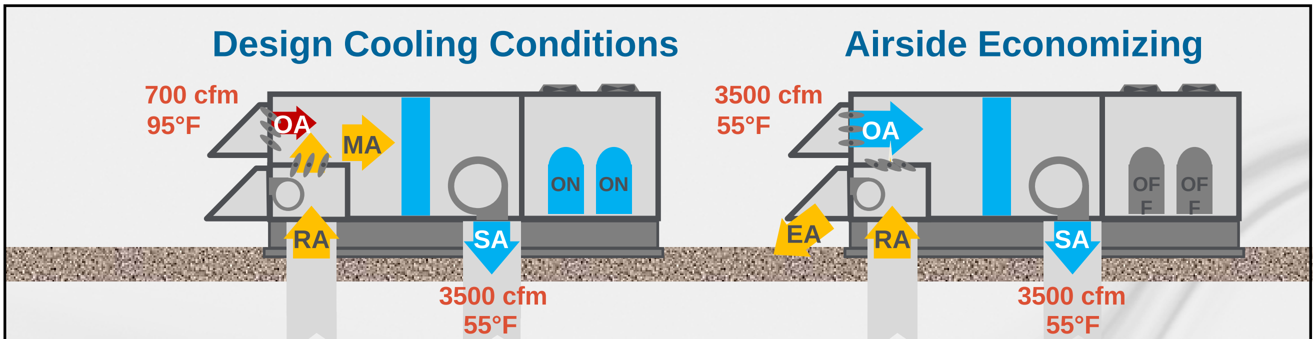
- Columbus, Ohio (climate zone 5A)
- Retail store
  - Constant-volume rooftop
- Office building
  - Rooftop VAV system

TRACE Analysis: CV System



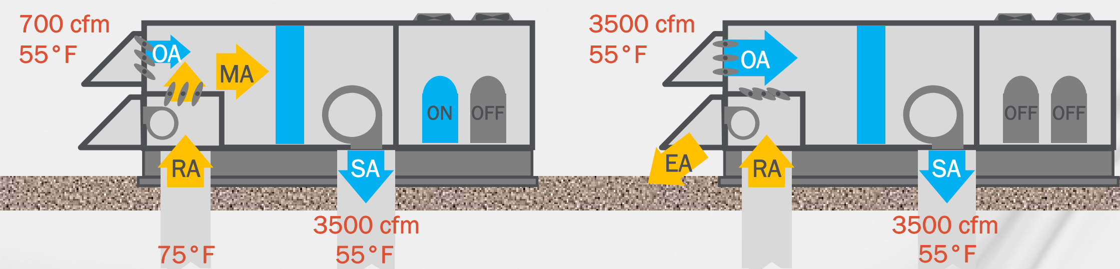
TRACE Analysis: VAV System





	Design Cooling Conditions	Airside Economizing
compressors	7.8 kW	0 kW
condenser fans	0.5 kW	0 kW
supply fan	1.2 kW	1.2 kW
relief (exhaust) fan	0 kW	0.3 kW
total power	**9.5 kW**	**1.5 kW**
cooling capacity	112 MBh (9.3 tons)	76 MBh (6.3 tons)
efficiency, EER	**11.8 EER**	**50.7 EER**

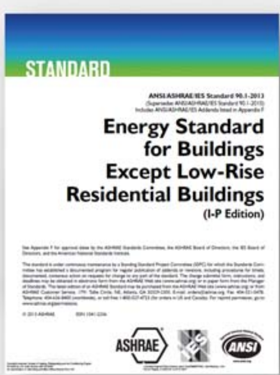
	Economizer Disabled	Airside Economizing



	Economizer Disabled	Airside Economizing
compressors	3.0 kW	0 kW
condenser fans	0.3 kW	0 kW
supply fan	1.2 kW	1.2 kW
relief (exhaust) fan	0 kW	0.3 kW
total power	**4.5 kW**	**1.5 kW**
cooling capacity	76 MBh (6.3 tons)	76 MBh (6.3 tons)
efficiency, EER	**16.9 EER**	**50.7 EER**

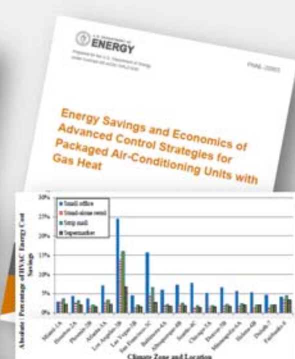
economizer energy savings

What Others Say



ASHRAE

Texas A&M University



U.S. Department of Energy

Advanced Energy Design Guides

Common Problems with Economizers

- Dampers, actuators, or controls not setup properly
- Damper or actuator failure
- Humidity sensor accuracy/reliability
- Elevated indoor humidity levels
- Building pressure control

Economizer Setup

- On-site inspection
- Functional testing
- Commissioning

A. Functional Testing	Results
Step 1: Disable demand control ventilation systems (if applicable)	
Step 2: Enable the economizer and simulate a cooling demand large enough to drive the economizer fully open. Verify the following:	
a. Economizer damper modulates 100% open.	Y / N
b. Return air damper modulates 100% closed.	Y / N
c. For systems that meet the criteria of 2013 Building Energy Efficiency Standards Section 140.4(e)1, verify that the economizer remains 100% open with the use of mechanical cooling. This occurs when the cooling demand can no longer be met by the economizer alone.	Y / N
d. All applicable fans and dampers operate as intended to maintain building pressure.	Y / N
e. The unit heating is disabled (if applicable).	Y / N / NA
Step 3: Disable the economizer and simulate a cooling demand. Verify the following:	
a. Economizer damper closes to its minimum position.	Y / N
b. All applicable fans and dampers operate as intended to maintain building pressure.	Y / N
c. The unit heating is disabled (if applicable).	Y / N / NA
Step 4: If the unit is equipped with heating, simulate a heating demand and enable the economizer. Verify the following:	
a. Economizer damper closes to its minimum position.	Y / N / NA
b. Return air damper opens.	Y / N / NA
Step 5: Turn off the unit and verify the following:	
a. Economizer damper closes completely.	Y / N
Step 6: System returned to initial operatin	

California Title 24, 2013 Nonresidential Compliance Manual (Section 13.7.10) and form NRCA-MCH-05-A

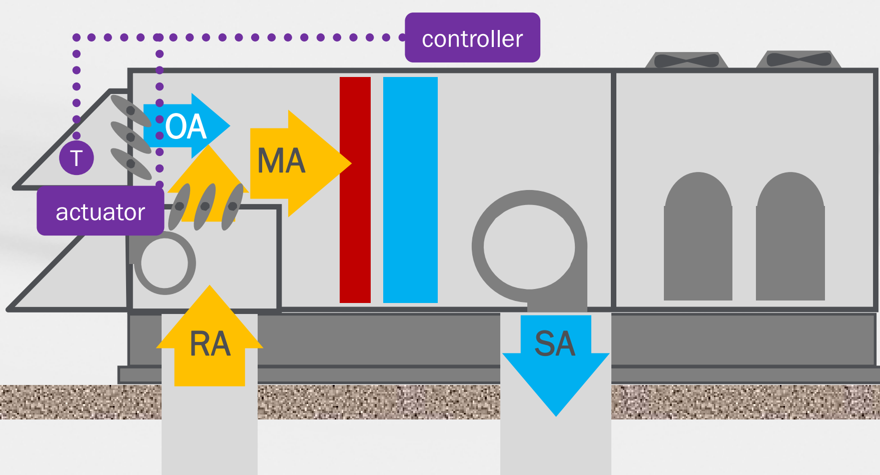
Video demonstration of acceptance testing.

Common Problems with Economizers

- Dampers, actuators, or controls not setup properly
- Damper or actuator failure
- Humidity sensor accuracy/reliability
- Elevated indoor humidity levels
- Building pressure control

Damper or Actuator Failure

Automatic Fault Detection



2015 IECC Fault Detection and Diagnostics (FDD)

Temperature Sensors

- Outdoor air temperature
- Supply air temperature
- Return air temperature

Accuracy

- ±2°F over the range of 40°F to 80°F

Operating Modes Indication

- Free cooling available
- Economizer enabled
- Compressor enabled
- Heating enabled
- Mixed air low limit cycle active

Fault Detection and Diagnostics (FDD)

- Air temperature sensor failure/fault
- Not economizing when the unit should be economizing
- Economizing when the unit should not be economizing
- Damper not modulating
- Excess outdoor air

Source: International Energy Conservation Code

FDD Certified with State of California

- AAON
- Alerton
- Bard
- Belimo
- Bryant
- Carrier
- Daikin
- Honeywell
- Johnson Controls
- Lennox
- Seasons 4
- Trane
- Transformative Wave
- WattMaster
- XCSpec

www.energy.ca.gov/title24/equipment_cert/fdd/


Active Space Temp
76.1 °F
Auto
Stop
Edit
Custom Report 1
Supply Fan Speed %
100.0 %
Supply Air Temp
72.3 °F
Active Space Temp Setpoint
55.0 °F
Active Supply Air Temp Setpoint
47.0 °F
Active Cooling Stages
1
Cooling Stages Configured
2
Outdoor Air Damper %
19.0 %
Economizing
Enabled
Alarms
Reports
Graphs
Settings


Active Space Temp
76.1 °F
Auto
Stop
Reset Alarms
Alarms
2 Active Alarms
Severity
Description
Date/Time
Service Required
Economizer Actuator Fault
06/17/2015 04:44 PM
Information
Unit Not Economizing When It Should Be
06/17/2015 04:44 PM
Active Alarms
Historic Alarms
Alarms
Reports
Graphs
Settings

Common Problems with Economizers

- Dampers, actuators, or controls not setup properly
- Damper or actuator failure
- Humidity sensor accuracy/reliability
- Elevated indoor humidity levels
- Nuisance freezestat trips
- Building pressure control

Humidity Sensor Accuracy and Reliability

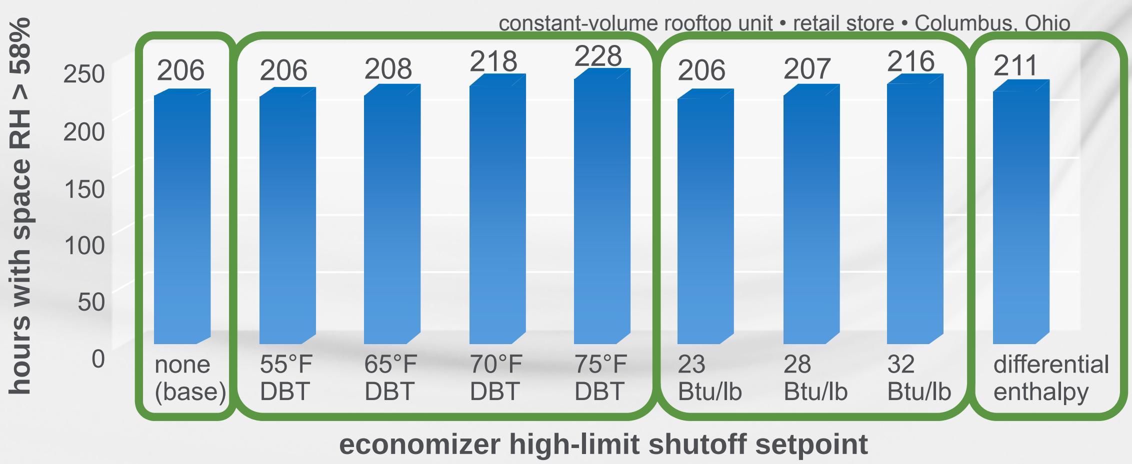
Common Problems with Economizers

- Dampers, actuators, or controls not setup properly
- Damper or actuator failure
- Humidity sensor accuracy/reliability
- Elevated indoor humidity levels
- Nuisance freezestat trips
- Building pressure control

Economizers and indoor humidity

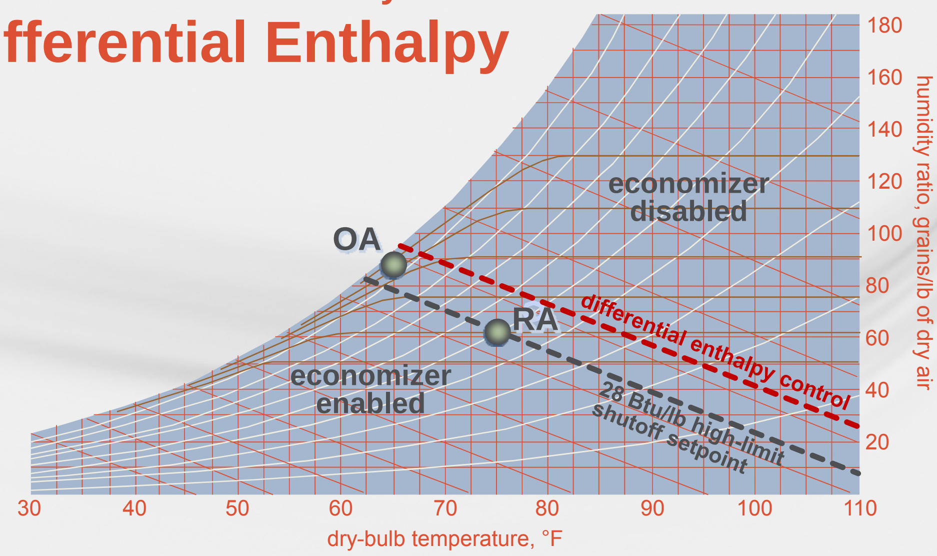
- “All airside economizers do is bring humid outdoor air into the building.”
- Choose a control scheme that includes enthalpy
- Integrated economizer control

TRACE Analysis: CV System

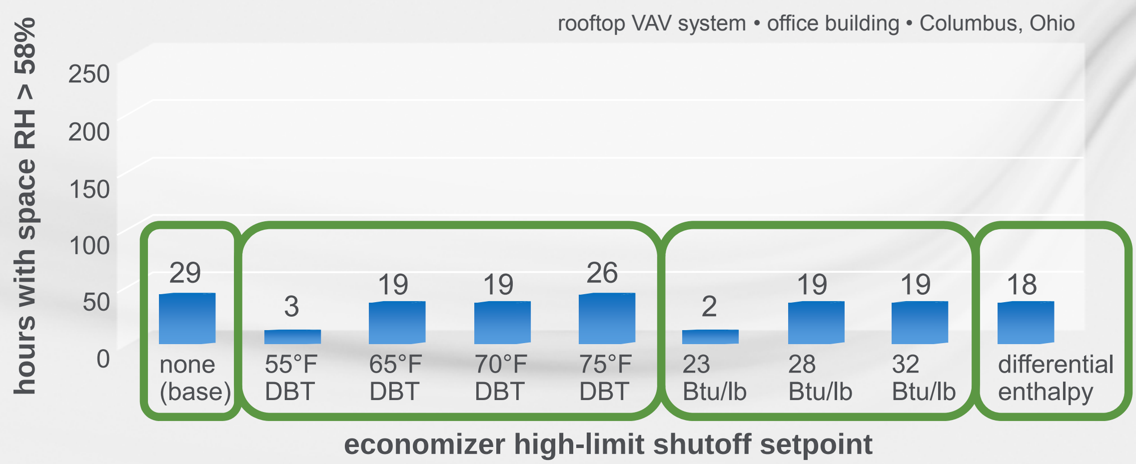


impact on indoor humidity levels

Differential Enthalpy

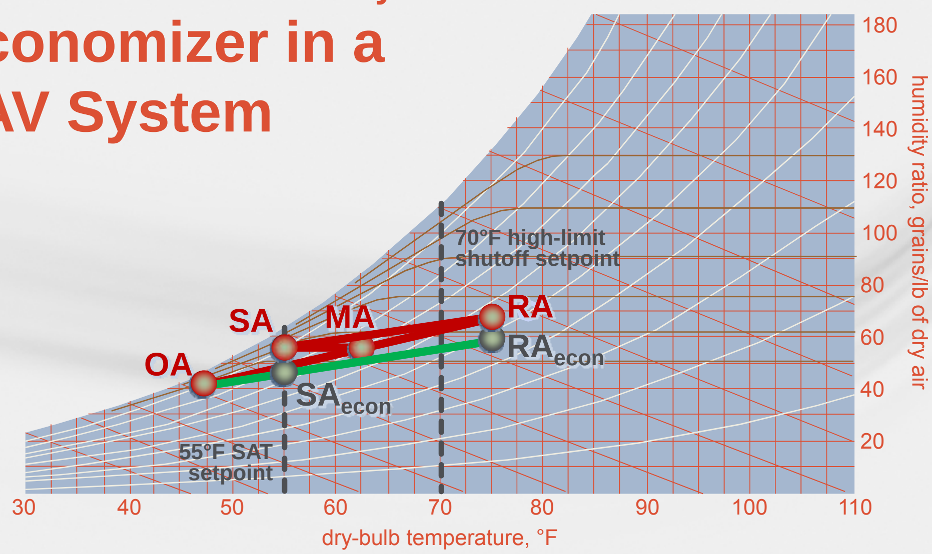


TRACE Analysis: VAV System



impact on indoor humidity levels

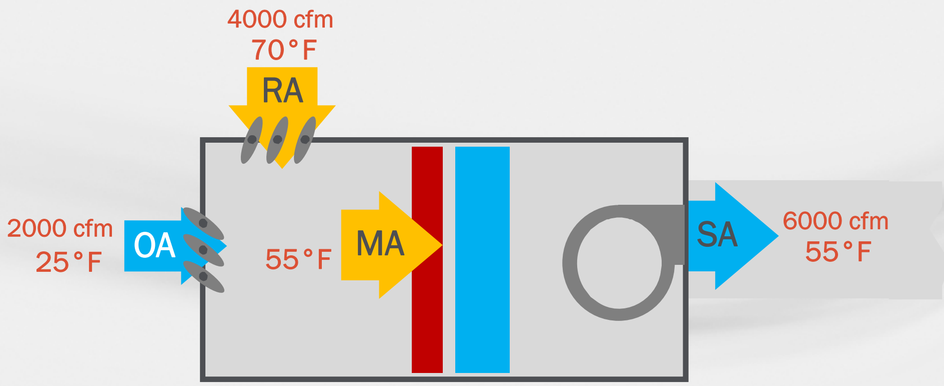
Economizer in a VAV System



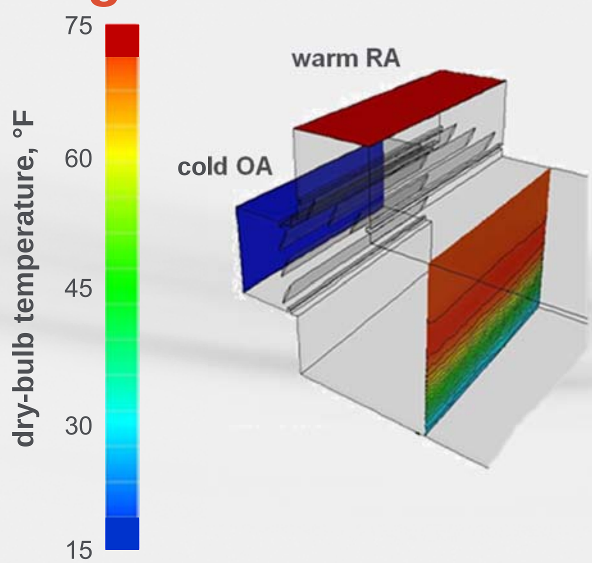
Common Problems with Economizers

- Dampers, actuators, or controls not setup properly
- Damper or actuator failure
- Humidity sensor accuracy/reliability
- Elevated indoor humidity levels
- Nuisance freezestat trips
- Building pressure control

Economizing in Sub-Freezing Weather

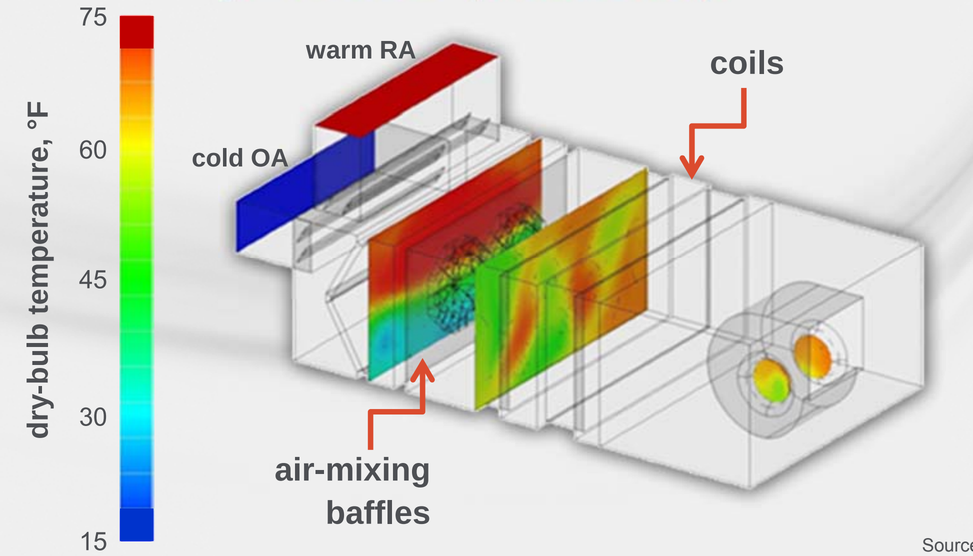


Mixing Box Stratification



Source: Blender Products, Inc.

Air-Mixing Baffles (Blender)



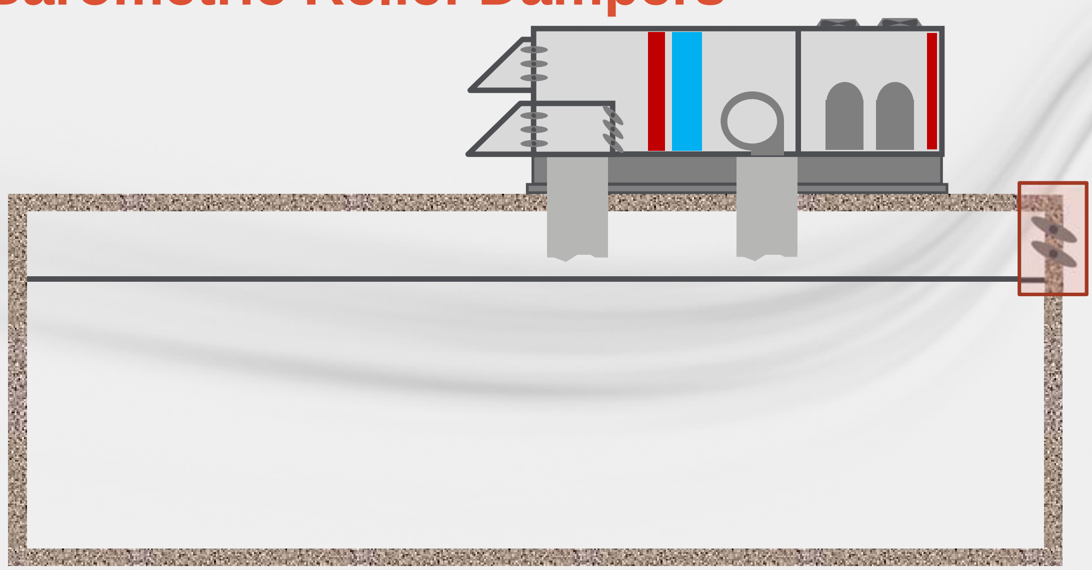
Common Problems with Economizers

- Dampers, actuators, or controls not setup properly
- Damper or actuator failure
- Humidity sensor accuracy/reliability
- Elevated indoor humidity levels
- Nuisance freezestat trips
- Building pressure control

Building Pressure Control

Section 6.5.1.1.5 Relief of Excess Outdoor Air. Systems shall provide a means to relieve excess outdoor air during air economizer operation to prevent over-pressurizing the building. The relief air outlet shall be located so as to avoid recirculation into the building.

Barometric Relief Dampers



Local Barometric Relief Dampers

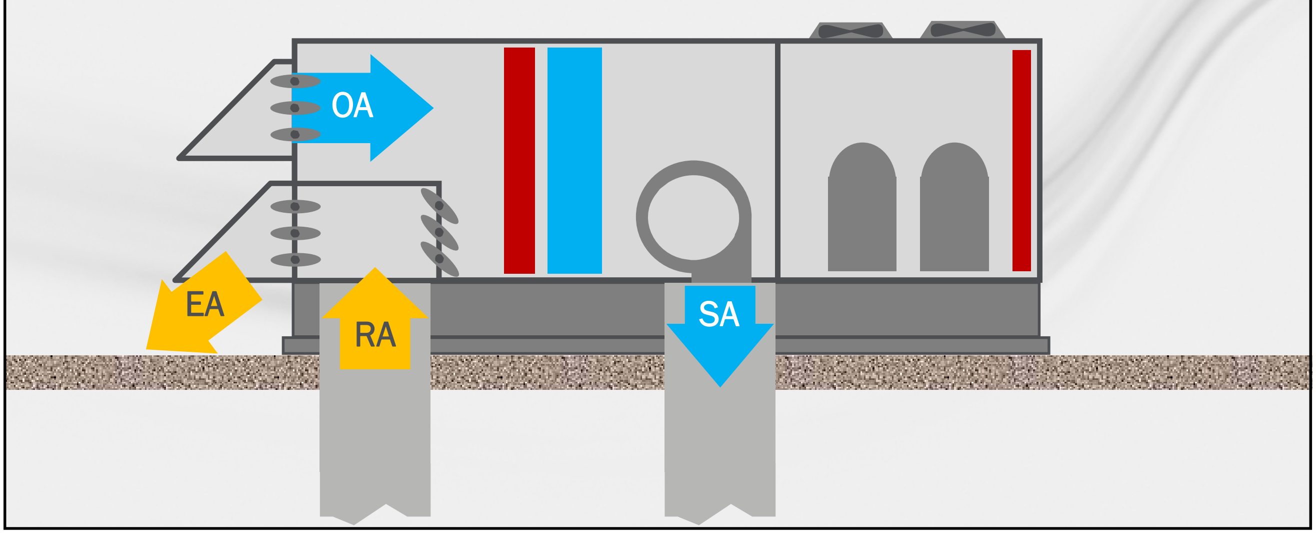
Benefits

- Inexpensive to install
- No controls or pressure sensors required for operation

Drawbacks

- Cannot maintain desired setpoint
- Must be designed to minimize the effects of wind
- May require multiple dampers
- Increases risk of leaks in envelope

Centralized Barometric Relief Dampers



Centralized Barometric Relief Dampers

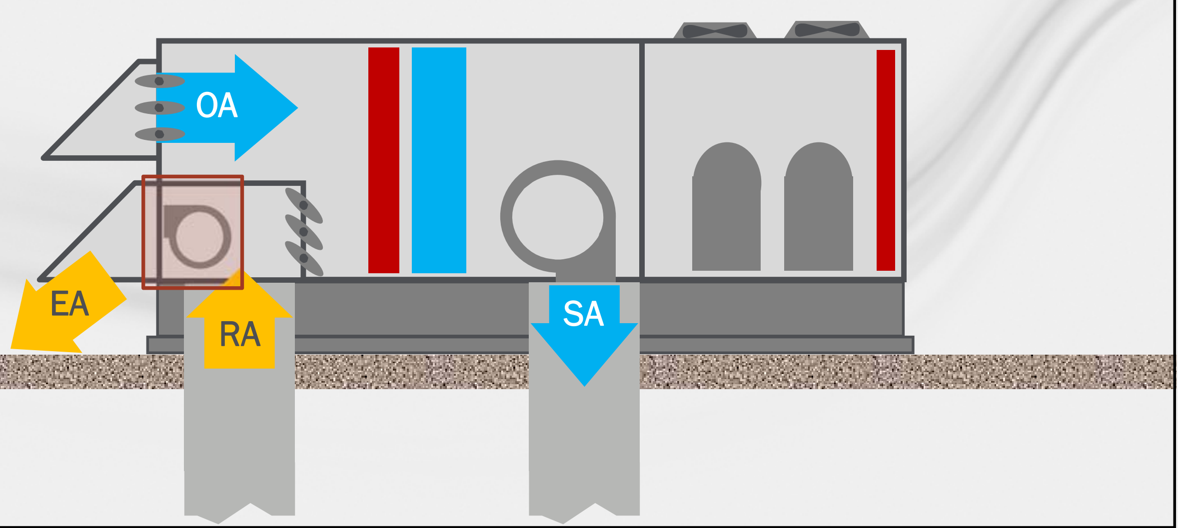
Benefits

- No controls or pressure sensors required for operation
- Factory-installed

Drawbacks

- Building pressure can fluctuate
- Only relieves under high positive pressure conditions

Central Relief Fan

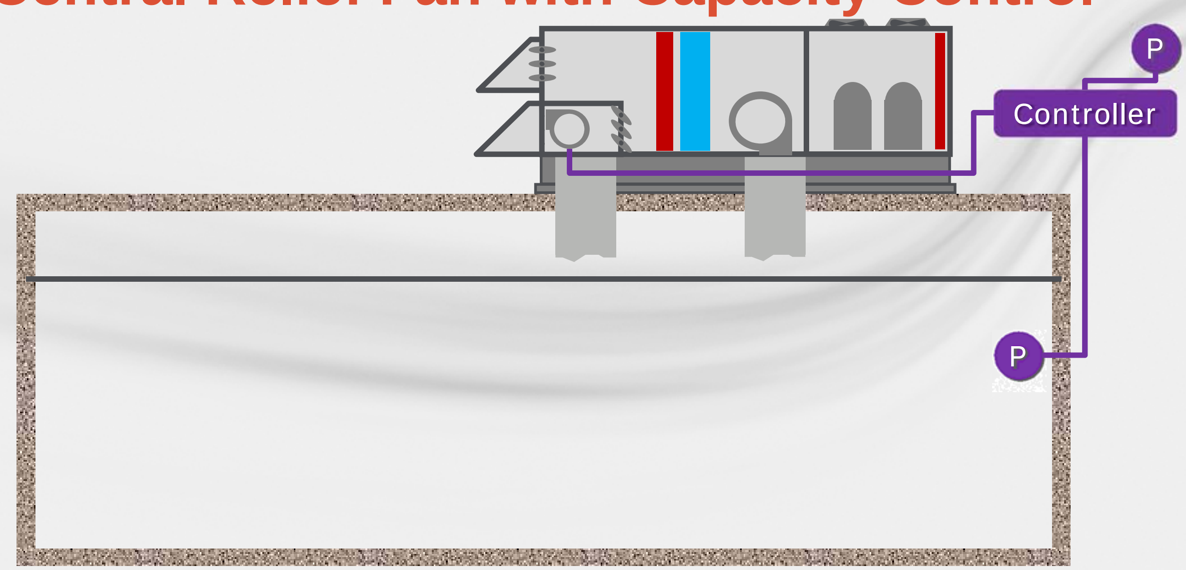


Centralized Relief Fan – On/Off Control

Benefits
- Simple control, no pressure sensors
- Easily included in air handlers and packaged units

Drawbacks
- Cannot maintain a setpoint
- Excessive depressurization during modulated economizer mode

Central Relief Fan with Capacity Control



Centralized Relief Fan – Fan Capacity Control

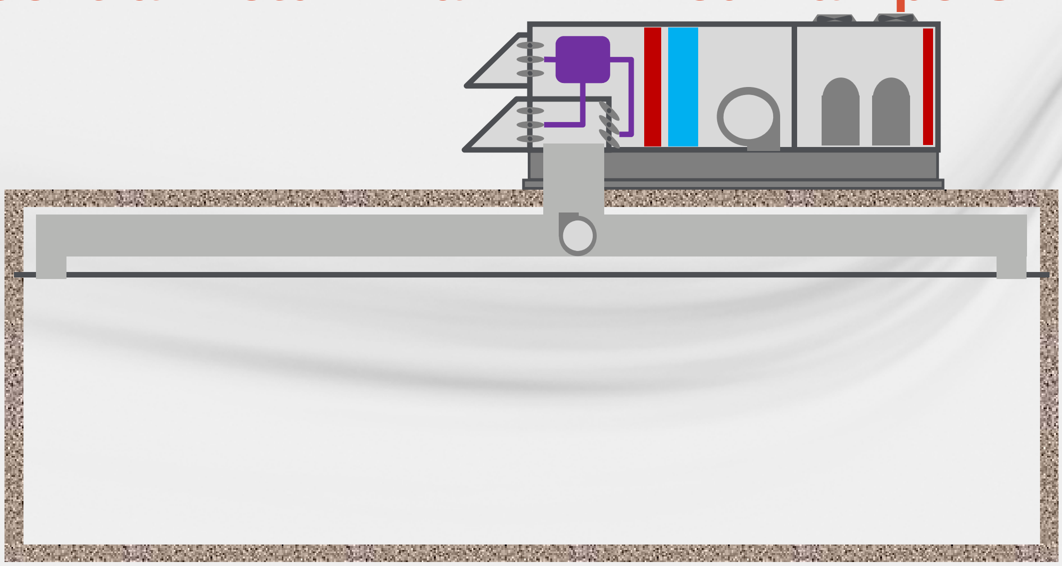
Benefits

- Stable building-pressure control
- Compensates for external influences
- Setpoints can be changed
- Modulated centralized fan can be placed anywhere in return path

Drawbacks

- May not be suitable for systems with high return-pressure drop
- Stable operation depends on pressure sensor selection and location

Central Return Fan – Linked Dampers

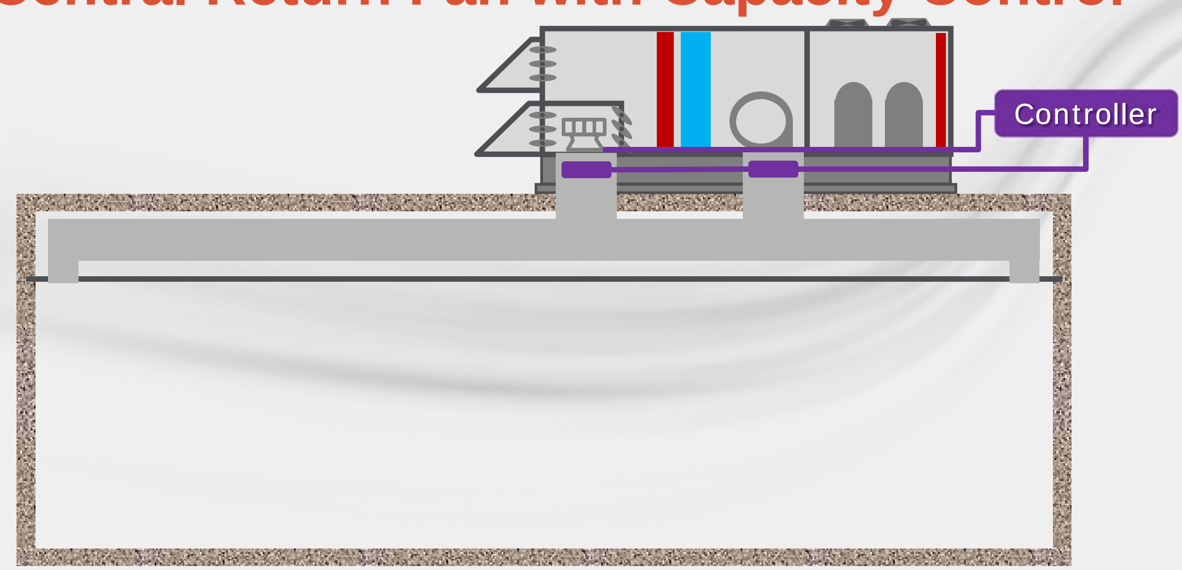


Central Return Fan – Linked Dampers

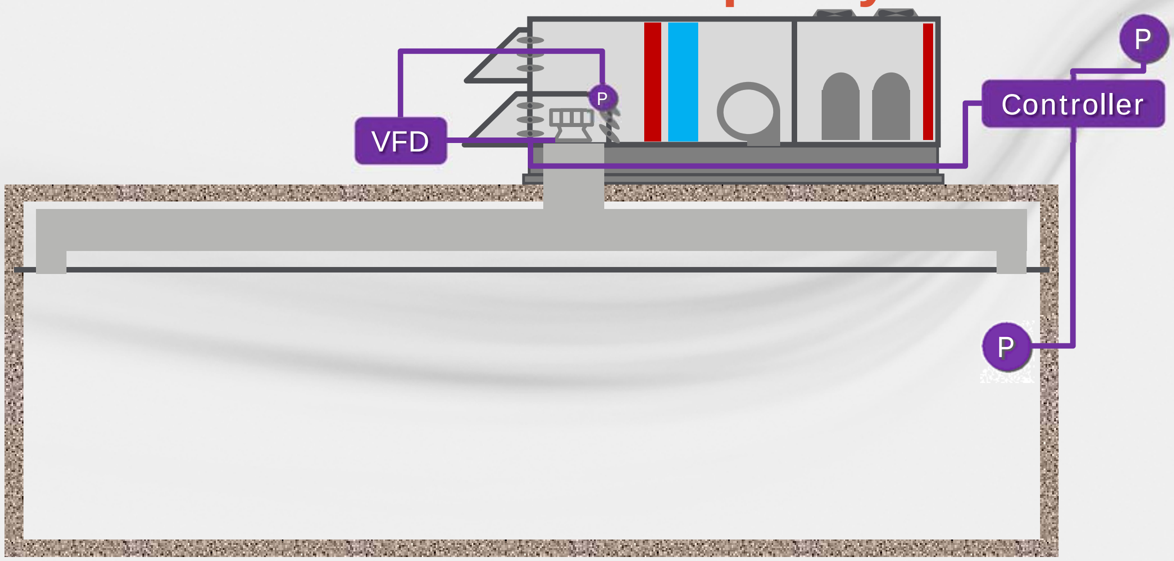
Benefits
- Simple control, no pressure sensors
- May reduce the size of the supply fan and motor

Drawbacks
- Cannot maintain a setpoint
- Limited layout flexibility

Central Return Fan with Capacity Control



Central Return Fan with Capacity Control



Centralized Return Fan – Fan Capacity Control

Benefits

- Stable building-pressure control
- Compensates for external influences
- Setpoints can be changed
- May reduce the size of the supply fan and motor

Drawbacks

- Requires additional controls: pressure sensors in return-air plenum and return fan modulation
- Stable operation depends on pressure sensor selection and location
- Limited layout flexibility

Sensor Selection

Indoor Sensor
- Type: pickup probe
- Location: large open space or central hallway on ground floor with external doors. Should be protected from wind gusts (near doors).

Outdoor Sensor
- Type: weatherproof and wind resistant
- Location: exterior of building or fixed to HVAC equipment
- Sensor should be secure to prevent people tampering or damaging it.

Building Pressure Control Summary

Local Relief
- Small buildings

Central Relief
- Locate upstream of return-air damper

Relief fan
- Constant volume – on/off control
- Variable volume – use building pressure to modulate relief fan

Return fan
- Constant volume – linked dampers
- Variable volume – relief damper modulated by building pressure; return fan modulated by return-air plenum pressure

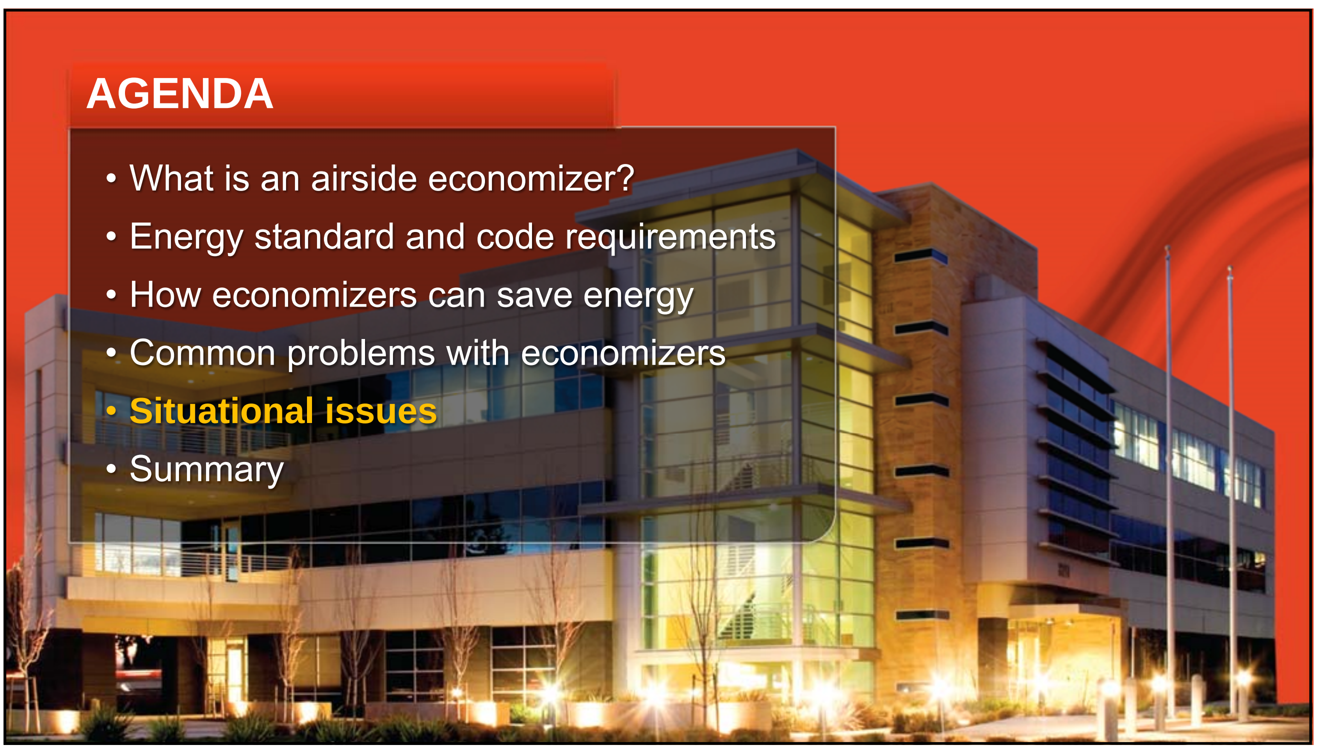
ASHRAE Guideline 16

Discusses three system arrangements:

- Return fan
- Relief fan
- Gravity or motorized relief damper

For each arrangement:

- Example control sequence
- Damper selection and sizing
- System diagram



What if an economizer cannot be used?

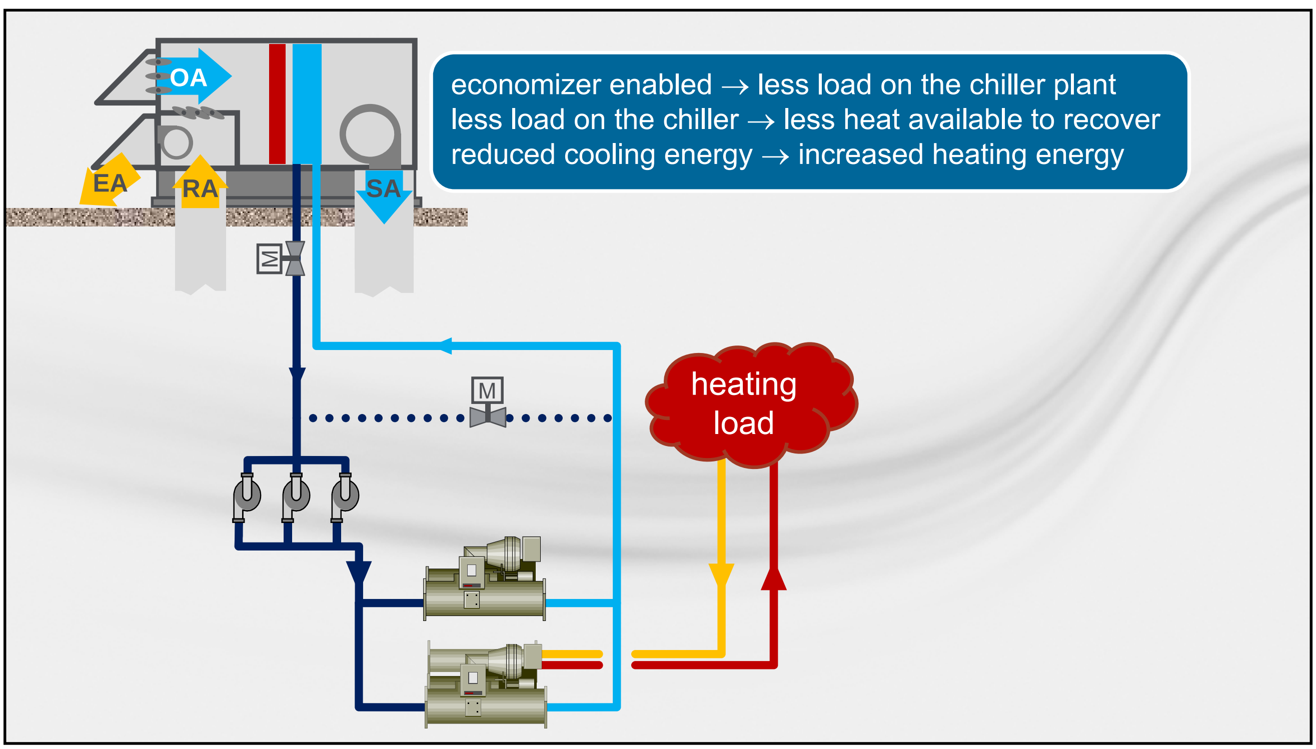
- Water economizer?
- ASHRAE Standard 90.1 – Section 11, Energy Cost Budget

Standard 90.1-2013 – Table 6.5.1-3

Climate Zone	Efficiency Improvement
2A	17%
2B	21%
3A	27%
3B	32%
3C	65%
4A	42%
4B	49%
4C	64%

Climate Zone	Efficiency Improvement
5A	49%
5B	59%
5C	74%
6A	56%
6B	65%
7	72%
8	77%

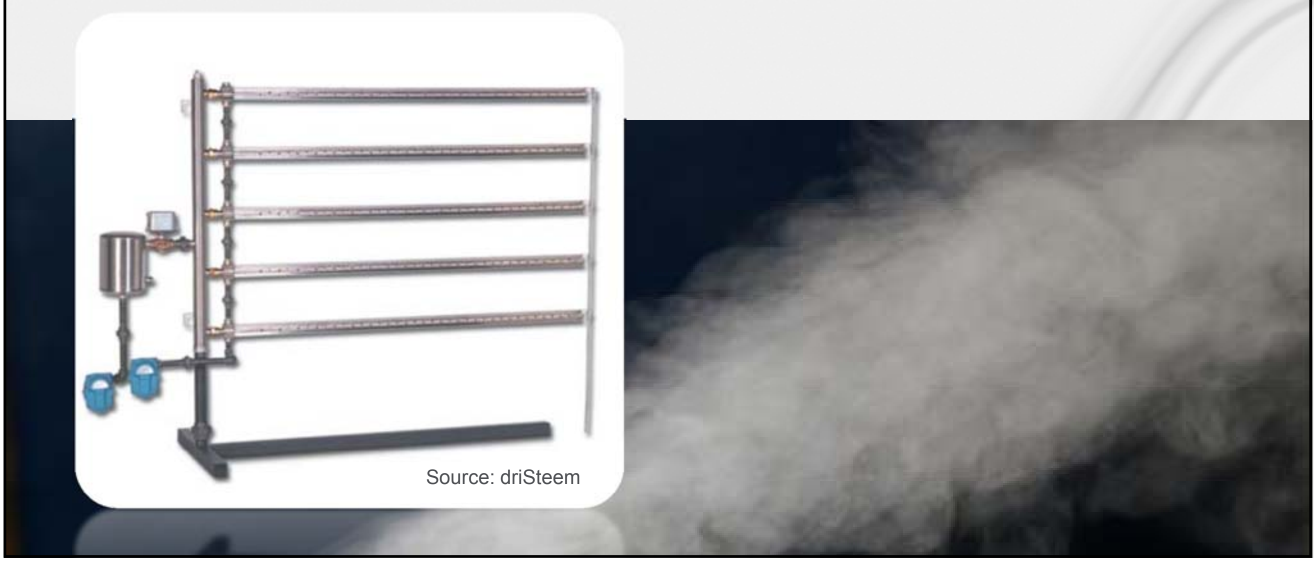

Economizers and Waterside Heat Recovery
water-cooled centrifugal chiller
with a heat-recovery condenser

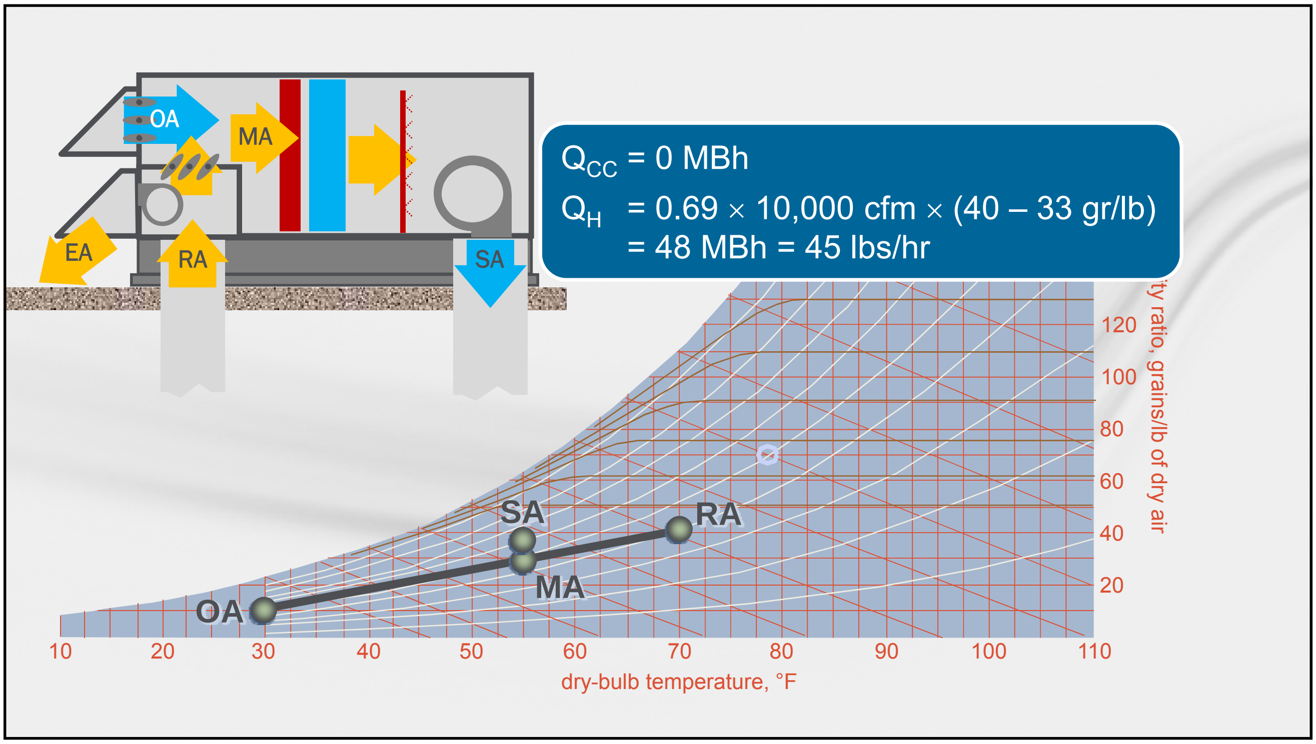

OA
EA
RA
SA
M
M
economizer enabled → less load on the chiller plant
less load on the chiller → less heat available to recover
reduced cooling energy → increased heating energy
heating load

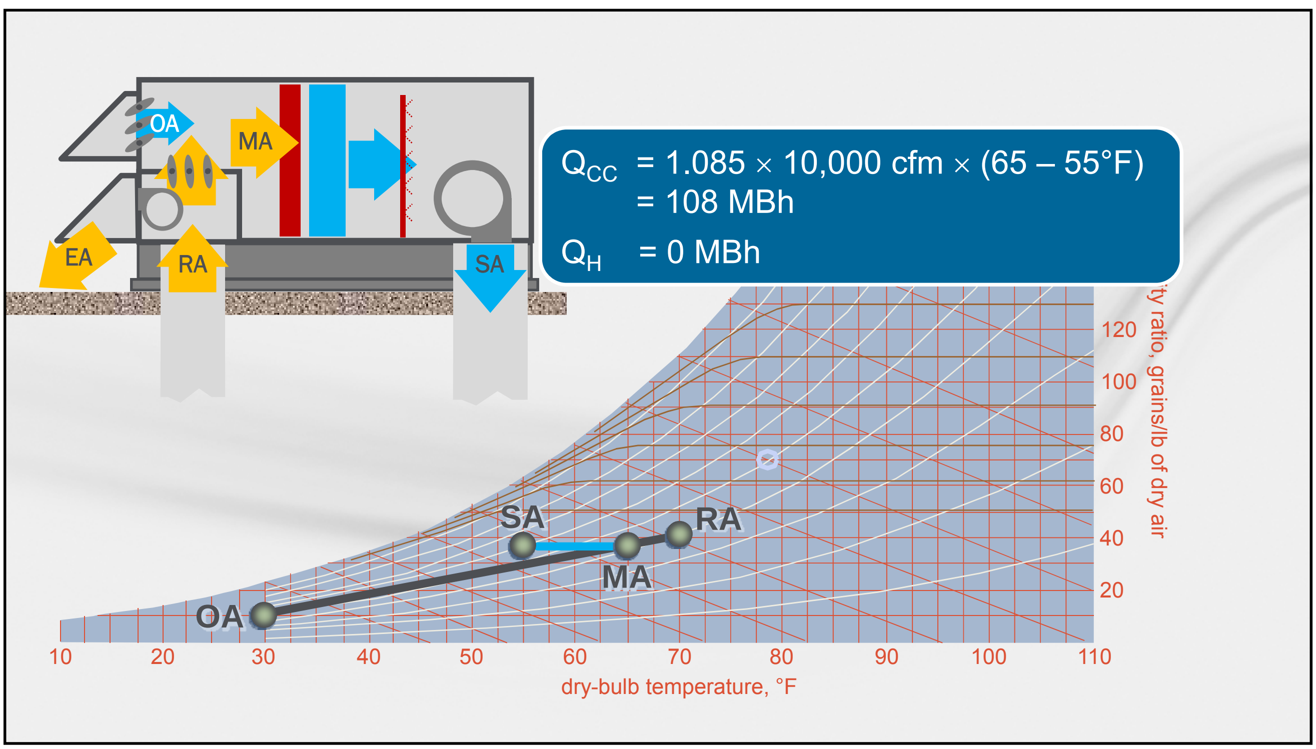
Economizers or Waterside Heat Recovery

- If heating loads are always > heat available for recovery, operate heat-recovery chiller(s); no economizing
  - *ASHRAE 90.1-2013, Section 6.5.1, Exception 4*
- If heating loads are often < heat available for recovery, limit airside economizing so heat rejected from chiller offsets entire heating load ("load-shedding economizer")

Economizers and Humidification




Q_{CC} = 0 MBh
Q_H = 0.69 × 10,000 cfm × (40 – 33 gr/lb)
= 48 MBh = 45 lbs/hr
OA
MA
EA
RA
SA
RA
SA
MA
OA
humidity ratio, grains/lb of dry air
120
100
80
60
40
20
10
20
30
40
50
60
70
80
90
100
110
dry-bulb temperature, °F


Q_{CC} = 1.085 × 10,000 cfm × (65 – 55°F)
= 108 MBh
Q_H = 0 MBh
OA
MA
EA
RA
SA
SA
RA
MA
OA
humidity ratio, grains/lb of dry air
120
100
80
60
40
20
10
20
30
40
50
60
70
80
90
100
110
dry-bulb temperature, °F

Closing

- Economizer implementation – control method, sensor accuracy, climate zone, space humidity, etc.
- Consider high-quality humidity sensors and compare readings to the internet to determine calibration needs
- Commission the system after installation
- Consider using a fault detection and diagnostic system for continuous monitoring
- Use air mixing baffles for low ambient operation

www.trane.com/bookstore

Where to Learn More

www.trane.com/bookstore

www.trane.com/ContinuingEducation

Continuing Education Courses

on-demand, no charge, 1.5 CE LEED, PE, AIA credits

- **NEW!** Chilled-Water System Design Trends
- **NEW!** Coil Selection and Optimization
- **NEW!** Evaluating Sound Data
- All-Variable Speed Compressors on Chillers
- ASHRAE Standard 62.1, 90.1 and 189.1
- High-Performance VAV Systems
- Single-Zone VAV Systems
- All Variable-Speed Chiller Plant Operation

GBCI CMP

EDUCATION PROVIDER

CONTINUING EDUCATION AIA

Remaining 2016 Programs

- Chiller Plant Performance Modeling DIY-
  Easy and Easier
- New Fan Efficiency Regulations and Recent Fan Technology Advances
- Designing Acoustics for Outdoor Applications

Trane ***Engineers Newsletter LIVE: Delivering Performance from Airside Economizers***
APP-CMC058-EN QUIZ

1. Which industry standard lists prescriptive economizer requirements for buildings?
   a. ASHRAE Standard 55
   b. ASHRAE Standard 90.1
   c. ASHRAE Standard 140
   d. AHRI Standard 885

2. Which industry model code lists prescriptive economizer requirements for buildings?
   a. International Fire Code (IFC)
   b. International Energy Conservation Code (IECC)
   c. International Building Code (IBC)

3. True/False: "integrated economizer mode" means the system operates the refrigeration compressors in combination with the airside economizer (outdoor air damper wide open).

4. True/False: the "high-limit shutoff setpoint" is a setpoint that describes when the system switches from integrated economizer mode to normal cooling (outdoor air damper at minimum position).

5. True/False: The most recent version of the International Energy Conservation Code (IECC) requires automatic fault detection and diagnostics for airside economizers.

6. What device is used to mix return and outdoor air thoroughly?
   a. Air-mixing baffles (blender)
   b. Modulating economizers
   c. Return fans

7. **True**/False: barometric relief dampers cannot control space pressure to a specific setpoint.

8. Which device might be used in a building pressure control system if the return-air path pressure drop is very high?
   a. Barometric relief dampers
   b. Return fan
   c. Integrated economizer

9. **True**/False: Standard 90.1 allows designers to increase cooling equipment efficiency by a climate-zone-dependent threshold to exempt economizer usage.

10. What type of economizer limits the operation of an airside economizer to maintain chiller heat rejection (to satisfy heating loads)?
    a. Integrated economizer
    b. Water economizer
    c. Load-shedding economizer

Bibliography

May 2016

Delivering Performance from Airside Economizers

Industry Resources

ANSI/ASHRAE/*IESNA Standard 90.1-2013: Energy Standard for Buildings Except Low-Rise Residential Buildings*. Available from www.ashrae.org/bookstore

American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc. (ASHRAE). *Standard 90.1-2013 User's Manual*. Available from www.ashrae.org/bookstore

ASHRAE Advanced Energy Design Guides. Available at www.ashrae.org/aedg

ANSI/AMCA. Standard 500-D-12 Laboratory Methods of Testing Dampers for Rating. Arlington Heights: AMCA, 2012.

California Title 24, 2013 Nonresidential Compliance Manual. Available at www.energy.ca.gov/title24

International Code Council. 2015 International Energy Conservation Code. 2014.

Wang, W., Huang, Y., Katipamula, S., and M. Brambley. "Energy Savings and Economics of Advanced Control Strategies for Packaged Air-Conditioning Units with Gas Heat." U.S. Department of Energy. December 2011.

Zhou, J., Wei, G., Turner, W., and D. Claridge. "Airside Economizer: Comparing Different Control Strategies and Common Misconceptions." Texas A&M University. October 2008.

Industry Articles (Available at www.ashrae.org)

Moser, D. "Commissioning Existing Airside Economizer Systems." *ASHRAE Journal* (March 2013).

Taylor, S. and C, Hwakong Cheng. "Economizer High Limit Controls and Why Enthalpy Economizers Don't Work." *ASHRAE Journal* (June 2010).

Trane Resources (visit http://www.trane.com/bookstore)

Sturm, E. "Airside Economizers and ASHRAE Standard 90.1-2013." *Engineers Newsletter* 44-2 (2015).

Stanke, D. "Managing the Ins and Outs of...Commercial Building Pressurization." *Engineers Newsletter* 31-2 (2002).

Stanke, D. "Keeping Cool With Outdoor Air...Airside Economizers." *Engineers Newsletter* 35-2 (2006).

Sturm, M., Hanson, S., Harshaw, J., Schwedler, M and Patterson, M., "ASHRAE Standard 90.1-2010," *Engineers Newsletter Live* program (2010) APP-CMC040-EN (DVD). (Available on-demand in Trane Continuing Education)

Murphy, J. and J. Harshaw. *Rooftop VAV Systems*. Trane Application Manual SYS-APM007-EN. La Crosse: Trane, 2012.

Trane, "Mix It Up: Mixing Air to Maximize Savings" white paper, CLCH-PRB033-EN. La Crosse: Trane, 2013.

Analysis Software

Trane Air-Conditioning and Economics (TRACE™ 700). Available at www.trane.com/TRACE