What's Required for Commercial HVAC and Covered Processes in Title 24 2013?

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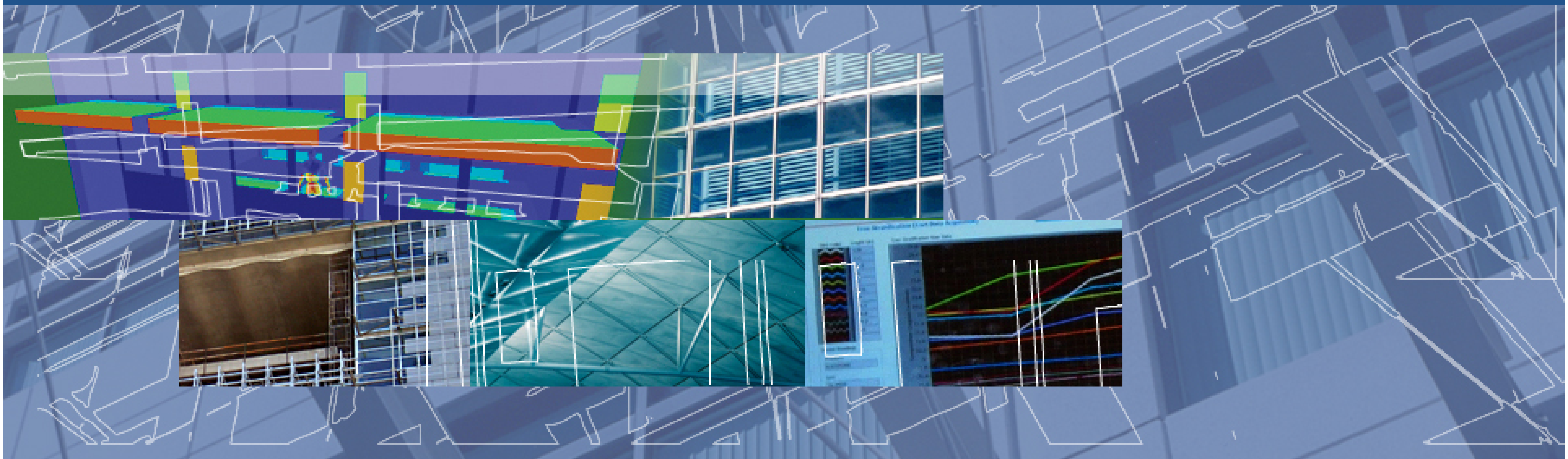
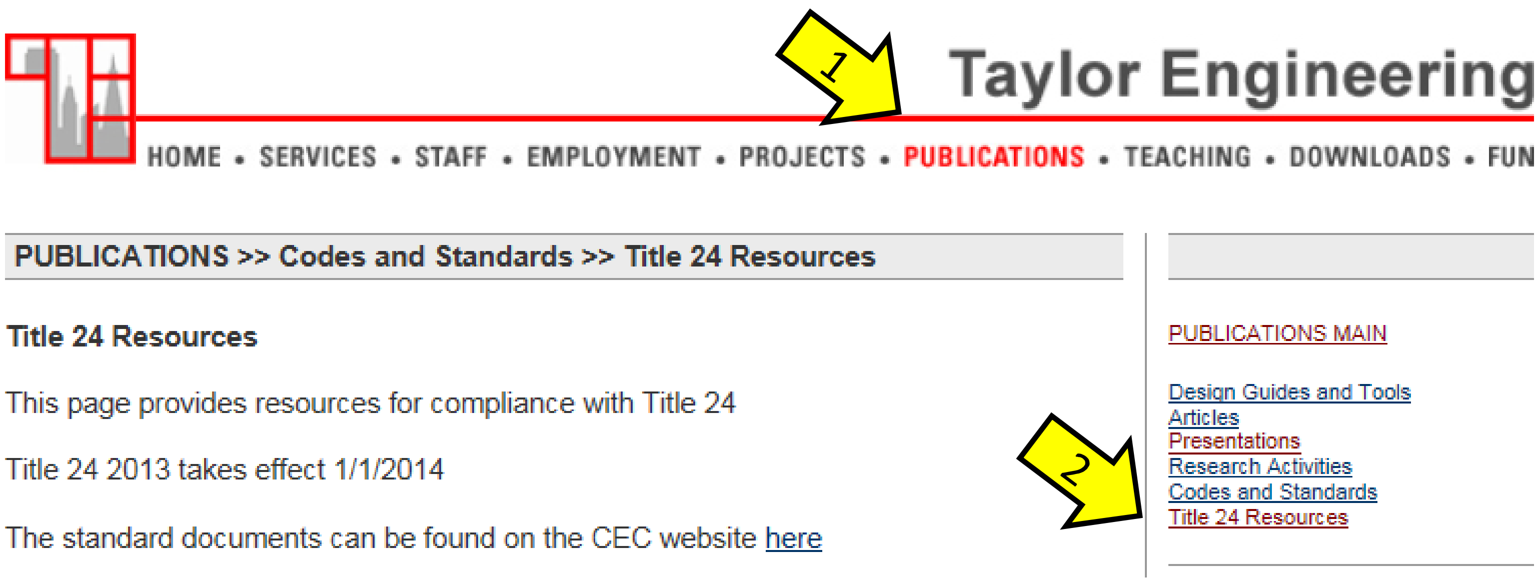


Agenda

- Overview
- ECMs
- Controls
- Equipment Efficiencies
- Central Plants
- Process
  - Overview
  - Computer Rooms
  - Laboratories
  - Kitchens
  - Garage Exhaust
  - Refrigeration
  - Compressed Air
  - Boilers

Handouts

- You can download the latest Title 24 slides from our website at: http://www.taylor-engineering.com
- Click on Publication in the top bar
- Click on Title 24 Resources on the right



Handouts

PUBLICATIONS >> Codes and Standards >> Title 24 Resources

Title 24 Resources

This page provides resources for compliance with Title 24

Title 24 2013 takes effect 1/1/2014

The standard documents can be found on the CEC website here

Note: Efficiency of small heating and cooling equipment that is covered under NAECA is located in the Appliance Efficiency Standards.

California Title 24 2013 HVAC Presentations

Presentation on HVAC and Process Requirements in Adobe Acrobat (16.1 MBytes)
DOWNLOAD

Presentation on HVAC and Process Acceptance Tests in Adobe Acrobat (10.4 MBytes)
DOWNLOAD

These slides were developed by Taylor Engineering under contract to Pacific Gas and Electric Company (PG&E).

Title 24 2016 Development

The 2016 Standards development process is just starting. We'll link to the CEC web page for the 2016 Standards when it is developed.

Other resources

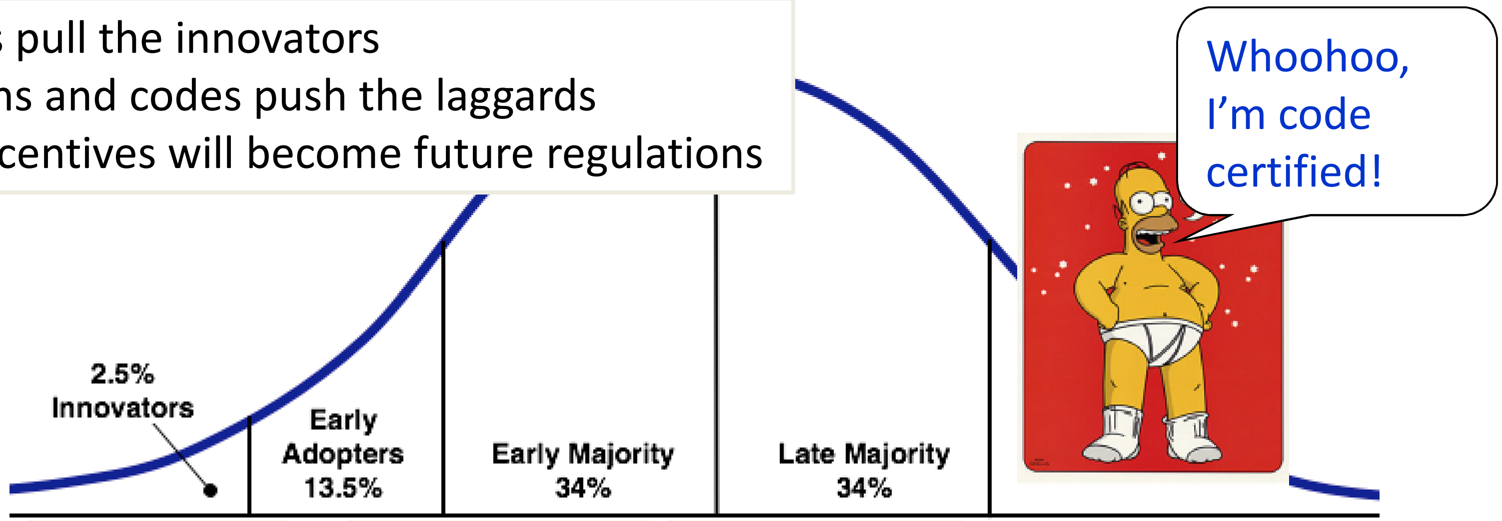
Research from Iowa Energy Center on Sensors: Download

Proposal comparing CMC and Title 24 Ventilation Requirements: Download

Overview

New Building Regulations and Incentives Overview

- Incentives pull the innovators
- Regulations and codes push the laggards
- Today's incentives will become future regulations



PIER Research | Utility Incentives | Product Rebates

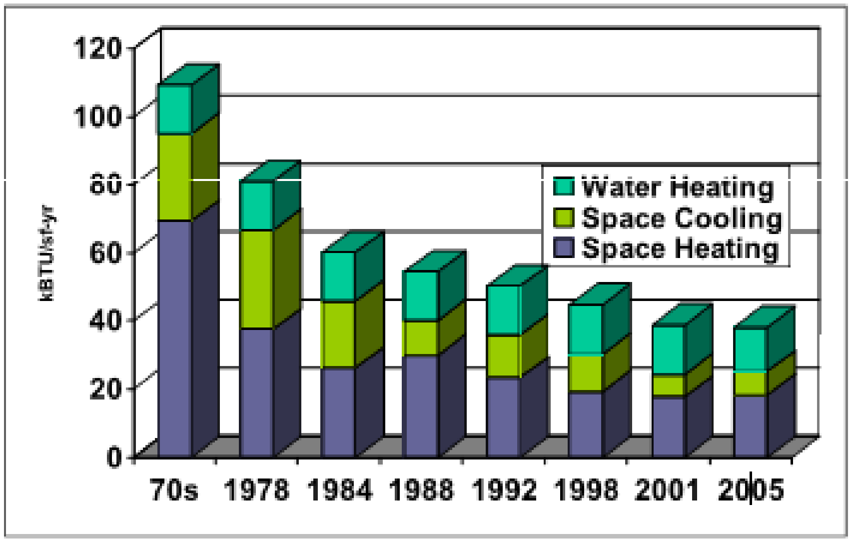
LEED **NC**: Platinum Gold Silver Rated

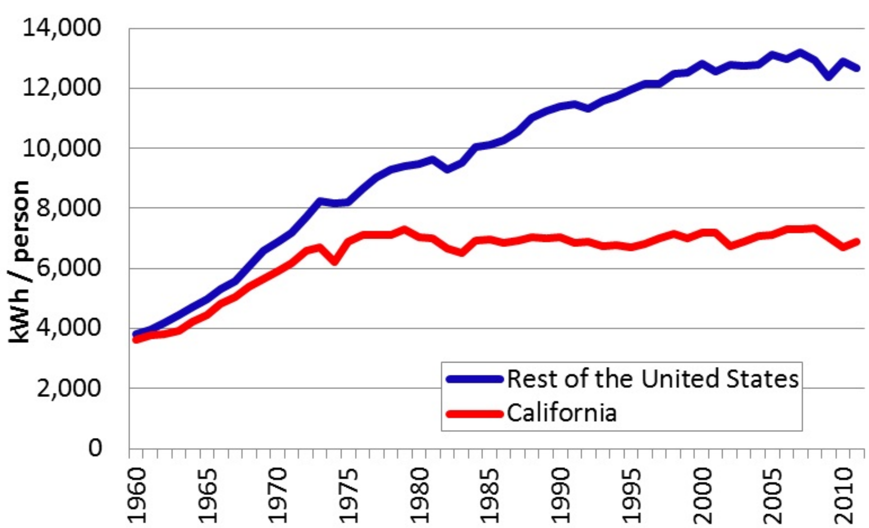
AEDG Guides | Green Building Code & 189 | 90.1 & T24

History of T-24 Energy Standards

- Section 25402 of the Public Resources Code (aka Warren Alquist Act)
  - Created the Energy Commission in 1974 and gave it authority to develop and maintain Building Energy Efficiency Standards
    - First Standards were issued in 1978, largely based on ASHRAE Standard 90-75
  - Requires the Standards and new requirements to be **cost effective** over the economic life of the structure
  - Requires the Energy Commission to update the Standards periodically (about every 3 years)

Historical Impact

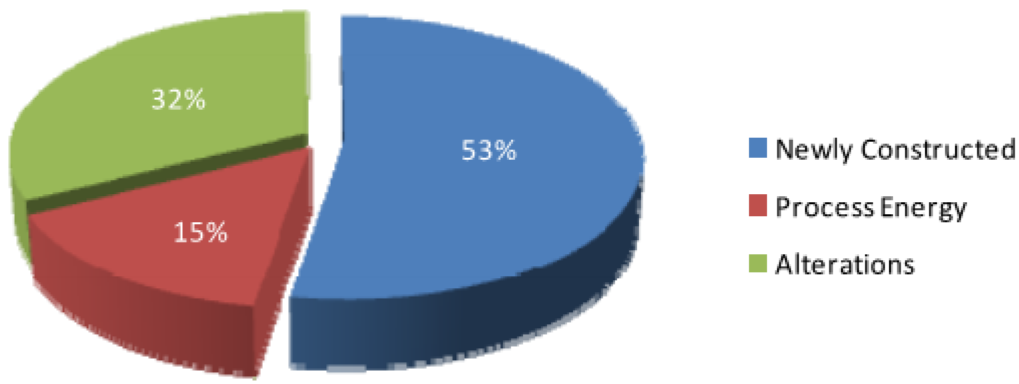




- Achieved over $65 billion in savings to ratepayers since mid-70s
- Avoided building 15000 MW of power plants
- CA has lowest per capita energy use in US

2013 Nonresidential Energy Savings

- Overall, 30% "better" than 2008 Standards
- 2013 Nonresidential Standards will save
  - 372 GWH/yr
  - 6.7 Mtherms/yr



Comparison to 90.1 2010

- See: http://www.energy.ca.gov/2013publications/CEC-400-2013-007/CEC-400-2013-007.pdf or
- http://tinyurl.com/qyona7v

Table 2: Comparison of New Building Energy Consumption under Title 24-1023 and 90.1-2010, (2014 forecasted construction)

Code	TDV Energy (GBtu)	Electricity (GWh)	Natural Gas (Mtherm)	Site Energy (GBtu)
90.1-2010	31,486	1,168	19.3	5,915
Title 24-2013	27,804	1,012	18.0	5,253
Savings	3,682	156	1.3	662
Savings	12%	13%	7%	11%

Source: Architectural Energy Corporation

Title 24-2013 Updated Schedule

- Implementation Date
  - Delayed to July 1, 2014
  - Any projects that submit for permit on or after July 1, 2014 will be subject to the 2013 Standards.

New or Expanded HVAC Measures

110.X and 120.X are Mandatory Measures
140.X are Prescriptive Measures
120.6 and 140.9 are for "Covered Processes"

- Computer Rooms – 140.9(a)
- Kitchen Ventilation – 140.9(b)
- Garage Ventilation – 120.6(c)
- ECM Fan Motors – 140.4(c)
- SZ VAV Fan Control – 140.4(m)
- Economizers
  - Scope – 140.4(e)
  - Trade-Off – Table 140.4-A
  - High Limit Switches – Table 140.4-B
  - DX Compressor Unloading – Table 140.4-C
  - Components – 140.4(e)4
  - Fault Detection – 120.2(i)
- Occupant Sensors Ventilation Control – 120.1(c)5
- Hotel Room Setback – 120.2(e)4
- EMCS Demand Shed Controls – 120.2(h)
- Unitary Thermostats and Demand Shed – 110.2(c), 120.2(b)4 and NA7.5
- Reduce Reheat – Exception to 140.4(d)
- Chiller Efficiency: – 120.2(a), Table 110.2-D and 140.4(i)
- Cooling Towers – Table 110.2-G and 110.2(e)
- Large Boilers – 120.6(d) and 120.9
- Pipe Insulation – Table 120.3-A

Other New Requirements (partial list)

- Process Boilers
- Air Compressors
- Acceptance Testing
- Supermarket Refrigeration
- Refrigerated Warehouses
- Insulation (e.g. ¾” HW pipe insulation goes from ½” to 1.5” insulation)
- Solar ready buildings
  - Requires designated solar area, clear path for conduit routing
  - Does not apply to non-residential > 3 stories or hotel/residential > 10 stories
- Lighting and lighting controls
- Separate Electrical Power Distribution Systems for Lighting, HVAC, DHW, Plug loads – uncontrolled, Plug loads – controlled (e.g. timeclock), Elevators, Large appliances
- Max voltage drop of feeders, branch circuits
- Building Commissioning (OPR, BOD, 3rd party design review, Cx specs, Cx Plan, FPT, Systems Manual, Cx Report)

Title 24 2013 Resources

- CEC Title 24 2013 Website:
  Start Here! http://www.energy.ca.gov/title24/2013standards/

2013 Building Energy Efficiency Standards

California's Building Energy Efficiency Standards are updated on an approximate three-year cycle. The 2013 Standards improve upon the 2008 Standards for new construction of, and additions and alterations to, residential and nonresidential buildings. The 2013 Standards went into effect July 1, 2014.

The Energy Standards

Standards → 2013 Building Energy Efficiency Standards for Residential and Nonresidential Buildings - Revised
Posted November 25, 2013. (PDF file, 263 pages, 1.9 mb)

- 2013 Reference Appendices. Revised
  Posted June 30, 2014. (PDF file, 476 pages, 4.7 mb) ← NA, RA & JA
- Errata:
  - Nonsubstantial Errata - June 2014
  - Nonsubstantial Errata - November 2013
  - Nonsubstantial Errata - October 2013
  - Nonsubstantial Errata - September 2013
  - Supplement to Nonsubstantial Errata - December 2012
  - Nonsubstantive Errata - May 2012

Included in standards

Title 24 2013 Resources

- http://www.energy.ca.gov/title24/2013standards/

Forms and Worksheets

Compliance Forms

- Residential Compliance Forms
- Nonresidential Compliance Forms

Compliance Calcs

- Open and Closed Circuit Cooling Towers - Maximum Achievable Cycles Calculator
  Posted June 9, 2014 (Excel file)
- Solar Reflectance Index Calculator (SRI)
  Posted June 30, 2014
- Ventilation Worksheet
  Posted July 28, 2014 (Excel file)

Alternative Calculation Method

Modelling Rules

- Alternative Calculation Method (ACM) - 2013 Residential Approval Manual. Revised
  (PDF file, 14 pages, 594 kb)
- Alternative Calculation Method (ACM) - 2013 Nonresidential Approval Manual. Revised
  (PDF file, 14 pages, 336 kb)
- Alternative Calculation Method (ACM) 2013 Residential Reference Manual. Revised
  (PDF file, 314 pages, 5.3 mb)
- Alternative Calculation Method (ACM) 2013 Nonresidential Reference Manual.
  (PDF file, 272 pages, 1.57 mb)

Title 24 2013 Resources

- CEC Title 24 2013 Website: http://www.energy.ca.gov/title24/2013standards/

Start Here!

Alternative Calculation Method Manuals

Performance Method Rules

- 2013 Residential Alternative Calculation Method (ACM) Approval Manual. **Revised**
  (PDF file, 14 pages, 594 kb)
- 2013 Nonresidential Alternative Calculation Method (ACM) Approval Manual. **Revised**
  (PDF file, 14 pages, 336 kb)
- 2013 Residential Alternative Calculation Method (ACM) Reference Manual
  (PDF file, 306 pages, 4.6 mb)
- 2013 Nonresidential Alternative Calculation Method (ACM) Reference Manual
  (PDF file, 272 pages, 1.57 mb)

Supporting Content

Performance Method Programs

- 2013 Approved Computer Compliance Programs
- Local Ordinances Exceeding the 2013 Building Energy Efficiency Standards
- Documents Relied Upon

Title 24 2013 Resources

- CEC Title 24 2013 Website:
  http://www.energy.ca.gov/title24/2013standards/

Start Here!

Additional Information

Compliance Manuals

- Residential Compliance Manual
- Nonresidential Compliance Manual
- Frequently Asked Questions
- Summary of Major Changes from 2008
- 2013 HVAC Change-Out
- Standards Infographics

Supporting Content

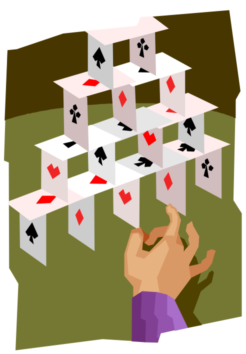
Approved Programs

- 2013 Approved Computer Software Compliance Programs
- Acceptance Test Technician Certification Program
- Home Energy Rating System Program
- Requirements for Manufacturer Certified Equipment, Products and Devices
- Local Ordinances Exceeding the 2013 Building Energy Efficiency Standards
- Training Resources
- Energy Code Ace

On-Line Training

New Foundations

- Weather Files
- Time Dependent Valuations (TDV)
- ACM
- Covered Processes
- Water



Revised Numbering

		2008	2013
Mandatory HVAC		11x 12x	110.x 120.x
	Equipment Efficiencies	112	110.2
	Thermostats	112(c)	110.2(c)
	Ventilation	121	120.1
	Acceptance Tests	125	120.5
Prescriptive HVAC		144	140.4
	Fan Power	144(c)	140.4(c)
	Economizers	144(e)	140.4(e)

Brushless DC and EC Motors (140.4(c)4)

Scope (140.4(c)4)

- Covered >=1/12 hp to <1 hp
  - Exhaust fans
  - Supply fans
  - Fan-powered VAV boxes
  - Fan-coil units (FCU)
- Exception for heating only fans
  - Parallel style VAV boxes
  - Heating only FCUs
- No requirement for pumps
- Separate requirement for refrigeration systems (covered this afternoon)

Advantages

- Higher efficiency than PSCs 70% vs 30%
- Provides means for motor speed adjustment
  - Automatic speed control, or
  - Manual balancing in the field

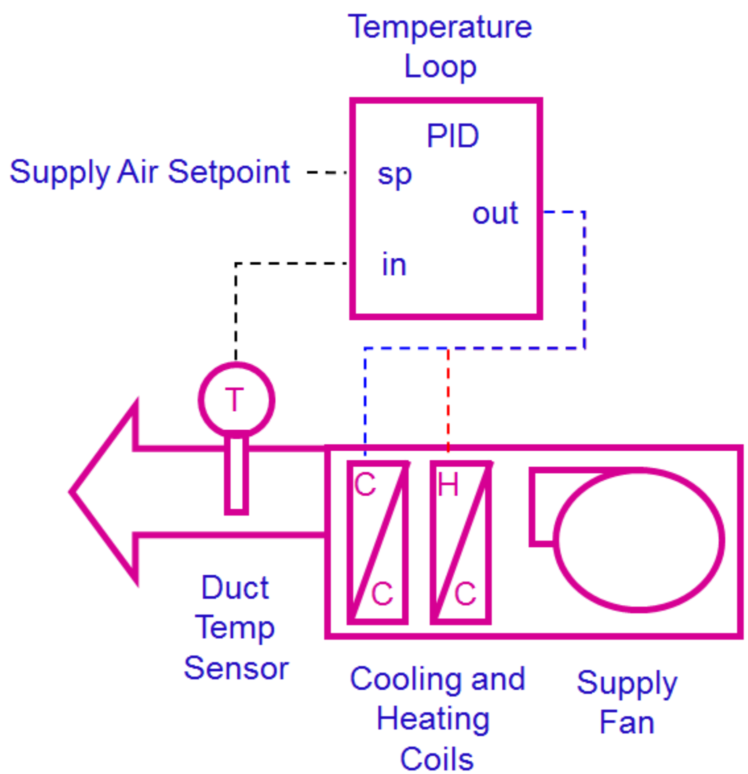
ECM Motors (140.4(c)4) (Modifed)

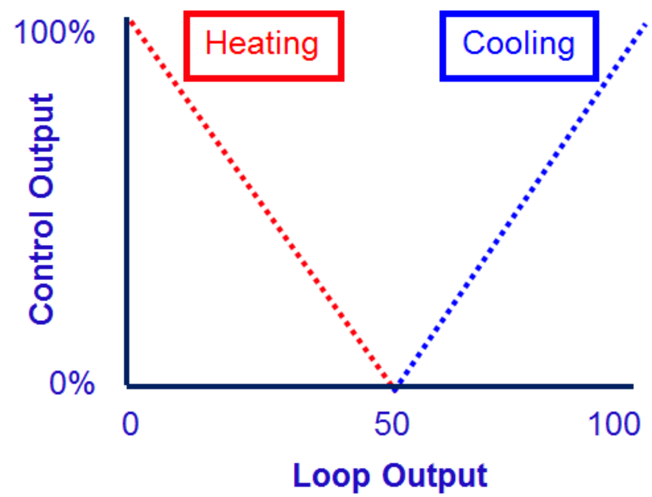
4. **Fractional HVAC Motors for Fans.** HVAC motors for fans that are less than1 hp and 1/12 hp or greater shall be electronically-commutated motors or shall have a minimum motor efficiency of 70 percent when rated in accordance with NEMA Standard MG 1-2006 at full load rating conditions. These motors shall also have the means to adjust motor speed for either balancing or remote control. Belt-driven fans may use sheave adjustments for airflow balancing in lieu of a varying motor speed.

   EXCEPTION 1 to Section 140.4(c)4: Motors in fan-coils and terminal units that operate only when providing heating to the space served.

   EXCEPTION 2 to Section 140.4(c)4: Motors in space conditioning equipment certified under Section 110.1 or 110.2.

Controls


Temperature Loop
PID
Supply Air Setpoint
sp
out
in
T
C
C
H
C
Duct Temp Sensor
Cooling and Heating Coils
Supply Fan


100%
0%
Control Output
Heating
Cooling
0
50
100
Loop Output

Control Requirements

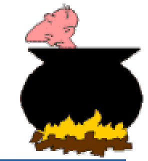
- Demand Shed
  - Automatic Demand Shed Controls (120.2(h))
  - Unitary Thermostats (110.2(c))
- Economizers
  - Economizer Trade-Off (Table 140.4-A)
  - Economizer Scope (140.4(e))
  - Economizer High Limit Switches (Table 140.4-B)
  - Economizer Components (140.4(e)4)
  - DX Unloading (140.4(e)5 and Table 140.4-C)
  - Economizer FDD (120.2(i))
- Fan Control (140.4(m))
- Occupant Sensors for DCV (120.1(c)5)
- Reheat Controls (Exception 1 to 140.4(d))

Automatic Demand Shed Controls (120.2(h)) Modified

(h) **Automatic Demand Shed Controls.** HVAC systems with DDC to the Zone level shall be programmed to allow centralized demand shed for non-critical zones as follows:

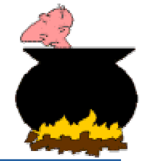
1. The controls shall have a capability to remotely setup the operating cooling temperature set points by 4 degrees or more in all non-critical zones on signal from a centralized contact or software point within an Energy Management Control System (EMCS).
2. The controls shall have a capability to remotely setdown the operating heating temperature set points by 4 degrees or more in all non-critical zones on signal from a centralized contact or software point within an EMCS.
3. The controls shall have capabilities to remotely reset the temperatures in all non-critical zones to original operating levels on signal from a centralized contact or software point within an EMCS.
4. The controls shall be programmed to provide an adjustable rate of change for the temperature setup and reset.
5. The controls shall have the following features:
   A. Disabled. Disabled by authorized facility operators; and
   B. Manual control. Manual control by authorized facility operators to allow adjustment of heating and cooling set points globally from a single point in the EMCS; and
   C. Automatic Demand Shed Control. Upon receipt of a demand response signal, the space-conditioning systems shall conduct a centralized demand shed, as specified in Sections 120.2(h)1 and 120.2(h)2, for non-critical zones during the demand response period.

Demand Limit of Central AC



- This does not meet the requirement
- Limiting chillers (demand limit) and/or central fans (max speed) serving multiple zones
  - Near zones (boxes or coils) will receive more air or water
  - Far zones will be starved
  - Limiting chiller on a variable flow system will increase pump energy (as coils will open up)
- The requirement is to limit zone demand and leave central systems in control
  - This functionality requires either DDC to the zone level or "communicating thermostats"

Zone Based Demand Shed



- Reset cooling setpoints upwards
  - One time or stepped to predetermined level, or
  - Slowly at ~2° per hour (preferred)
- Both use the building's mass
- Either of these will share the burden equally throughout the building

ASHRAE Standard 55-2004

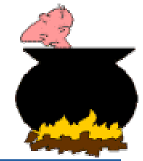


Table 5.2.5.2
Limits on Temperature Drifts and Ramps

Time Period	1/4 h	1/2 h	1 h	2 h	4 h
Maximum Operative Temperature Change Allowed	2.0° F	3.0° F	4.0° F	5.0° F	6.0° F

The most restrictive change rate rules

Automatic Demand Shed Controls (110.2(c) & 120.2(b)4) Unitary HVAC (NEW)

(c) **Thermostats.** All unitary heating or cooling systems, including heat pumps, not controlled by a central energy management control system (EMCS) shall have a setback thermostat.

1. **Setback Capabilities.** All thermostats shall have a clock mechanism that allows the building occupant to Program the temperature setpoints for at least four periods within 24 hours. Thermostats for heat pumps shall meet the requirements of Section 110.2(b).

EXCEPTION to Section 110.2(c): Gravity gas wall heaters, gravity floor heaters, gravity room heaters, noncentral electric heaters, fireplaces or decorative gas appliances, wood stoves, room air conditioners, and room air-conditioner heat pumps.

4. Thermostatic controls for all unitary single zone, air conditioners, heat pumps, and furnaces, shall comply with the requirements of Section 110.2(c) and Reference Joint Appendix JA5 or, if equipped with DDC to the Zone level, with the Automatic Demand Shed Controls of Section 120.2(h).

EXCEPTION 1 to Section 120.2(b)4: Systems serving exempt process loads that must have constant temperatures to prevent degradation of materials, a process, plants or animals.

EXCEPTION 2 to Section 120.2(b)4: Gravity gas wall heaters, gravity floor heaters, gravity room heaters, non-central electric heaters, fireplaces or decorative gas appliances, wood stoves, room air conditioners, and room air-conditioner heat pumps.

JA5 Defines Technical Specifications for "Occupant Controlled Smart Thermostats"

Occupant Controlled Smart Thermostats (JA5) Unitary HVAC (NEW)

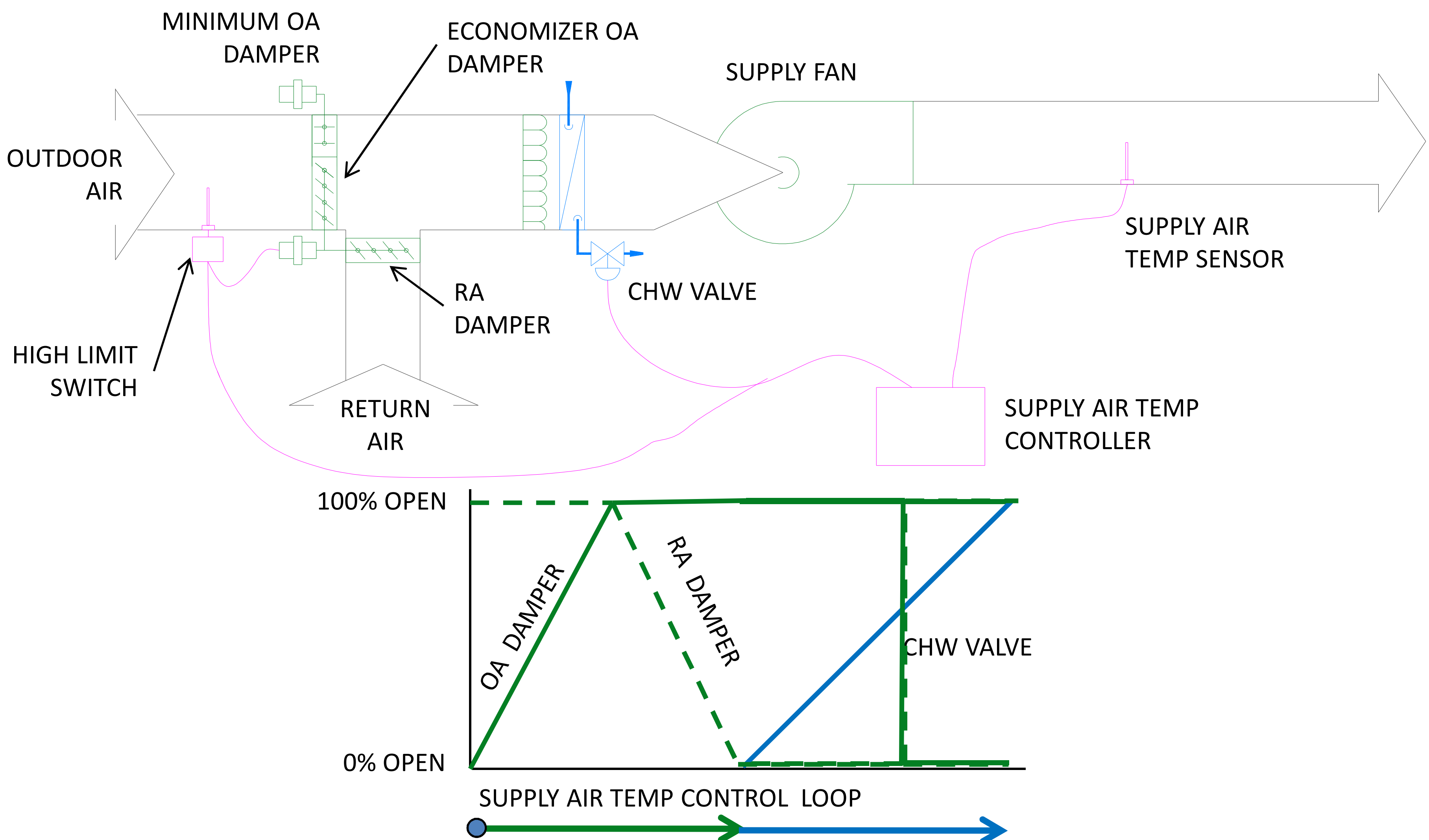
JA5.2.4 Event Response

Event response, unless overridden by the occupant or modified by an energy management control system or service, may be triggered by price signals or Demand Response Signals. The OCST shall provide one set of event responses for price signals and one set of event responses for Demand Response Signals. The responses may be common for both types of events.

OCSTs, with communications enabled, shall be capable of receiving and automatically responding to the Demand Response Signals as follows:

(a) A Demand Response Signal shall trigger the OCST to adjust the thermostat setpoint by either the default number of degrees or the number of degrees established by the occupant.
(b) When a price signal indicates a price in excess of a price threshold established by the occupant, the OCST shall adjust the thermostat setpoint by either the default number of degrees or the number of degrees established by the occupant.
(c) In response to price signals or Demand Response signals, the OCST shall default to an event response that initiates setpoint offsets of +4°F for cooling and -4°F for heating relative to the current setpoint.
(d) The OCST shall have the capability to allow occupants or their representative to modify the default event response with occupant defined event responses for cooling and heating relative to the current setpoint in response to price signals or Demand Response Signals.
(e) Override Function: Occupants shall be able to change the event responses and thermostat settings or setpoints at any time, including during price events or Demand Response Periods.
(f) The Demand Response Signal shall start the Demand Response Period either immediately or at a specific start time as specified in the event signal and continue for the Demand Response Period specified in the Demand Response Signal or until the occupant overrides the event setpoint.
(g) The thermostat's price response shall start either immediately or at a specific start time as specified in the pricing signal and continue for the duration specified in the pricing signal or until the occupant overrides the event setpoint.
(h) The OCST shall have the capability to allow occupants to define setpoints for cooling and heating in response to price signals or Demand Response signals as an alternative to the default event response.
(i) At the end of a price event or Demand Response Period, the thermostat setpoint shall be set to the setpoint that is programmed for the point in time that the event ends or to the manually established setpoint that existed just prior to the Demand Response Period.

Air Economizer Control



Economizers

Air Economizers

- Economizer Scope (140.4(e))
- Economizer Trade-Off (Table 140.4-A)
- Economizer High Limit Switches (Table 140.4-B)
- Economizer Components (140.4(e)4)
- DX Unloading (140.4(e)5 and Table 140.4-C)
- Economizer FDD (120.2(i))

Economizer Scope (140.4(e))

≥4.5 tons

Economizers

(e) **Economizers.**

1. Each cooling fan system that has a design total mechanical cooling capacity over 54,000 Btu/hr shall include either:

   A. An air economizer capable of modulating outside-air and return-air dampers to supply 100 percent of the design supply air quantity as outside-air; or

   B. A water economizer capable of providing 100 percent of the expected system cooling load as calculat in accordance with a method approved by the Commission, at outside air temperatures of 50°F dry-bu and 45°F wet-bulb and below.

EXCEPTION 1 to Section 140.4(e)1: Where special outside air filtration and treatment, for the reductior and treatment of unusual outdoor contaminants, makes compliance infeasible.

EXCEPTION 2 to Section 140.4(e)1: Where the use of outdoor air for cooling will affect other systems, such as humidification, dehumidification, or supermarket refrigeration systems, so as to increase overall building TDV energy use.

EXCEPTION 3 to Section 140.4(e)1: Systems serving high-rise residential living quarters and hotel/mot guest rooms.

EXCEPTION 4 to Section 140.4(e)1: Where comfort cooling systems have the cooling efficiency that meets or exceeds the cooling efficiency improvement requirements in TABLE 140.4-A.

EXCEPTION 5 to Section 140.4(e)1: Fan systems primarily serving computer room(s). See Section 140.9(a) for computer room economizer requirements.

Economizers

Economizer Trade-Off Table (140.4-A)

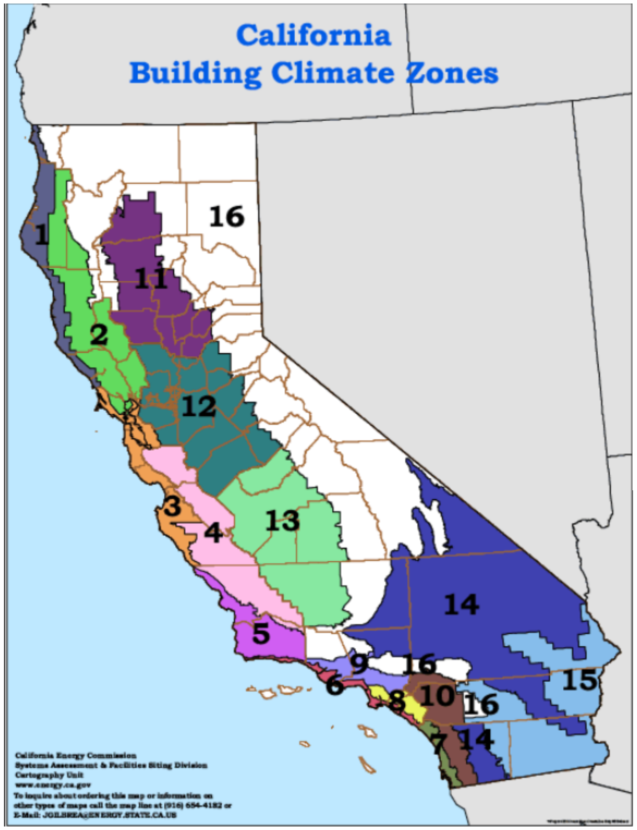


TABLE 140.4-A ECONOMIZER TRADE-OFF TABLE FOR COOLING SYSTEMS

Climate Zone	Efficiency Improvement [a]
1	70%
2	65%
3	65%
4	65%
5	70%
6	30%
7	30%
8	30%
9	30%
10	30%
11	30%
12	30%
13	30%
14	30%
15	30%
16	70%

[a] If a unit is rated with an IPLV, IEER or SEER, then to eliminate the required air or water economizer, the applicable minimum cooling efficiency of the HVAC unit must be increased by the percentage shown. If the HVAC unit is only rated with a full load metric, such as EER or COP cooling, then that metric must be increased by the percentage shown.

TABLE 110.2-A ELECTRICALLY OPERATED UNITARY AIR CONDITIONERS AND CONDENSING UNITS – MINIMUM EFFICIENCY REQUIREMENTS

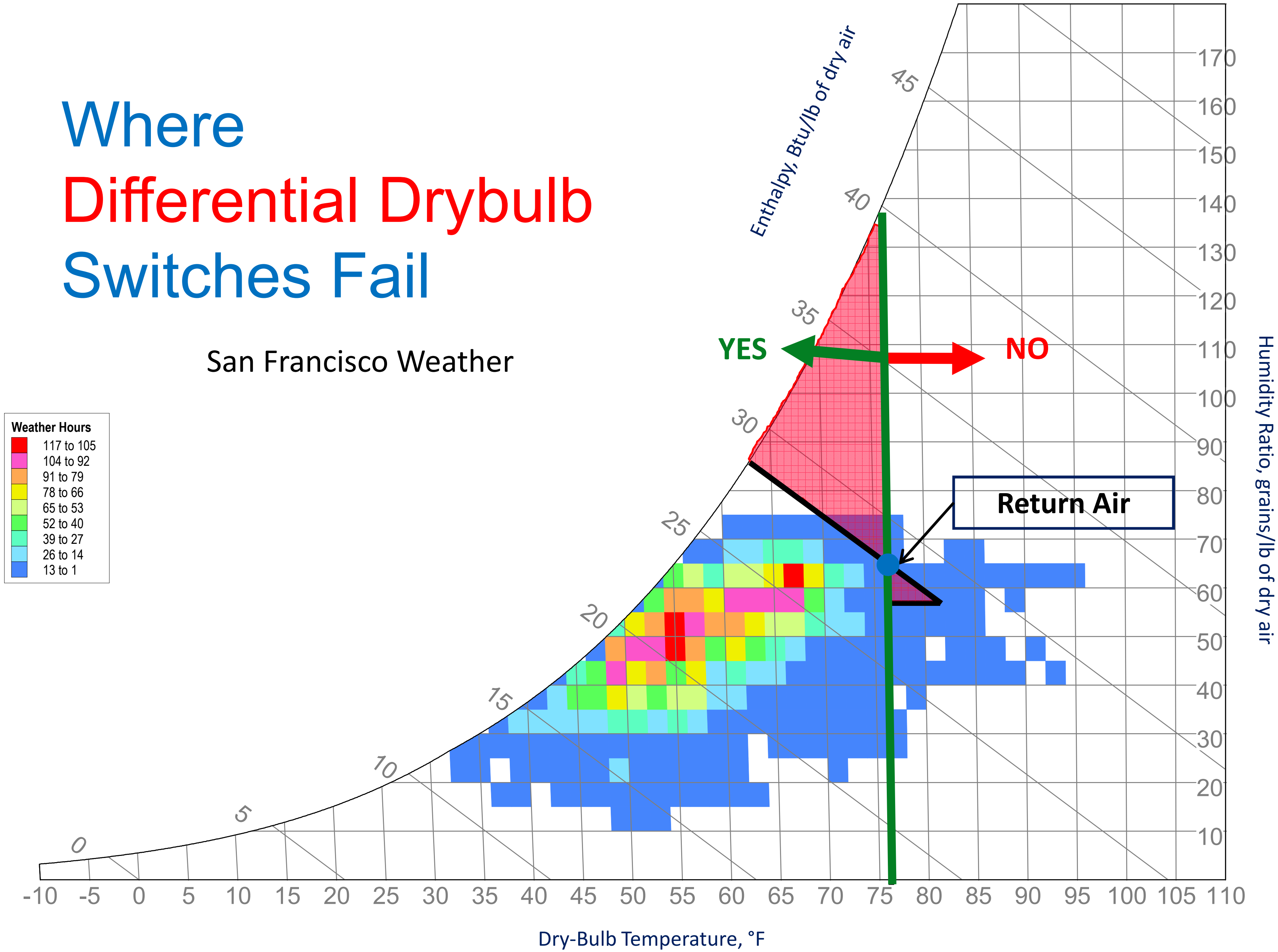
Equipment Type	Size Category	Efficiency [a]		Test Procedure [c]
		Before 1/1/2015	After 1/1/2015	
Air conditioners, air cooled both split system and single package	≥ 65,000 Btu/h and < 135,000 Btu/h	11.2 EER[b] 11.4 IEER[b]	Applicable minimum efficiency values as determined by Title 20 California Code of Regulations Section 1605.1	ANSI/AHRI 340/360
	≥ 135,000 Btu/h and < 240,000 Btu/h	11.0 EER[b] 11.2 IEER[b]		ANSI/AHRI 340/360
	≥ 240,000 Btu/h and < 760,000 Btu/h	10.0 EER[b] 10.1 IEER[b]		
	≥ 760,000 Btu/h	9.7 EER[b] 9.8 IEER[b]		

Economizer High Limit Devices (Table 140.4-B)

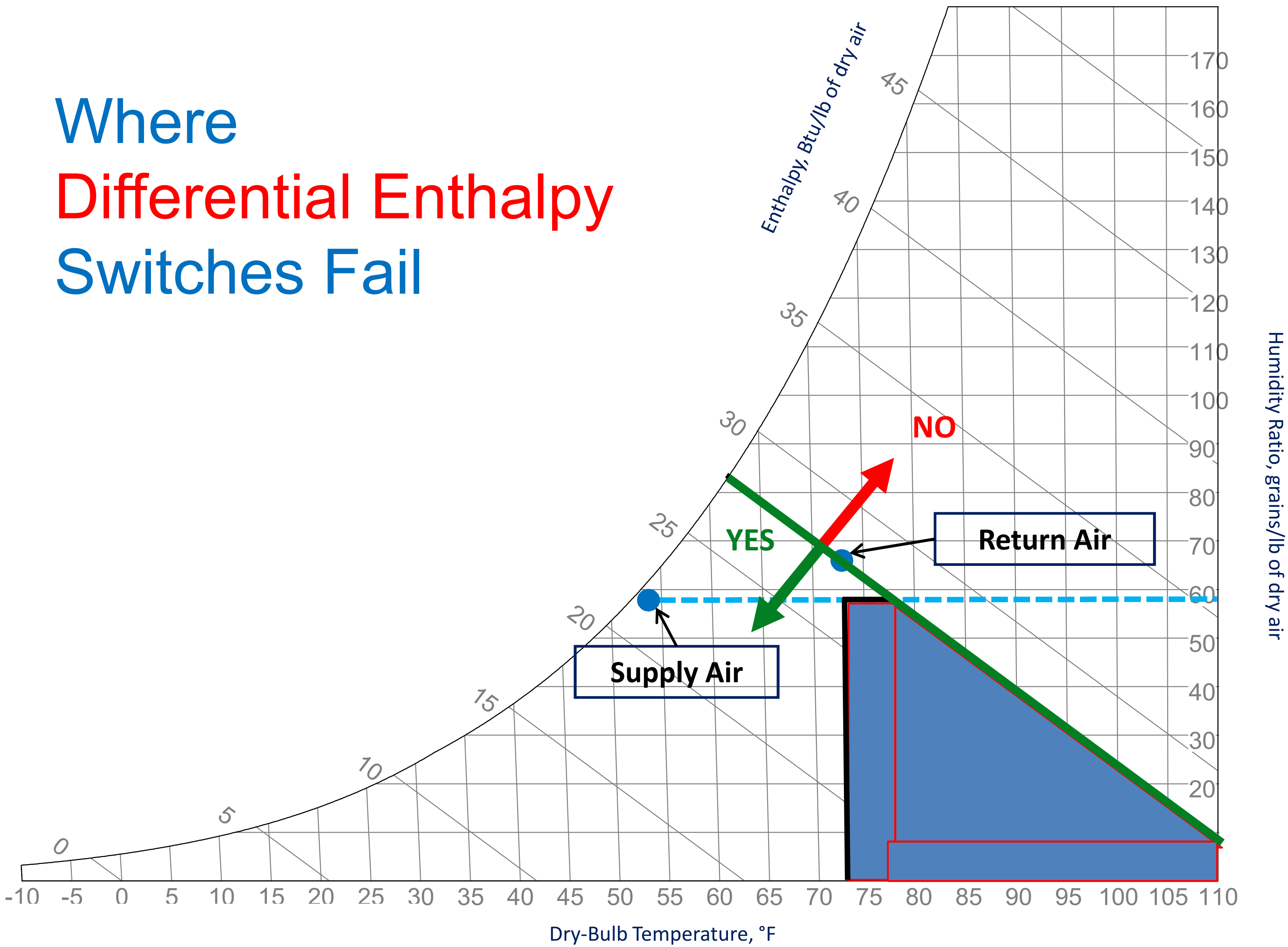
- Fixed Drybulb Temperature
  - Compares outdoor air drybulb to a fixed setpoint
- Differential Drybulb Temperature
  - Compares outdoor air drybulb to return air drybulb
- Fixed Enthalpy
  - Compares outdoor air enthalpy to a fixed setpoint
- Differential Enthalpy
  - Compares outdoor air enthalpy to return air enthalpy
- Electronic Enthalpy
  - Compares outdoor air temperature and humidity to a setpoint that is a curve on the psychrometric chart

Where Differential Drybulb Switches Fail

San Francisco Weather



Where
Differential Enthalpy
Switches Fail

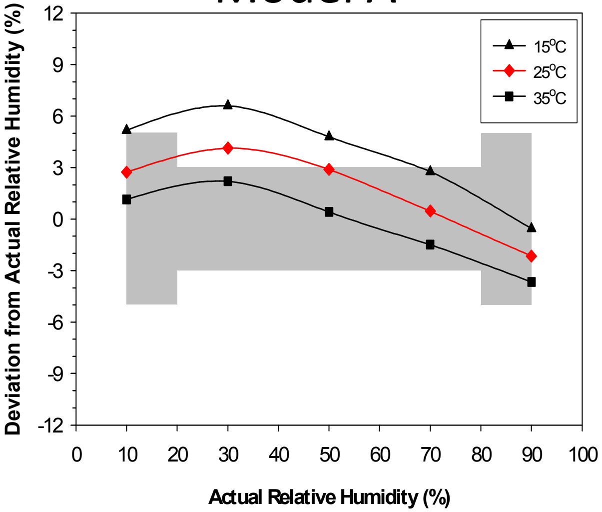


Economizers

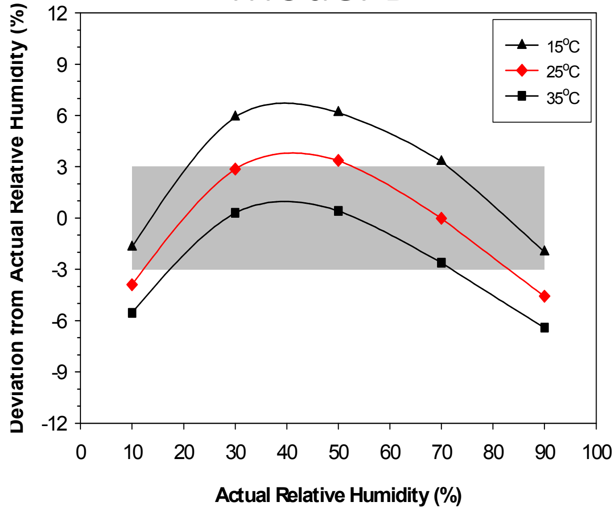
Measured Accuracy of New Sensors

Iowa Energy Center

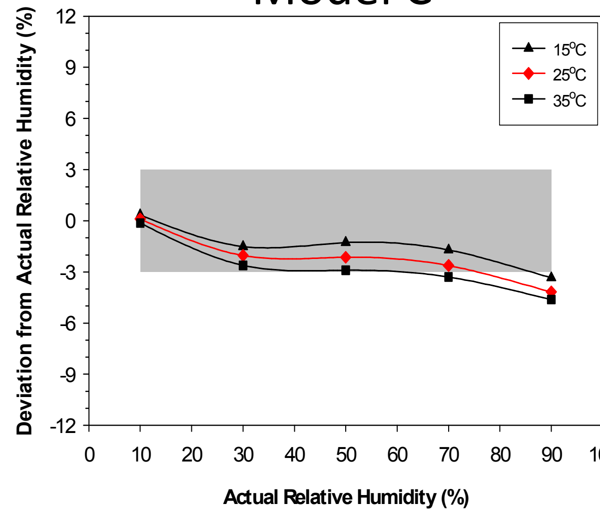
Model A



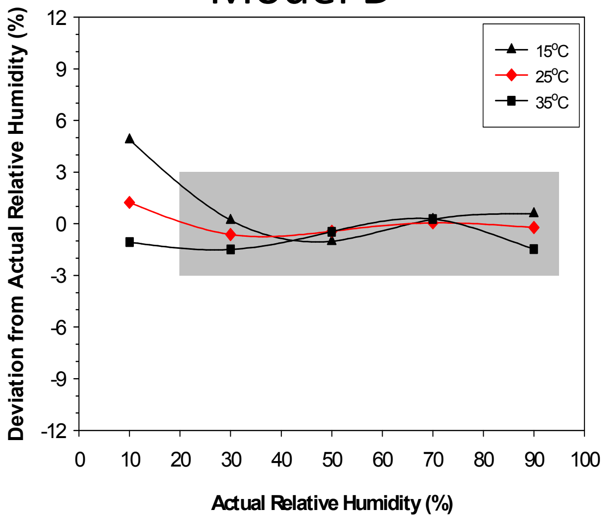
Model B



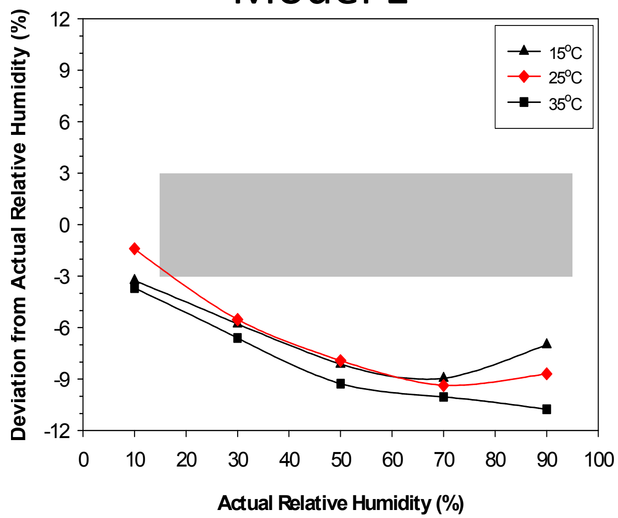
Model C



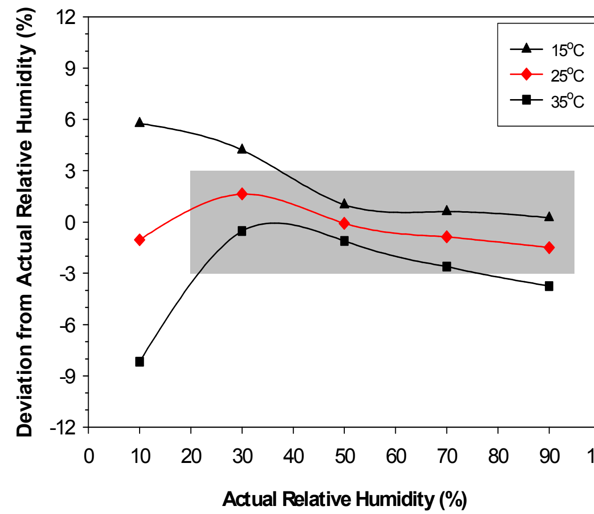
Model D



Model E



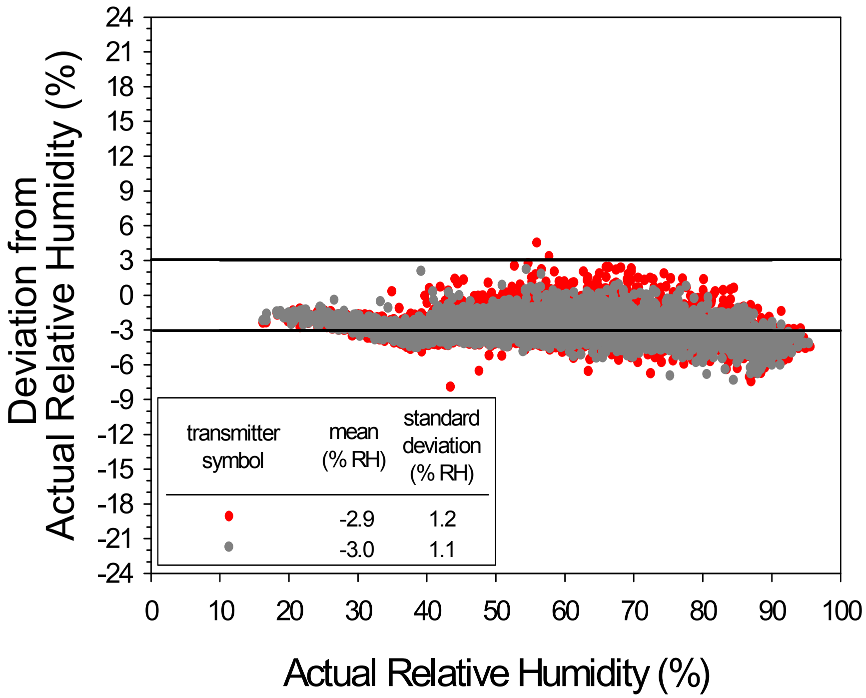
Model F



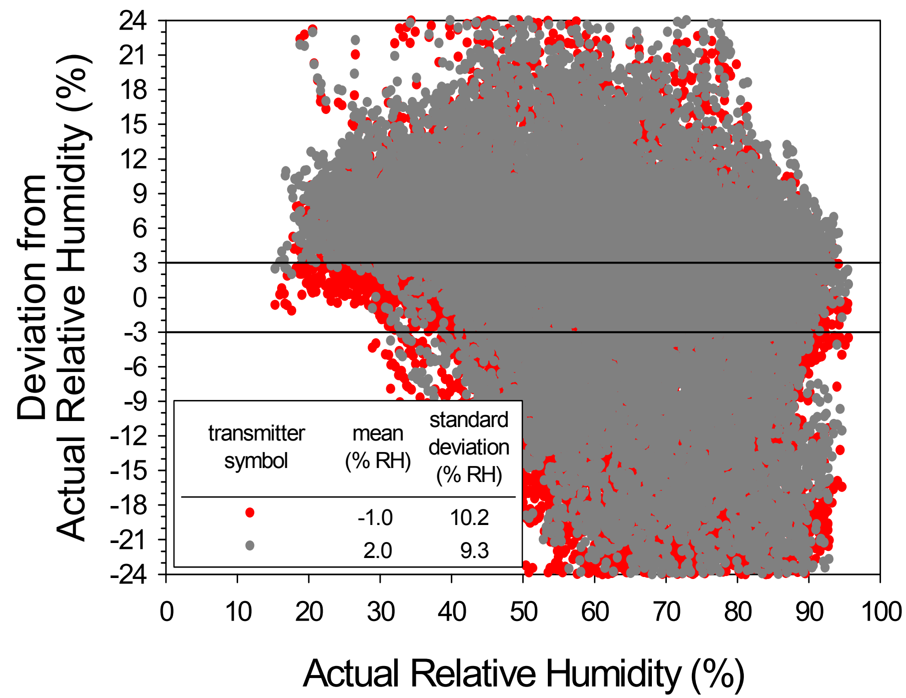
Economizers

Aging / Drift Testing Results

Model C



Model E



- One year of data collected at 15 minute intervals
- Reference: Precision Grade ±1% RH in-situ reference sensor

Results

	High Limit Control Option	Setpoint	Error	Remarks
1	Fixed Dry Bulb	See Remarks	±2°F	The fixed dry bulb setpoint was that which resulted in the lowest energy use for each climate zone. See *Table 2*.
2	Differential Dry Bulb	–	±4°F	Twice the error due to two sensors.
3	Fixed Enthalpy	28 Btu/lb_{da}	±2 Btu/lb_{da}	Cumulative error of ±2°F dry bulb and ±4% RH. Setpoint corresponds to 75°F and 50% RH, adjusted for elevation above sea level.
4	Differential Enthalpy	–	±4 Btu/lb_{da}	Twice the error due to two sensors.
5	Differential Enthalpy + Fixed Dry Bulb	– 75°F	±4 Btu/lb_{da} ±2°F	Error impact modeled cumulatively for both sensors (both low or both high). Differential dry bulb was not modeled because DOE-2.2 does not allow it to be combined with differential enthalpy.
6	Fixed Enthalpy + Fixed Dry Bulb	28 Btu/lb_{da} 75°F	±2 Btu/lb_{da} ±2°F	Error impact modeled cumulatively for both sensors (both low or both high). Setpoint corresponds to 75°F and 50% RH, adjusted for elevation above sea level.
7	Dew Point + Fixed Dry Bulb	55°F 75°F	±5°F DPT ±2°F	Error impact modeled cumulatively for both sensors (both low or both high). This option was analyzed only because it is listed as an option in Standard 90.1.

Table 1: Seven high limit controls and combinations modeled and summarized.

Results

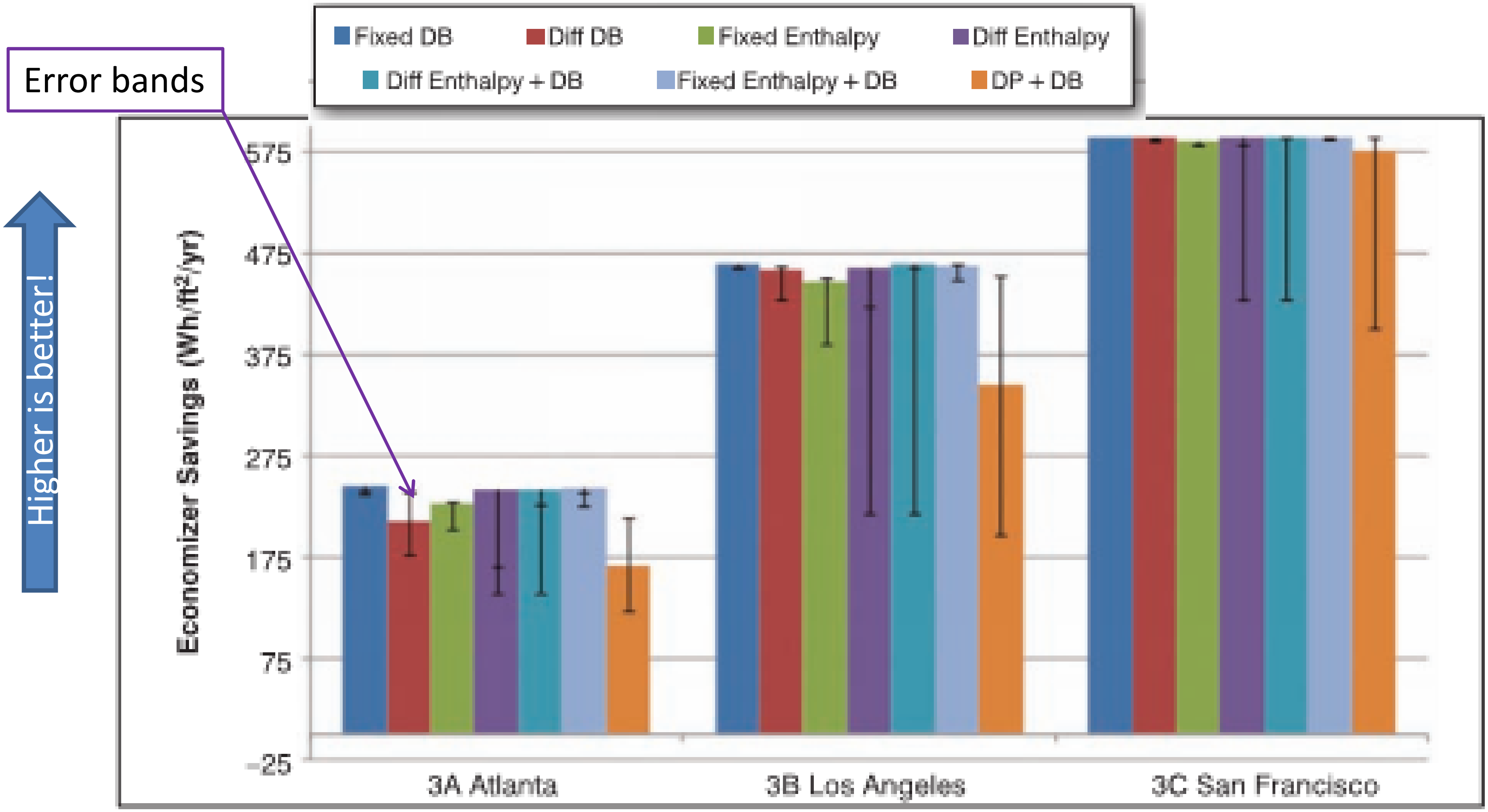


Figure 21: High limit control performance: Climate Zone 3.

High Limit Switch (140.4(e)3 &Table 140.4-B)

3. If an economizer is required by Section 140.4(e)1, and an air economizer is used to meet the requirement, then it shall be a type listed in, and shall have high limit shutoff controls complying with TABLE 140.4-B,

TABLE 140.4-B AIR ECONOMIZER HIGH LIMIT SHUT OFF CONTROL REQUIREMENTS

Device Type[a]	**Climate Zones**	**Required High Limit (Economizer Off When):**	
		Equation[b]	**Description**
Fixed Dry Bulb	1, 3, 5, 11-16	$T_{OA} > 75°F$	Outdoor air temperature exceeds 75°F
	2, 4, 10	$T_{OA} > 73°F$	Outdoor air temperature exceeds 73°F
	6, 8, 9	$T_{OA} > 71°F$	Outdoor air temperature exceeds 71°F
	7	$T_{OA} > 69°F$	Outdoor air temperature exceeds 69°F
Differential Dry Bulb	1, 3, 5, 11-16	$T_{OA} > T_{RA}°F$	Outdoor air temperature exceeds return air temperature
	2, 4, 10	$T_{OA} > T_{RA}$-2°F	Outdoor air temperature exceeds return air temperature minus 2°F
	6, 8, 9	$T_{OA} > T_{RA}$-4°F	Outdoor air temperature exceeds return air temperature minus 4°F
	7	$T_{OA} > T_{RA}$-6°F	Outdoor air temperature exceeds return air temperature minus 6°F
Fixed Enthalpy[c] + Fixed Drybulb	All	$h_{OA} > 28$ Btu/lb[c] or $T_{OA} > 75°F$	Outdoor air enthalpy exceeds 28 Btu/lb of dry air[c] or Outdoor air temperature exceeds 75°F

[a] Only the high limit control devices listed are allowed to be used and at the setpoints listed. Others such as Dew Point, Fixed Enthalpy, Electronic Enthalpy, and Differential Enthalpy Controls, may not be used in any Climate Zone for compliance with Section 140.4(e)1 unless approval for use is provided by the Energy Commission Executive Director.

[b] Devices with selectable (rather than adjustable) setpoints shall be capable of being set to within 2°F and 2 Btu/lb of the setpoint listed.

[c] At altitudes substantially different than sea level, the Fixed Enthalpy limit value shall be set to the enthalpy value at 75°F and 50% relative humidity. As an example, at approximately 6,000 foot elevation, the fixed enthalpy limit is approximately 30.7 Btu/lb.

Reference

- Economizer High-Limit Controls and Why Enthalpy Economizers Don't Work
  - By Steve Taylor and Hwakong Cheng
  - ASHRAE Journal November 2010
  - Available at http://tinyurl.com/23xegku.

Economizer Components – 140.4(e)4

4. If an economizer is required by Section 140.4(e)1, and an air economizer is used to meet the requirement, then the air economizer, and all return air dampers on any individual cooling fan system that has a total mechanical cooling capacity over 54,000 Btu/hr shall have the following features:

   A. **Warranty.** 5-year Manufacturer warranty of economizer assembly.

   B. **Damper reliability testing.** Suppliers of economizers shall certify that the economizer assembly, including but not limited to outdoor air damper, return air damper, drive linkage, and actuator, have been tested and are able to open and close against the rated airflow and pressure of the system after 60,000 damper opening and closing cycles.

   C. **Damper leakage.** Economizer and return dampers shall be certified to have a maximum leakage rate of 10 cfm/sf at 1.0 in. w.g. when tested in accordance with AMCA Standard 500.

   D. **Adjustable setpoint.** If the high-limit control is fixed dry-bulb or fixed enthalpy + fixed dry-bulb then the control shall have an adjustable setpoint.

   E. **Sensor accuracy.** Outdoor air, return air, mixed air, and supply air sensors shall be calibrated within the following accuracies.

      i. Drybulb and wetbulb temperatures accurate to ±2°F over the range of 40°F to 80°F.

      ii. Enthalpy accurate to ±3 Btu/lb over the range of 20 Btu/lb to 36 Btu/lb.

      iii. Relative humidity (RH) accurate to ±5 percent over the range of 20percent to 80 percent RH.

   F. **Sensor calibration data.** Data used for control of the economizer shall be plotted on a sensor performance curve.

   G. **Sensor high limit control.** Sensors used for the high limit control shall be located to prevent false readings, including but not limited to being properly shielded from direct sunlight.

   H. **Relief air system.** Relief air systems shall be capable of providing 100 percent outside air without over-pressurizing the building.

DX Compressor Unloading – 140.4(e)5 & Table 140.4-C

5. Systems that include an air economizer to meet Section 140.4(e)1 shall include the following:

   A. Unit controls shall have mechanical capacity controls interlocked with economizer controls such that the economizer is at 100 percent open position when mechanical cooling is on and does not begin to close until the leaving air temperature is less than 45°F.

   B. Direct Expansion (DX) units that control the capacity of the mechanical cooling directly based on occupied space temperature shall have a minimum of 2 stages of mechanical cooling capacity, per the following effective dates:

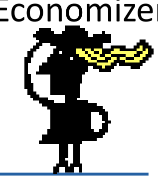
      i. ≥ 75,000 Btu/hr – Effective 1/1/2014

      ii. ≥ 65,000 Btu/hr – Effective 1/1/2016

   C. Effective 1/1/2014, DX units not within the scope of Section 140.4(e)5,B, such as those that control space temperature by modulating the airflow to the space, shall (i) comply with the requirements in TABLE 140.4-C, and (ii) shall have controls that do not false load the mechanical cooling system by limiting or disabling the economizer or by any other means, such as hot gas bypass, except at the lowest stage of mechanical cooling capacity.

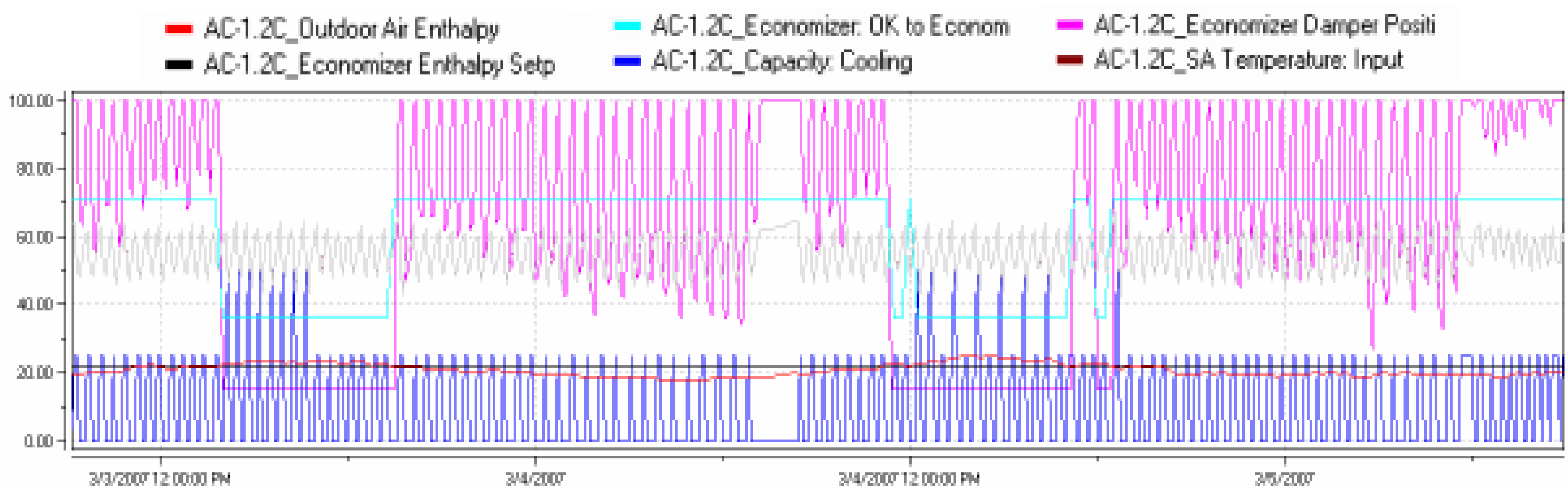
TABLE 140.4-C DIRECT EXPANSION (DX) UNIT REQUIREMENTS FOR COOLING STAGES AND COMPRESSOR DISPLACEMENT

Cooling Capacity	Minimum Number of Mechanical Cooling Stages	Minimum Compressor Displacement
≥ 65,000 Btu/h and < 240,000 Btu/h	3 stages	≤ 35% full load
≥ 240,000 Btu/h	4 stages	≤ 25% full load



Economizer DX System Unloading (140.4(e)5)

Figure 4 - AC Unit Control - M5 AC-1.2C



Economizer Fault Detection – 120.2(i)

(i) **Economizer Fault Detection and Diagnostics (FDD).** All newly installed air-cooled unitary direct-expansion units, equipped with an economizer and with mechanical cooling capacity at AHRI conditions of greater than or equal to 54,000 Btu/hr, shall include a Fault Detection and Diagnostics (FDD) system in accordance with Subsections 120.2(i)1 through 120.2(i)9. Air-cooled unitary direct expansion units include packaged, split-systems, heat pumps, and variable refrigerant flow (VRF), where the VRF capacity is defined by that of the condensing unit.

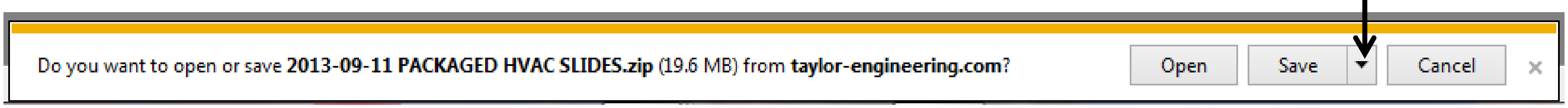
1. The following temperature sensors shall be permanently installed to monitor system operation: outside air, supply air, and when required for differential economizer operation, a return air sensor; and
2. Temperature sensors shall have an accuracy of ±2°F over the range of 40°F to 80°F; and
3. Refrigerant pressure sensors, if used, shall have an accuracy of ±3 percent of full scale; and
4. The controller shall have the capability of displaying the value of each sensor; and
5. The controller shall provide system status by indicating the following conditions:
    A. Free cooling available
    B. Economizer enabled
    C. Compressor enabled
    D. Heating enabled
    E. Mixed air low limit cycle active
6. The unit controller shall manually initiate each operating mode so that the operation of compressors, economizers, fans, and heating system can be independently tested and verified; and
7. Faults shall be reported to a fault management application accessible by day-to-day operating or service personnel, or annunciated locally on zone thermostats; and

Economizer Fault Detection – 120.2(i) continued

8. The FDD system shall detect the following faults:
   - A. Air temperature sensor failure/fault
   - B. Not economizing when it should
   - C. Economizing when it should not
   - D. Damper not modulating
   - E. Excess outdoor air
9. The FDD System shall be certified by the Energy Commission as meeting requirements of Sections 120.2(i)1 through 120.2(i)8 in accordance with Section 100(h).

- The following products comply:
  - Honeywell JADE,
  - Belimo ZIP, and
  - Transformative Wave Catalyst EEC
- Presentations on the JADE and ZIP are posted here: http://tinyurl.com/kan2g5o

Click on "Save" or "Save As"



Break

Fan Control – 140.4(m)

(m) **Fan Control.** As of the applicable date listed in TABLE 140.4-D, each cooling system listed in TABLE 140.4-D shall be designed to vary the indoor fan airflow as a function of load and shall comply with the following requirements:

1. DX and chilled water cooling systems that control the capacity of the mechanical cooling directly based on occupied space temperature shall (i) have a minimum of 2 stages of fan control with no more than 66percent speed when operating on stage 1; and (ii) draw no more than 40 percent of the fan power at full fan speed, when operating at 66 percent speed.

2. All other systems, including but not limited to DX cooling systems and chilled water systems that control the space temperature by modulating the airflow to the space, shall have proportional fan control such that at 50 percent air flow the power draw is no more than 30 percent of the fan power at full fan speed.

3. Systems-that include an air side economizer to meet 140.4(e)1 shall have a minimum of 2 speeds of fan control during economizer operation.

Single-Zone VAV

Multi-Zone VAV

EXCEPTION to Section 140.4(m): Modulating fan control is not required for chilled water systems with all fan motors <1 HP, or for evaporative systems with all fan motors < 1 HP, if the systems are not used to provide ventilation air and all indoor fans cycle with the load.

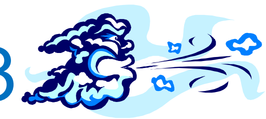
TABLE 140.4-D EFFECTIVE DATES FOR FAN CONTROL SYSTEMS

Cooling System Type	Fan Motor Size	Cooling Capacity	Effective Date
DX Cooling	any	≥ 110,000 Btu/hr	1/1/2012
		≥ 75,000 Btu/hr	1/1/2014
		≥ 65,000 Btu/hr	1/1/2016
Chilled Water and Evaporative	≥ 5 HP	any	1/1/2010
	≥ 1 HP	any	1/1/2014
	≥ 1/4 HP	any	1/1/2016

Occupant Sensor Ventilation Control 120.2(e)3

- Required for:
  - Multipurpose rooms <1,000 ft2
  - Classrooms >750 ft2, and
  - Conference rooms and auditoria >750 ft2
  - Any space <1,500 ft2 using this as an alternate to DCV (Exception 5 to 120.1(c)3, DCV)
  - Exception for rooms with processes (dust, fumes...)
  - Exception if DCV is implemented as required by 120.1(4)
- NOT CLEAR if allowed or not allowed where not required (e.g. can a private office use an occupancy sensor to reduce ventilation below 0.15 cfm/ft2?)

Occupant Sensor Ventilation Control 120.2(e)3



3. Multipurpose room less than 1000 ft^2, classrooms greater than 750 ft^2 and conference, convention, auditorium and meeting center rooms greater than 750 ft^2 that do not have processes or operations that generate dusts, fumes, vapors or gasses shall be equipped with occupant sensor(s) to accomplish the following during unoccupied periods:

   A. Automatically setup the operating cooling temperature set point by 2°F or more and setback the operating heating temperature set point by 2˚F or more; and

   B. Automatically reset the minimum required ventilation rate with an occupant sensor ventilation control device according to Section 120.1(c)5.

EXCEPTION 1 to Sections 120.2(e)1, 2, and 3: Where it can be demonstrated to the satisfaction of the enforcing agency that the system serves an area that must operate continuously.

EXCEPTION 2 to Sections 120.2(e)1, 2, and 3: Where it can be demonstrated to the satisfaction of the enforcing agency that shutdown, setback, and setup will not result in a decrease in overall building source energy use.

EXCEPTION 3 to Sections 120.2(e)1, 2, and 3: Systems with full load demands of 2 kW or less, if they have a readily accessible manual shut-off switch.

EXCEPTION 4 to Sections 120.2(e)1 and 2: Systems serving hotel/motel guest rooms, if they have a readily accessible manual shut-off switch.

Exception 5 to Sections 120.2(e)3:. If Demand Control Ventilation is implemented as required by Section 120.1(4).

Occupant Sensor Ventilation Control 120.1(c)5

- Requirements
  - Integrated with pre-occupancy purge (120.1(c)5B)
  - Setup/setback 2^{o}F when unoccupied (120.2(e)3)
  - Reduce zone airflow to 0 within 30 min if unoccupied and not calling for heating/cooling (120.1(c)5C and D)
  - Able to reduce or cycle to meet 25% of the area based minimum zone airflow requirements over a 2 hour period (120.1(c)5E)
    - 25% = 0.04 cfm/ft2 for most spaces

Occupant Sensor Ventilation Control 120.1(c)5

5. **Occupant Sensor Ventilation Control Devices.** When occupancy sensor ventilation devices are required by Section 120.2(e)3 or when meeting EXCEPTION 5 to Section 120.1(c)3, occupant sensors shall be used to reduce the rate of outdoor air flow when occupants are not present in accordance with the following:

   A. Occupant sensors shall meet the requirements in Section 110.9(b)4 and shall have suitable coverage and placement to detect occupants in the entire space ventilated. Occupant sensors controlling lighting may be used for ventilation as long as the ventilation signal is independent of daylighting, manual lighting overrides or manual control of lighting. When a single zone damper or a single zone system serves multiple rooms, there shall be an occupancy sensor in each room and the zone is not considered vacant until all rooms in the zone are vacant.

   B. One hour prior to normal scheduled occupancy, the occupancy sensor ventilation control shall allow pre-occupancy purge as described in Section 120.1(c)2.

   C. Within 30 minutes after being vacant for all rooms served by a zone damper on a multiple zone system, and the space temperature is between the heating and cooling setpoints, then no outside air is required and supply air shall be zero.

   D. Within 30 minutes after being vacant for all rooms served by a single zone system, the single zone system shall cycle off the supply fan when the space temperature is between the heating and cooling setpoints.

   E. In spaces equipped with an occupant sensor, when vacant during hours of expected occupancy and the occupied ventilation rate required by Section 120.1(b)2 is not provided, then the system or zone controls shall cycle or operate to maintain the average outdoor air rate over an averaging period of 120 minutes equal to 25percent of the rate listed in TABLE 120.1-A.

Exception to 120.1(c)5: If Demand Control Ventilation is implemented as required by Section 120.1(4).

25% of these rates with Occupancy Sensor Control

TABLE 120.1-A MINIMUM VENTILATION RATES

TYPE OF USE	CFM PER SQUARE FOOT OF CONDITIONED FLOOR AREA
Auto Repair Workshops	1.50
Barber Shops	0.40
Bars, cocktail lounges, and casinos	0.20
Beauty shops	0.40
Coin-operated dry cleaning	0.30
Commercial dry cleaning	0.45
High-rise residential	Ventilation Rates Specified by the CBC
Hotel guest rooms (less than 500 ft^2)	30 cfm/guest room
Hotel guest rooms (500 ft^2 or greater)	0.15
Retail stores	0.20
All others	0.15

Hotel Room Setbacks 120.2(e)4

4. Hotel and motel guest rooms shall have captive card key controls, occupancy sensing controls, or automatic controls such that, no longer than 30 minutes after the guest room has been vacated, setpoints are setup at least +5°F (+3°C) in cooling mode and set-down at least -5°F (-3°C) in heating mode.

Demand Control Ventilation (120.1(c)3)

- Basically required for high density spaces like conference rooms and auditoria
  - Exceptions:
    - Classrooms,
    - Call centers,
    - Healthcare,
    - rooms < 150ft2,
    - Rooms <1500 ft2 where occupant sensor ventilation controls used
- Allowed anywhere
- Requirements
  - Minimum ventilation reset from 15 cfm/person down to 0.15 cfm/ft2 if CO_2 < 1000 ppm.

Demand Control Ventilation (120.1(c)3)

3. **Required Demand Control Ventilation.** HVAC systems with the following characteristics shall have demand ventilation controls complying with 120.1(c)4:

   A. They have an air economizer; and

   B. They serve a space with a design occupant density, or a maximum occupant load factor for egress purposes in the CBC, greater than or equal to 25 people per 1000 square feet (40 square feet or less per person); and

   C. They are either:

      i. Single zone systems with any controls; or

      ii. Multiple zone systems with Direct Digital Controls (DDC) to the zone level.

   EXCEPTION 1 to Section 120.1(c)3: Classrooms, call centers, office spaces served by multiple zone systems that are continuously occupied during normal business hours with occupant density greater than 25 people per 1000 ft^2 per Section 120.1(b)2B, healthcare facilities and medical buildings, and public areas of social services buildings are not required to have demand control ventilation.

   EXCEPTION 2 to Section 120.1(c)3: Where space exhaust is greater than the design ventilation rate specified in Section 120.1(b)2B minus 0.2 cfm per ft^2 of conditioned area.

   EXCEPTION 3 to Section 120.1(c)3: Spaces that have processes or operations that generate dusts, fumes, mists, vapors, or gases and are not provided with local exhaust ventilation, such as indoor operation of internal combustion engines or areas designated for unvented food service preparation, or beauty salons shall not install demand control ventilation.

   EXCEPTION 4 to Section 120.1(c)3: Spaces with an area of less than 150 square feet, or a design occupancy of less than 10 people per Section 120.1(b)2B.

   EXCEPTION 5 to Section 120.1(c)3: Spaces with an area of less than 1,500 square feet complying with Section 120.1(c)5.

Reheat Controls (Exception 1 to 140.4(d))

(d) **Space-conditioning Zone Controls.** Each space-conditioning zone shall have controls that prevent:

1. Reheating; and
2. Recooling; and
3. Simultaneous provisions of heating and cooling to the same zone, such as mixing or simultaneous supply of air that has been previously mechanically heated and air that has been previously cooled either by cooling equipment or by economizer systems.

EXCEPTION 1 to Section 140.4(d): Zones served by variable air-volume systems that are designed and controlled to reduce, to a minimum, the volume of reheated, recooled, or mixed air are allowed only if the controls meet all of the following requirements:

A. For each zone with direct digital controls (DDC):

i. The volume of primary air that is reheated, recooled or mixed air supply shall not exceed the larger of:

a. 50 percent of the peak primary airflow; or

b. The design zone outdoor airflow rate per Section 120.1.

ii. The volume of primary air in the deadband shall not exceed the larger of:

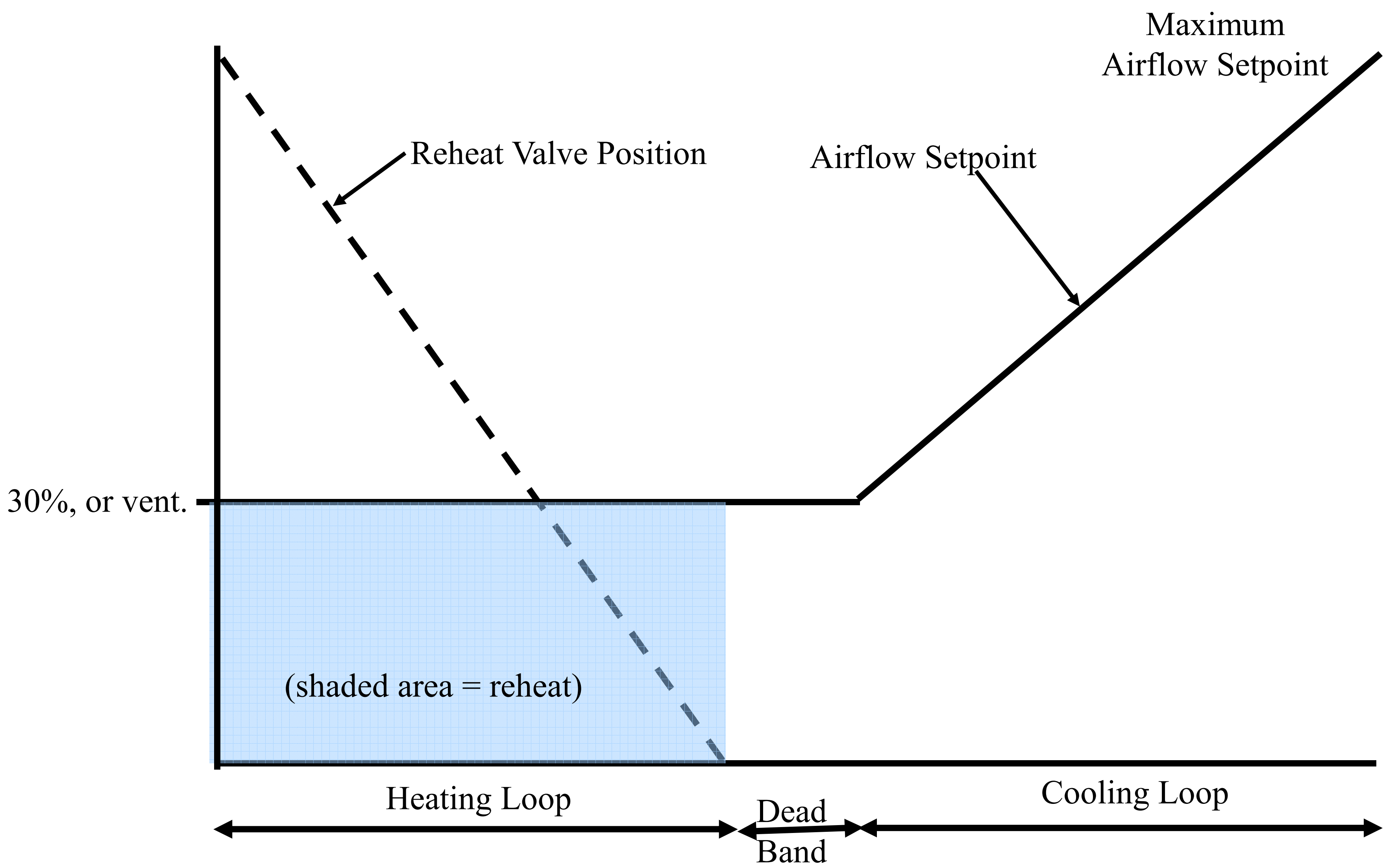
a. 20 percent of the peak primary airflow; or

b. The design zone outdoor airflow rate per Section 120.1.

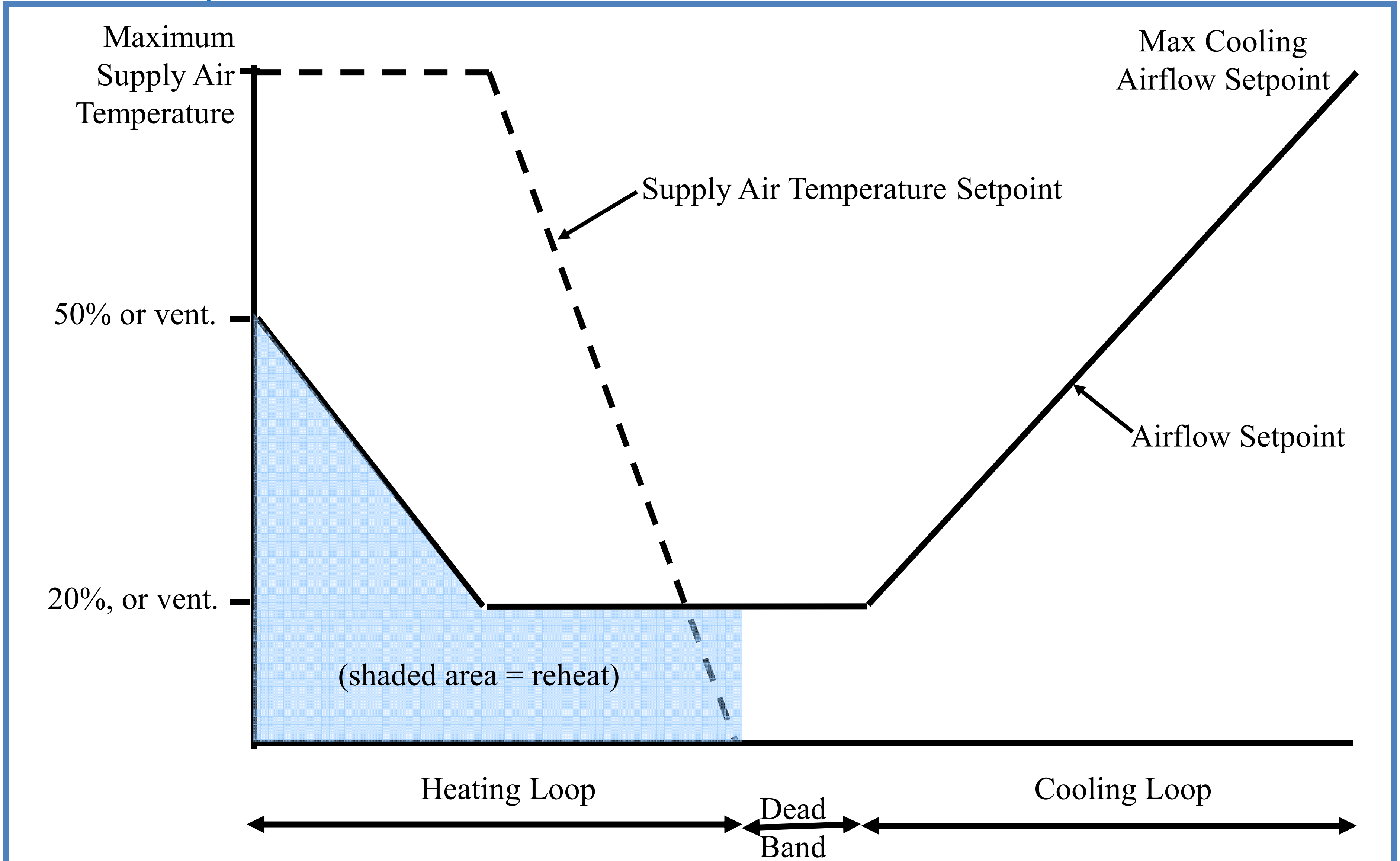
iii. The first stage of heating consists of modulating the zone supply air temperature setpoint up to a maximum setpoint no higher than 95°F while the airflow is maintained at the dead band flow rate.

iv. The second stage of heating consists of modulating the airflow rate from the dead band flow rate up to the heating maximum flow rate.

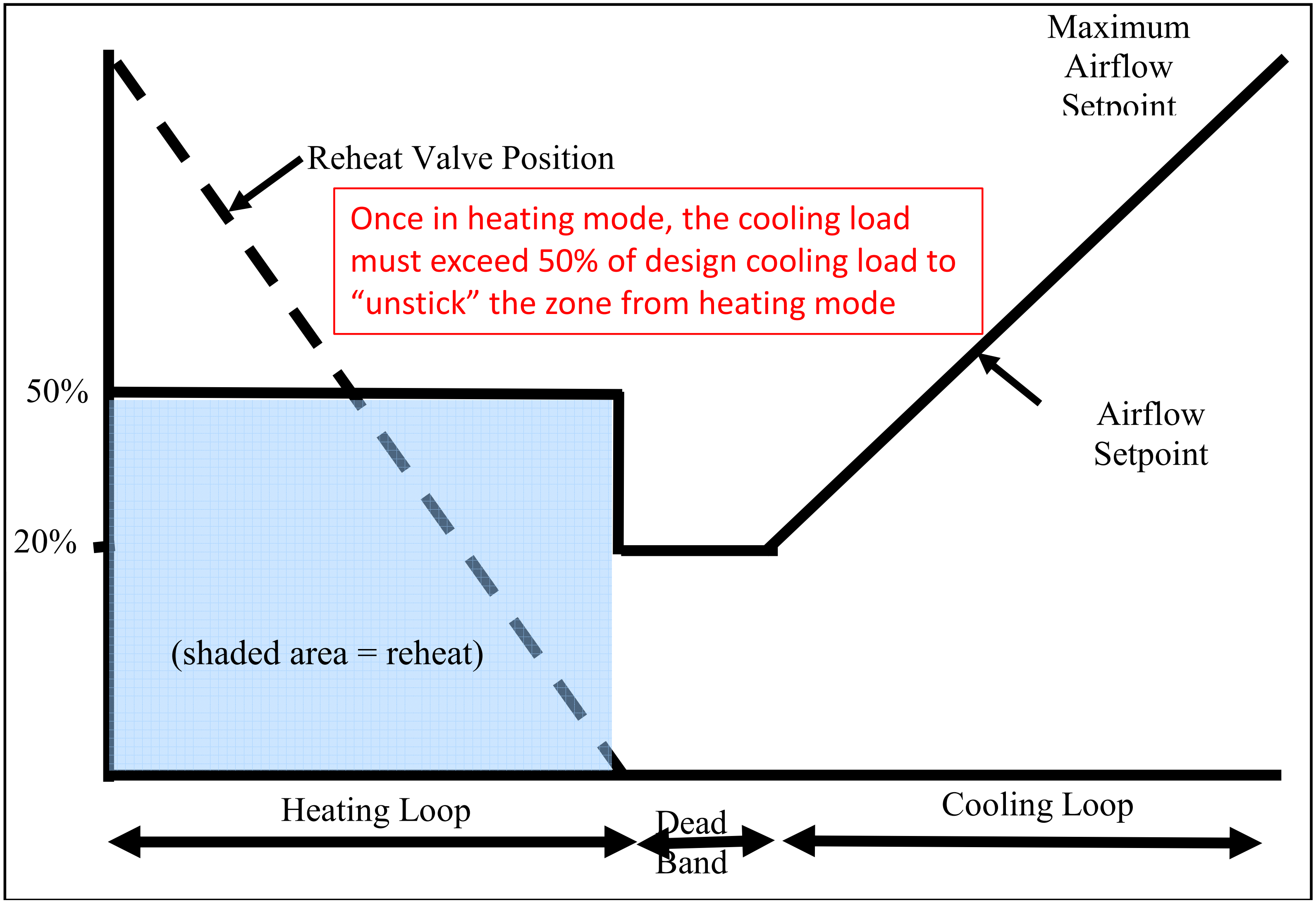
Reheat Controls – 30% Single Max – Only Allowed for Non-DDC (pneumatics)



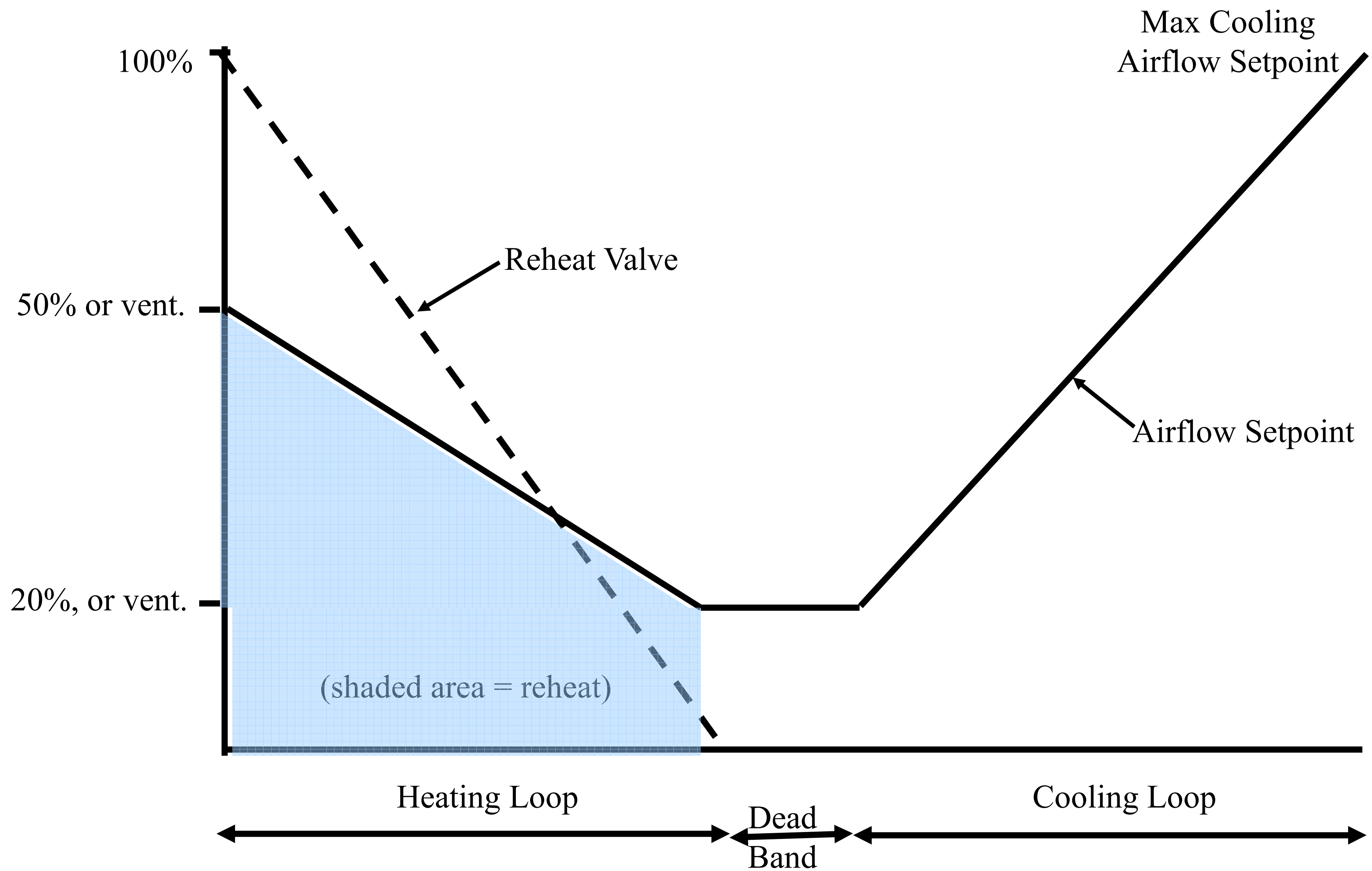
Reheat Controls – Dual Max / Temperature First (Most Efficient)



Reheat Controls – Dual Max/Constant Volume Heat – NOT ALLOWED!



Reheat Controls – Dual Max / Simultaneous - To be prohibited in T24-2013



Equipment Efficiencies 110.2(a)

- Summary of Changes:
  - Increased efficiencies adopted from 90.1-2010
  - Tables 110.2A and B, added IEER for DX units with capacity control
  - Table 110.2E PTAC/PTHP, increased stringency for manufacturing date >10/08/2012
  - Addition of AHRI 400 rating for heat-exchangers (table 110.2-F)
  - Changes to chillers and towers follow

Equipment Efficiencies 110.2(a)

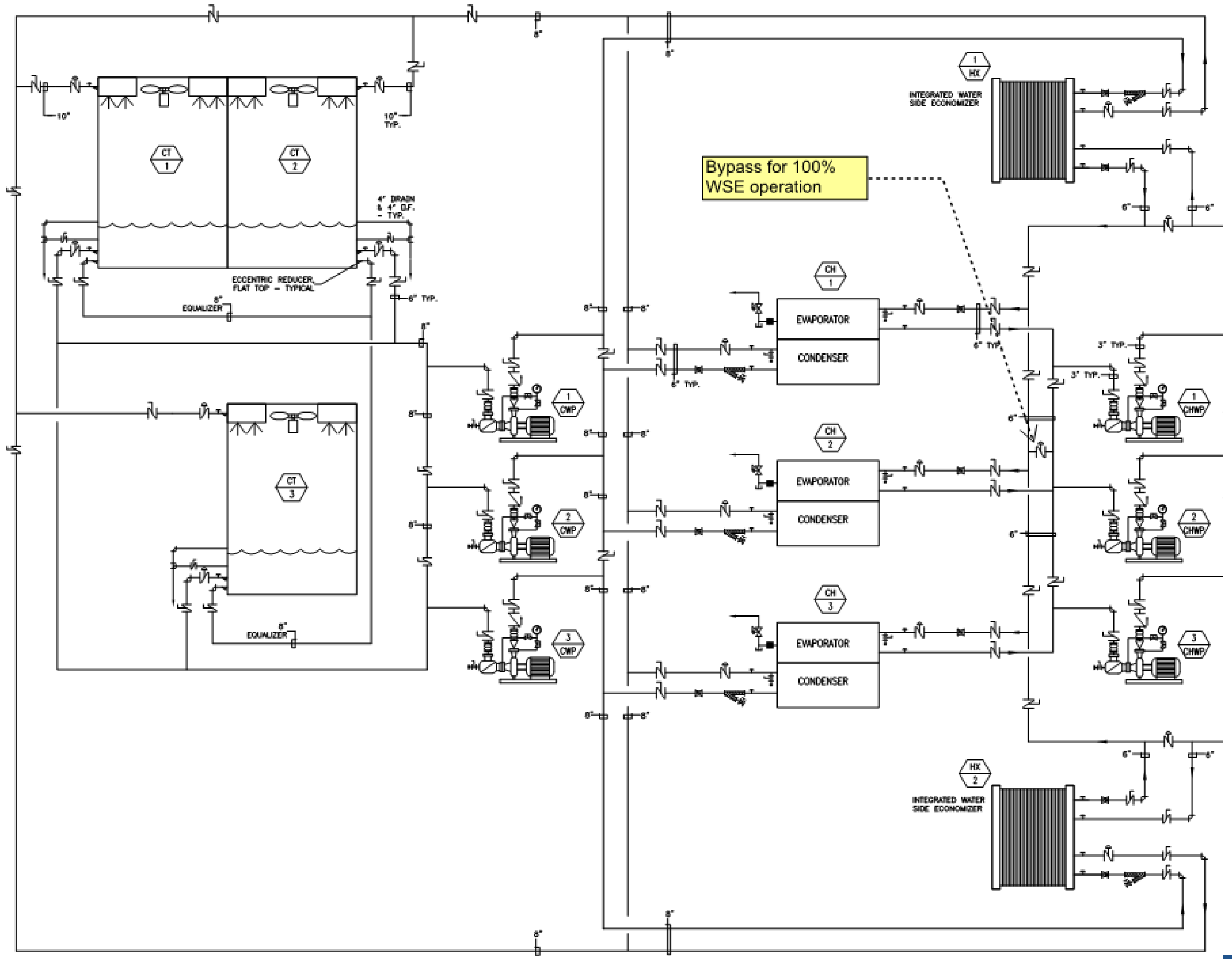
❖ **Integrated Energy Efficiency Ratio (IEER)**

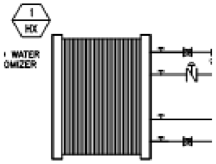
The integrated energy efficiency ratio (IEER) is a replacement for IPLV that was used for large unitary equipment in Standard 90.1–2007. The IEER is a significant improvement over IPLV as it allows for uniform rating of all products including single- and multi-stage units. It is based on a weighted average of performance at 100%, 75%, 50% and 25% of capacity. The new part-load metric is expected to more accurately rate the part-load performance of commercial unitary equipment. In addition, the IEER provides part-load rating for equipment down to 65 kBtuh (5.5 tons) in capacity. The IPLVs were provided for units 240kBtuh (20 tons) and larger.

❖ **Integrated Coefficient of Performance (ICOP)**

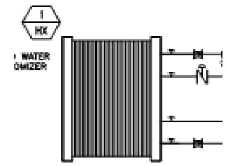
The ICOP is the SI version of the IEER. For a given piece of equipment, the IEER equals the ICOP times 3.413.

Central Plants



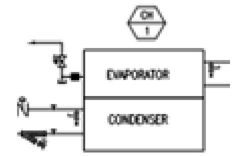


Central Plants

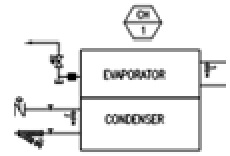


- Chillers
  - Wider application range (Exception 1 to 110.2(a))
  - New efficiency table (Table 110.2-D)
  - Prescriptive requirements for Path B chillers (140.4(i))
  - Tighter restriction on air-cooled chillers (140.4(j))
- Towers
  - New minimum requirements for closed-circuit fluid coolers (110.2(G))
  - Measures to reduce water usage (110.2(e))

Chillers



Chillers Range (Exception 1 to 110.2(a))



EXCEPTION 1 to Section 110.2(a): Water-cooled centrifugal water-chilling packages that are not designed for operation at ANSI/AHRI Standard 550/590 test conditions of 44°F leaving chilled water temperature and 85°F entering condenser water temperature with 3 gallons per minute per ton condenser water flow shall have a maximum full load kW/ton and NPLV ratings adjusted using the following equation:

Adjusted maximum full-load kW/ton rating = (fullload kW/ton from TABLE 110.2-D) / Kadj

Adjusted maximum NPLV rating = (IPLV from TABLE 110.2-D) / Kadj

Where:

Kadj = (A) x (B)

$A = 0.00000014592 \times (LIFT)^4 - 0.0000346496 \times (LIFT)^3 + 0.00314196 \times (LIFT)^2 - 0.147199 \times (LIFT) + 3.9302$

LIFT = LvgCond – LvgEvap (°F)

LvgCond = Full-load leaving condenser fluid temperature (°F)

LvgEvap = Full-load leaving evaporator fluid temperature (°F)

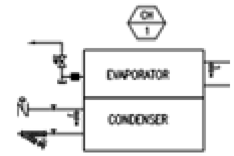
B = (0.0015 x LvgEvap) + 0.934

The adjusted full-load and NPLV values are only applicable for centrifugal chillers meeting all of the following full-load design ranges:

- Minimum Leaving Evaporator Fluid Temperature: 36°F
- Maximum Leaving Condenser Fluid Temperature: 115°F
- LIFT $\geq$ 20°F and $\leq$ 80°F

Centrifugal chillers designed to operate outside of these ranges are not covered by this exception.

Chillers Range (Exception 1 to 110.2(a))



- From the forward of Addendum BT to 90.1-2007

Based on shipped centrifugal chiller performance predictions, there is an expected efficiency improvement range of 0 to 23%, with an average of 1% improvement, depending on the performance conditions specified. Part load performance is also improved by the same new adjustment factor. It is anticipated that 10 percent more centrifugal chillers will be covered by this Standard versus Addendum M to 2007 and 5 percent more than were covered by the 2004 and 2007 versions. This proposal brings approximately 98% of the centrifugal chillers under the scope of the Standard.

As Addendum M claimed no scope improvement savings, this proposed addendum is estimated to save over 24 GWh annually worldwide. U.S. savings are an estimated 12 GWh per year, based on the average of the last 10 years of chiller shipments.

Chillers Efficiency Table (110.2-D)

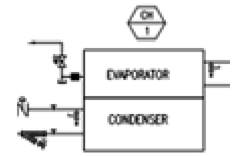
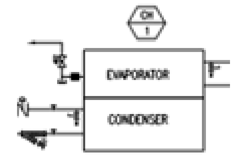


TABLE 110.2-D WATER CHILLING PACKAGES – MINIMUM EFFICIENCY REQUIREMENTS [a,b]

Equipment Type	Size Category	Path A Efficiency [a,b]	Path B Efficiency [a,b]	Test Procedure [c]
Air Cooled, With Condenser Electrically Operated	< 150 Tons	≥ 9.562 EER ≥ 12.500 IPLV	N.A. [d]	AHRI 550/590
	≥ 150 Tons	≥ 9.562 EER ≥ 12.750 IPLV	N.A. [d]	
Air Cooled, Without Condenser Electrically Operated	All Capacities	Air-cooled chillers without condensers must be rated with matching condensers and comply with the air-cooled chiller efficiency requirements.		
Water Cooled, Electrically Operated, Reciprocating	All Capacities	Reciprocating units must comply with the water-cooled positive displacement efficiency requirements.		AHRI 550/590
(Reciprocating)				
Water Cooled, Electrically Operated Positive Displacement	< 75 Tons	≤0.780 kW/ton ≤ 0.630 IPLV	≤ 0.800 kW/ton ≤ 0.600 IPLV	AHRI 550/590
	≥ 75 tons and < 150 tons	≤ 0.775 kW/ton ≤0.615 IPLV	≤ 0.790 kW/ton ≤ 0.586 IPLV	
	≥ 150 tons and < 300 tons	≤ 0.680 kW/ton ≤ 0.580 IPLV	≤ 0.718 kW/ton ≤ 0.540 IPLV	
	≥ 300 Tons	≤ 0.620 kW/ton ≤ 0.540 IPLV	≤ 0.639 kW/ton ≤ 0.490 IPLV	
Water Cooled, Electrically Operated, Centrifugal	< 150 Tons	≤ 0.634 kW/ton ≤ 0.596 IPLV	≤ 0.639 kW/ton ≤ 0.450 IPLV	
	≥ 150 tons and < 300 tons	≤0.634 kW/ton ≤ 0.596 IPLV	≤ 0.639 kW/ton ≤ 0.450 IPLV	
	≥ 300 tons and < 600 tons	≤0.576 kW/ton ≤0.549 IPLV	≤ 0.600 kW/ton ≤ 0.400 IPLV	
	≥ 600 Tons	≤ 0.570 kW/ton ≤ 0.539 IPLV	≤ 0.590 kW/ton ≤ 0.400 IPLV	

Chillers Efficiency Table (110.2-D)



CONTINUED: TABLE 110.2-D WATER CHILLING PACKAGES – MINIMUM EFFICIENCY REQUIREMENTS [a,b]

Equipment Type	Size Category	Path A Efficiency [a,b]	Path B Efficiency [a,b]	Test Procedure [c]
Air Cooled Absorption, Single Effect	All Capacities	≥0.600 COP	N.A. [d]	ANSI/AHRI 560
Water Cooled Absorption, Single Effect	All Capacities	≥ 0.700 COP	N.A. [d]	
Absorption Double Effect, Indirect-Fired	All Capacities	≥ 1.000 COP ≥ 1.050 IPLV	N.A. [d]	
Absorption Double Effect, Direct-Fired	All Capacities	≥ 1.000 COP ≥1.000 IPLV	N.A. [d]	
Water Cooled Gas Engine Driven Chiller	All Capacities	≥1.2 COP ≥2.0 IPLV	N.A. [d]	ANSI Z21.40.4A

[a] No requirements for:

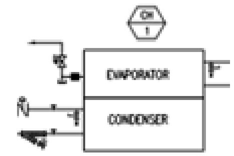
- Centrifugal chillers with design leaving evaporator temperature < 36°F; or
- Positive displacement chillers with design leaving fluid temperature ≤ 32°F; or
- Absorption chillers with design leaving fluid temperature < 40°F

[b] Must meet the minimum requirements of Path A or Path B. However, both the full load (COP) and IPLV must be met to fulfill the requirements of the applicable Path.

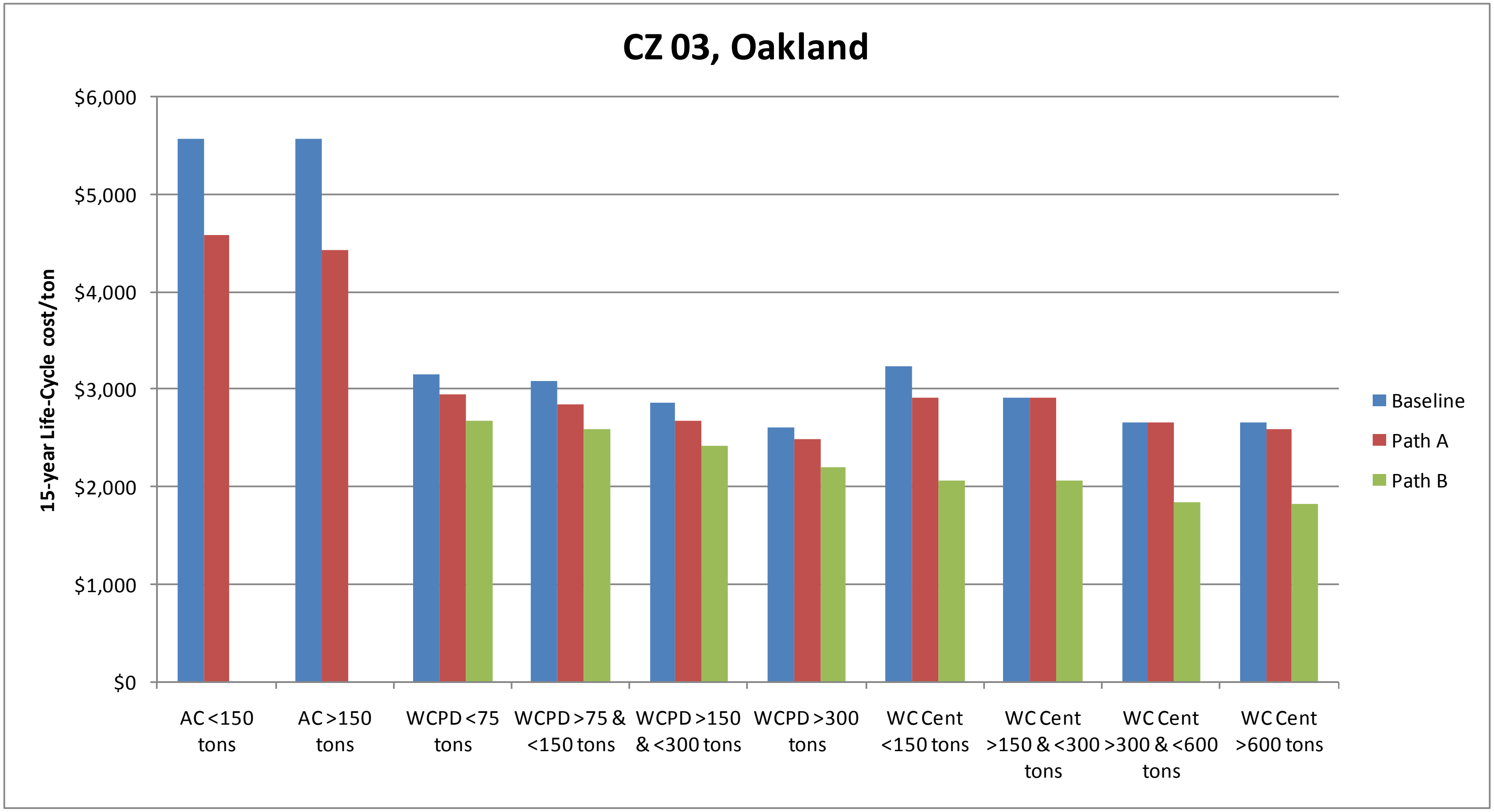
[c] See Section 100.1 for definitions

[d] NA means not applicable

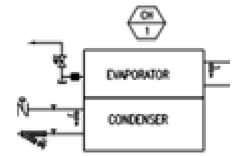
Prescriptive Requirement for Path B (140.4(i))



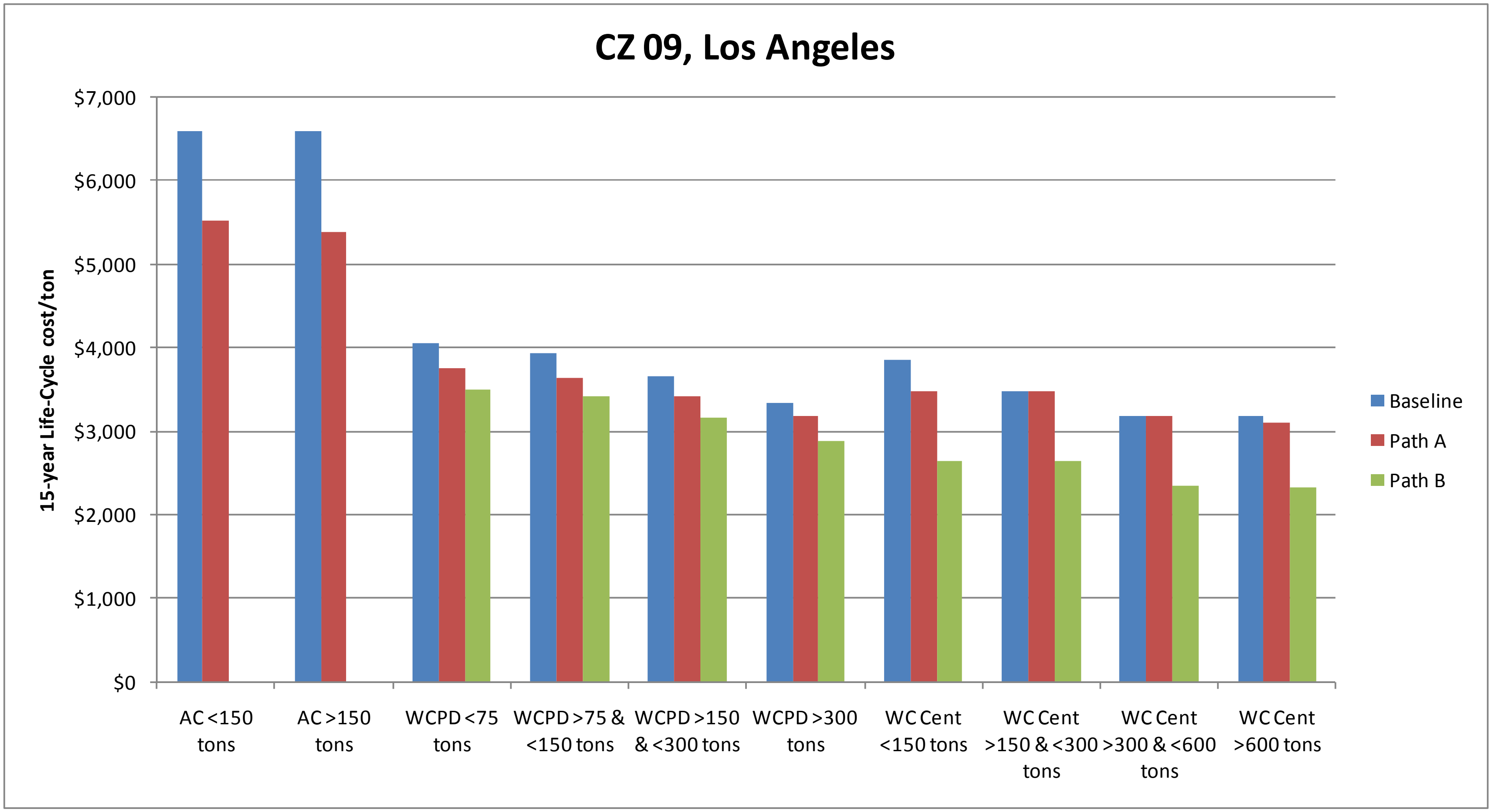
Simulation results: 15-year life-cycle cost of chillers per ton



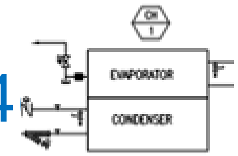
Prescriptive Requirement for Path B (140.4(i))



Simulation results: 15-year life-cycle cost of chillers per ton



Chiller Efficiency – 120.2(a), Table 110.2-D and 140.4



- Chiller efficiencies in Table 110.2-D have two efficiencies
  - Path A for fixed speed chillers, and
  - Path B for variable speed chillers.
- 140.4(i) Prescriptively requires Path B

(i) **Minimum Chiller Efficiency.** Chillers shall meet or exceed Path B from TABLE 110.2-D

EXCEPTION 1 to Section 140.4(i): Chillers with electrical service > 600V.

EXCEPTION 2 to Section 140.4(i): Chillers attached to a heat recovery system with a design heat recovery capacity > 40 percent of the design chiller cooling capacity.

EXCEPTION 3 to Section 140.4(i): Chillers used to charge thermal energy storage systems where the charging temperature is < 40 °F.

EXCEPTION 4 to Section 140.4(i): In buildings with more than 3 chillers, only 3 chillers are required to meet the Path B efficiencies.

Air Cooled Chiller Limitation – 140.4(j)

(j) **Limitation of Air-Cooled Chillers.** Chilled water plants shall not have more than 300 tons provided by air-cooled chillers.

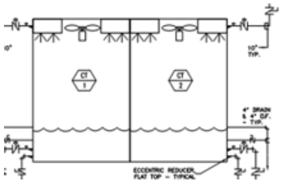
EXCEPTION 1 to Section 140.4(j): Where the water quality at the building site fails to meet manufacturer's specifications for the use of water-cooled chillers.

EXCEPTION 2 to Section 140.4(j): Chillers that are used to charge a thermal energy storage system with a design temperature of less than 40 degrees F (4 degrees C).

EXCEPTION 3 to Section 140.4(j): Air cooled chillers with minimum efficiencies approved by the Commission pursuant to Section 10-109(d).

The 2008 language was changed to limit air-cooled to 300 tons in any plant.

Cooling Towers



New requirements for heat exchangers (Table 110.2-F) and closed-circuit fluid coolers (Table 110.2-G)

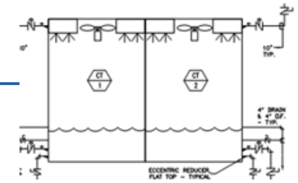


TABLE 110.2-F HEAT TRANSFER EQUIPMENT

Equipment Type	Subcategory	Minimum Efficiency[a]	Test Procedure [b]
Liquid-to-liquid heat exchangers	Plate type	NR	ANSI/AHRI 400

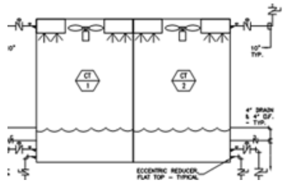
[a] NR = no requirement

[b] Applicable test procedure and reference year are provided under the definitions

TABLE 110.2-G PERFORMANCE REQUIREMENTS FOR HEAT REJECTION EQUIPMENT

Equipment Type	Total System Heat Rejection Capacity at Rated Conditions	Subcategory or Rating Condition	Performance Required ,[a ,b, c, d]	Test Procedure [e]
Propeller or axial fan Open-circuit cooling towers	All	95°F entering water 85°F leaving water 75 °F entering air wb	-42.1 gpm/hp	CTI ATC-105 and CTI STD-201
Centrifugal fan Open-circuit cooling towers	All	95°F entering water 85°F leaving water 75 °F entering air wb	- 20.0 gpm/hp	CTI ATC-105 and CTI STD-201
Propeller or axial fan closed-circuit cooling towers	All	102°F entering water 90°F leaving water 75 °F entering air wb	- 14.0 gpm/hp	CTI ATC-105S and CTI STD-201

New requirements for closed-circuit fluid coolers (Table 110.2-G)



[a] For purposes of this table, open-circuit cooling tower performance is defined as the water flow rating of the tower at the given rated conditions divided by the fan motor nameplate power.

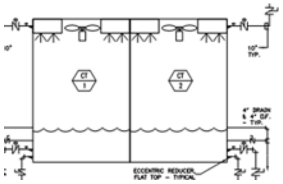
[b] For purposes of this table, closed-circuit cooling tower performance is defined as the process water flow rating of the tower at the given rated conditions divided by the sum of the fan motor nameplate rated power and the integral spray pump motor nameplate power .

[c] For purposes of this table air-cooled condenser performance is defined as the heat rejected from the refrigerant divided by the fan motor nameplate power.

[d] Open cooling towers shall be tested using the test procedures in CTI ATC-105. Performance of factory assembled open cooling towers shall be either certified as base models as specified in CTI STD-201 or verified by testing in the field by a CTI approved testing agency. Open factory assembled cooling towers with custom options added to a CTI certified base model for the purpose of safe maintenance or to reduce environmental or noise impact shall be rated at 90 percent of the CTI certified performance of the associated base model or at the manufacturer's stated performance, whichever is less. Base models of open factory assembled cooling towers are open cooling towers configured in exact accordance with the Data of Record submitted to CTI as specified by CTI STD-201. There are no certification requirements for field erected cooling towers.

[e] Applicable test procedure and reference year are provided under the definitions.

Measures to reduce tower water usage (110.2(e))

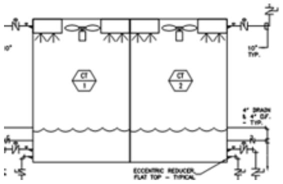


(e) **Open and Closed Circuit Cooling Towers.** All open and closed circuit cooling tower installations shall comply with the following:

1. Be equipped with Conductivity or Flow-based Controls that maximize cycles of concentration based on local water quality conditions. Controls shall automate system bleed and chemical feed based on conductivity, or in proportion to metered makeup volume, metered bleed volume, recirculating pump run time, or bleed time. Conductivity controllers shall be installed in accordance with manufacturer's specifications in order to maximize accuracy.
2. Documentation of Maximum Achievable Cycles of Concentration. Building owners shall document the maximum cycles of concentration based on local water supply as reported annually by the local water supplier, and using the calculator approved by the Energy Commission. The calculator is intended to determine maximum cycles based on a Langelier Saturation Index (LSI) of 2.5 or less. Building owner shall document maximum cycles of concentration on the mechanical compliance form which shall be reviewed and signed by the Professional Engineer (P.E.) of Record.
3. Be equipped with a Flow Meter with an analog output for flow either hardwired or available through a gateway on the makeup water line.
4. Be equipped with an Overflow Alarm to prevent overflow of the sump in case of makeup water valve failure. Overflow alarm shall send an audible signal or provide an alert via the Energy Management Control System to the tower operator in case of sump overflow.
5. Be equipped with Efficient Drift Eliminators that achieve drift reduction to 0.002 percent of the circulated water volume for counter-flow towers and 0.005 percent for cross-flow towers.

EXCEPTION to Section 110.2(e): Towers with rated capacity < 150 tons.

Measures to reduce tower water usage (110.1)



WATER BALANCE IN EVAPORATIVE COOLING TOWERS The water balance of a cooling tower is:

M = E + B, where:

M = makeup water (from the mains water supply)

E = losses due to evaporation

B = losses due to blowdown


Lunch
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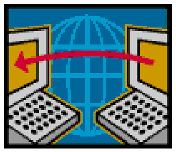
Process Heating and Cooling

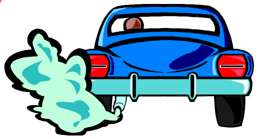
Computer Rooms



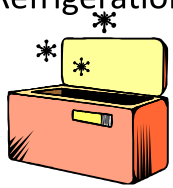
Labs

Kitchens

Garages



Refrigeration



Process Agenda

- Overview
- Computer Rooms
- Laboratories
- Kitchens
- Garage Exhaust
- Refrigeration
- Compressed Air
- Boilers

Process Overview

- Title 24 2008 and ASHRAE Standard 90.1 2007 exempted most process spaces.
- ASHRAE changed it's Title Purpose and Scope in 2010 to include processes and added requirement for Labs and Computer Rooms.
- Labs and Computer Rooms have energy utilization indices (EUI) 10X to >200X that of office buildings and run ~4 times more hours.
- Title 24 2013 includes requirements for "Covered Processes"

Process Definitions (100.1)

PROCESS is an activity or treatment that is not related to the space conditioning, lighting, service water heating, or ventilating of a building as it relates to human occupancy.

PROCESS BOILER is a type of boiler with a capacity (rated maximum input) of 300,000 Btus per hour (Btu/h) or more that serves a process.

PROCESS, COVERED are processes that are regulated under Part 6 which include but are not limited to computer rooms, laboratory exhaust, garage exhaust, commercial kitchen ventilation, refrigerator warehouses, supermarket refrigeration systems, compressed air systems, process cooling towers and process boilers.

PROCESS, EXEMPT is a process that is not a covered process.

PROCESS LOAD is a load resulting from a process.

PROCESS LOAD, COVERED the energy consumption of and/or the heat generated by a piece of equipment or device that is part of a covered process.

PROCESS LOAD, EXEMPT is the energy consumption of and/or the heat generated by a piece of equipment or device that is part of an exempt process.

PROCESS SPACE is a space that is thermostatically controlled to maintain a process environment temperature less than 55º F or to maintain a process environment temperature greater than 90º F for the whole space that the system serves, or that is a space with a space-conditioning system designed and controlled to be incapable of operating at temperatures above 55º F or incapable of operating at temperatures below 90º F at design conditions.

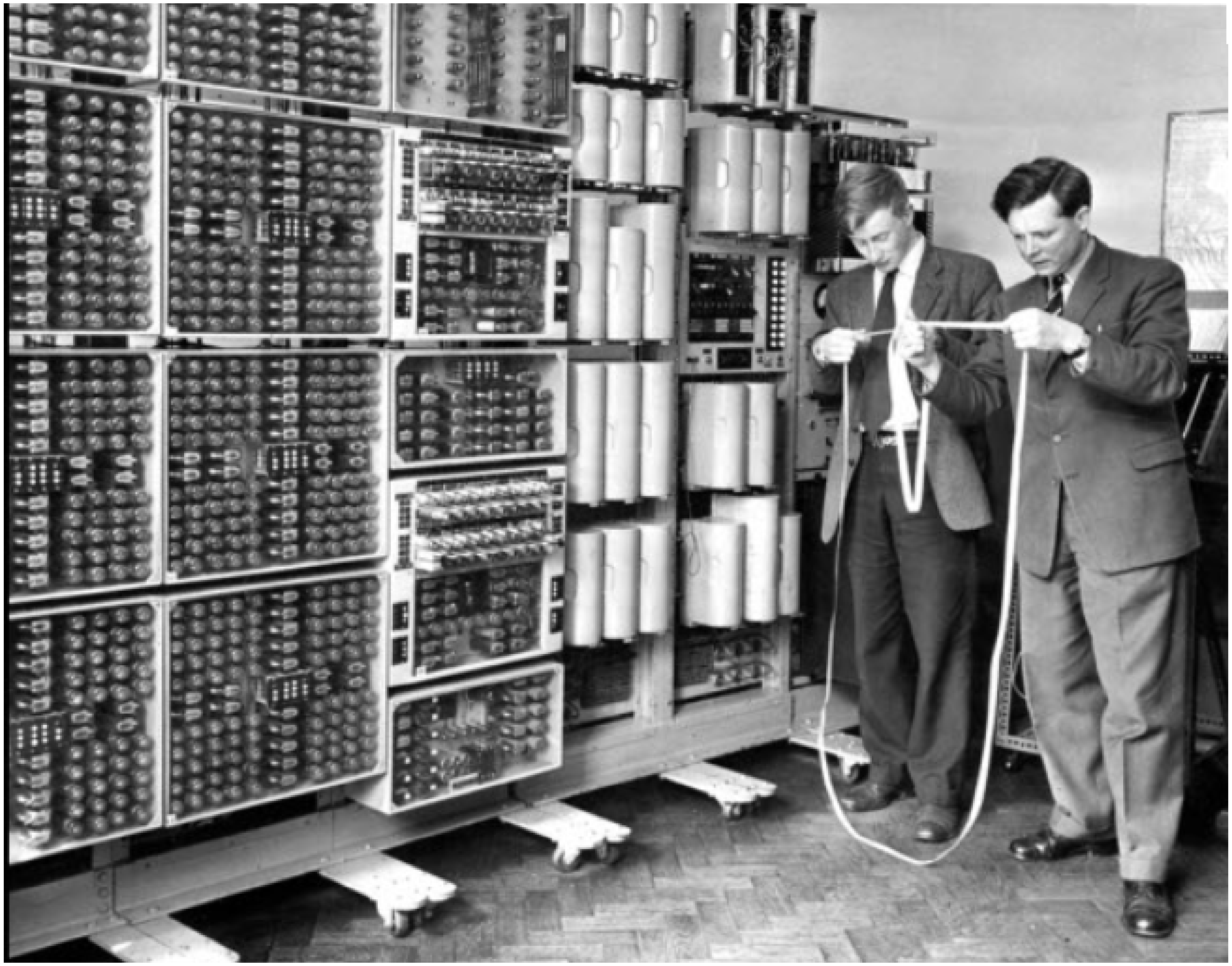
Process Overview Application (Table 100.0-A)

TABLE 100.0-A APPLICATION OF STANDARDS

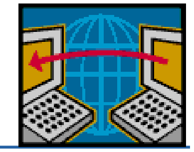
Occupancies	Application	Mandatory	Prescriptive	Performance	Additions/Alterations
General Provisions		100.0, 100.1, 100.2, 110.0, 110.10			
Nonresidential, High-Rise Residential, And Hotels/Motels	General	140.0	140.2	140.1	141.0
	Envelope (conditioned)	110.6, 110.7, 110.8,120.7	140.3		
	Envelope (unconditioned process spaces)	N.A.	140.3(c)		
	HVAC (conditioned)	110.2, 110.5, 120.0-120.5, 120.8	140.4		
	Water Heating	110.3, 120.3, 120.8	140.5		
	Indoor Lighting (conditioned, process spaces)	110.9, 120.8, 130.0, 130.1, 130.4	140.3(c), 140.6		
	Indoor Lighting (unconditioned and parking garages)	110.9, 120.8, 130.0, 130.1, 130.4	140.3(c), 140.6	N.A.	
	Outdoor Lighting	110.9, 130.0, 130.2, 130.4	140.7		
	Building Electrical Power	130.5	N.A.		
	Pool and Spa Systems	110.4, 150.0(p)	N. A.		N. A.
	Solar Ready Buildings	110.10	N.A.		N.A.
Covered Processes[1]	Envelope, Ventilation, Process Loads	110.2, 120.6, 120.8	140.9	140.1	120.6, 140.9

New Sections for Covered Processes

Computer Room

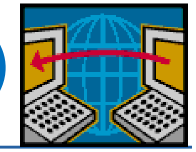


Computer Room Definition (100.1)



COMPUTER ROOM is a room whose primary function is to house electronic equipment and that has a design equipment power density exceeding 20 watts/ft^2 (215 watts/m^2) of conditioned floor area.

Computer Room Reheat Exception (140.4(d))



(d) **Space-conditioning Zone Controls.** Each space-conditioning zone shall have controls that prevent:

1. Reheating; and
2. Recooling; and
3. Simultaneous provisions of heating and cooling to the same zone, such as mixing or simultaneous supply of air that has been previously mechanically heated and air that has been previously cooled, either by cooling equipment or by economizer systems.

EXCEPTION 4 to Section 140.4(d): Zones in which specific humidity levels are required to satisfy exempt process loads. Computer Rooms or other spaces where the only process load is from IT equipment may not use this exception.

Labs and museums can use reheat or recool for process loads but Computer Rooms can't

Non-Computer Room Economizers (140.4(e)1)

(e) **Economizers.**

1. Each cooling fan system that has a design total mechanical cooling capacity over 54,000 Btu/hr shall include either:

   A. An air economizer capable of modulating outside-air and return-air dampers to supply 100 percent of the design supply air quantity as outside-air; or

   B. A water economizer capable of providing 100 percent of the expected system cooling load as calculated in accordance with a method approved by the Commission, at outside air temperatures of 50°F dry-bulb and 45°F wet-bulb and below.

EXCEPTION 5 to Section 140.4(e)1: Fan systems primarily serving computer room(s). See Section 140.9(a) for computer room economizer requirements.

Computer Room Economizers (140.9(a))

Prescriptive Requirements for Computer Rooms. A computer room complies with this section by being designed with and having constructed and installed a cooling system that meets the requirements of Subsections 1 through 6.

1. **Economizers.** Each individual cooling system primarily serving computer room(s) shall include either:

   A. An integrated air economizer capable of providing 100 percent of the expected system cooling load as calculated in accordance with a method approved by the Commission, at outside air temperatures of 55°F dry-bulb/50°F wet-bulb and below; or

   B. An integrated water economizer capable of providing 100 percent of the expected system cooling load as calculated in accordance with a method approved by the Commission, at outside air temperatures of 40°F dry-bulb/35°F wet-bulb and below.

   EXCEPTION 1 to Section 140.9(a)1: Individual computer rooms under 5 tons in a building that does not have any economizers.

   EXCEPTION 2 to Section 140.9(a)1: New cooling systems serving an existing computer room in an existing building up to a total of 50 tons of new cooling equipment per building.

   EXCEPTION 3 to Section 140.9(a)1: New cooling systems serving a new computer room in an existing building up to a total of 20 tons of new cooling equipment per building.

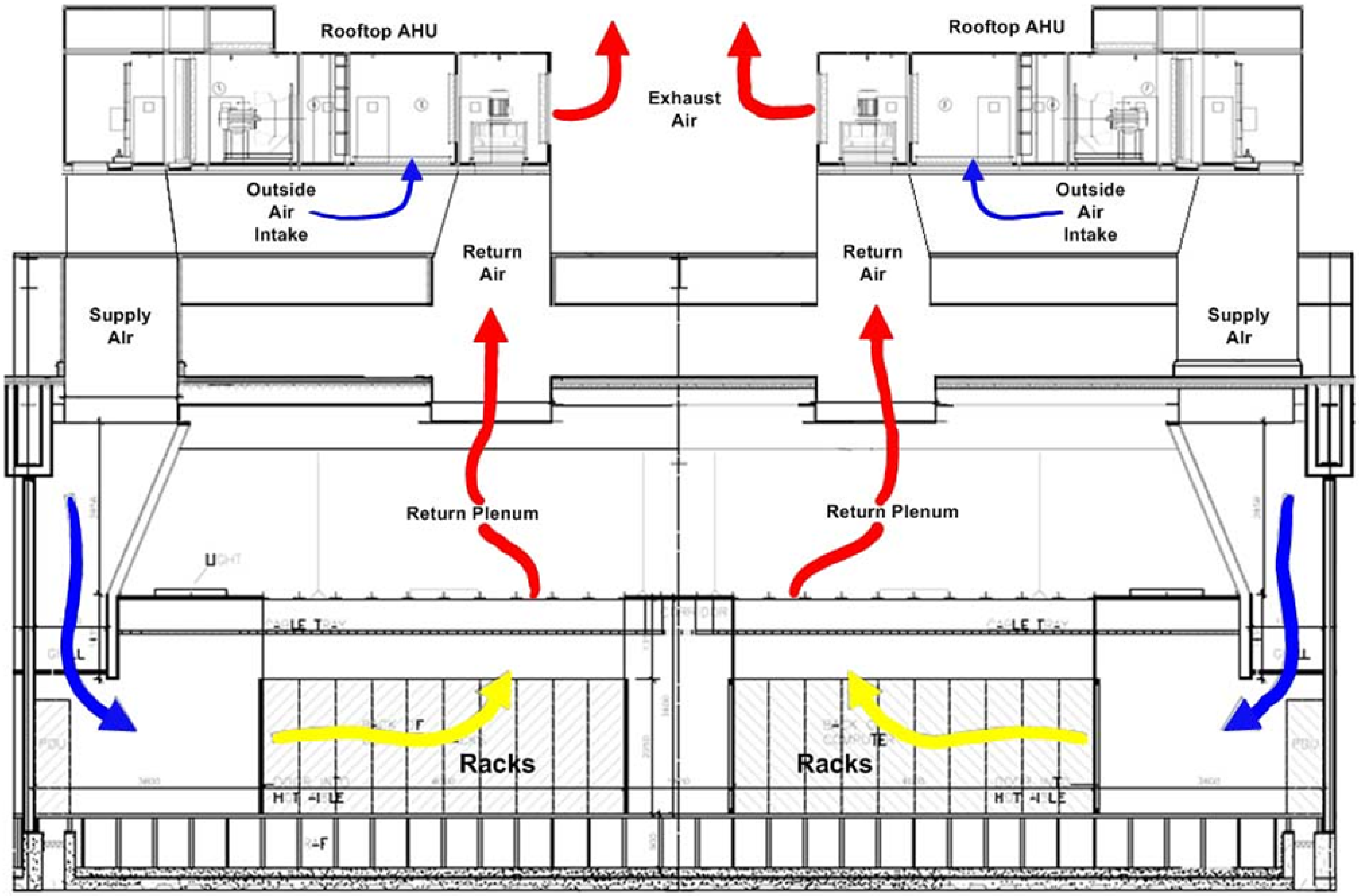
   EXCEPTION 4 to Section 140.9(a)1: A computer room may be served by a fan system without an economizer if it is also served by a fan system with an economizer that also serves non-computer room(s) provided that all of the following are met:

   i. The economizer system is sized to meet the design cooling load of the computer room(s) when the non-computer room(s) are at 50 percent of their design load; and

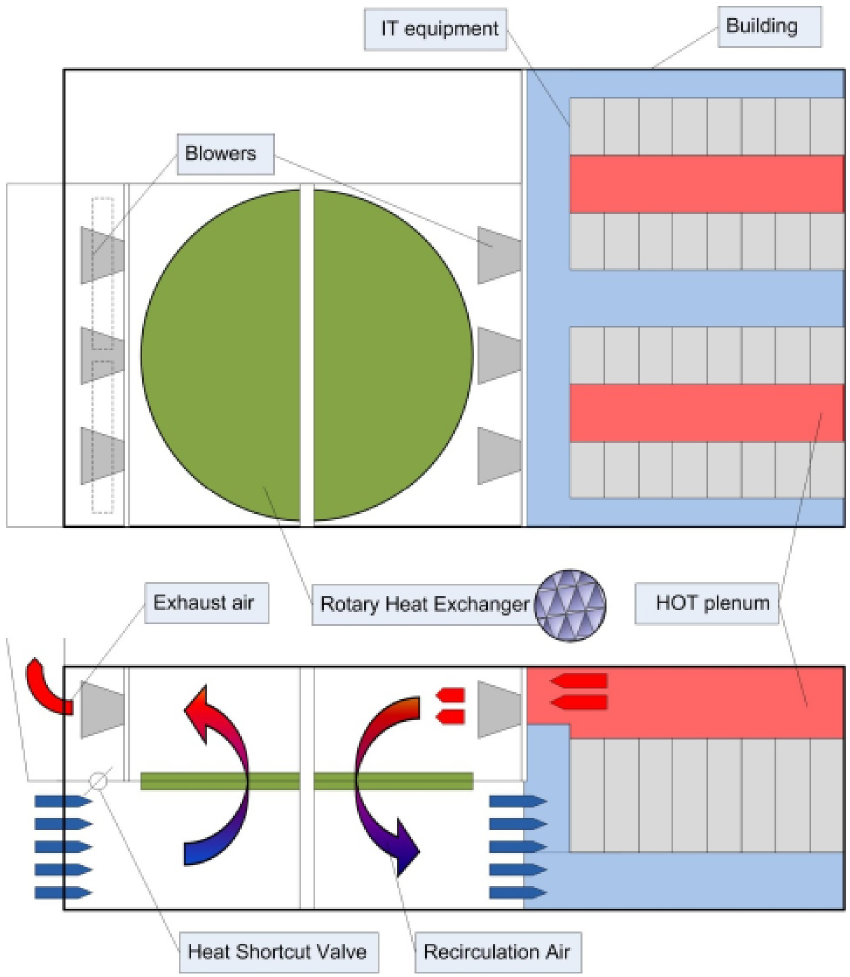
   ii. The economizer system has the ability to serve only the computer room(s), e.g. shut off flow to non-computer rooms when unoccupied; and

   iii. The non-economizer system does not operate when the outside air drybulb temperatures is below 60°F and, the cooling load of the non-computer room(s) served by the economizer system is less than 50 percent of design load.

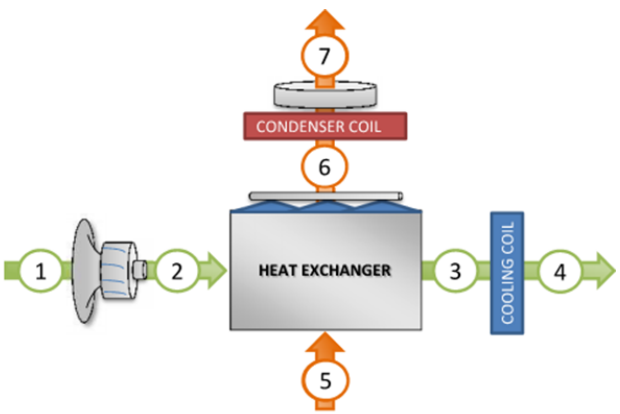
Computer Room Economizers
Air-side economizer



Computer Room Economizers
Heat Wheel Economizer

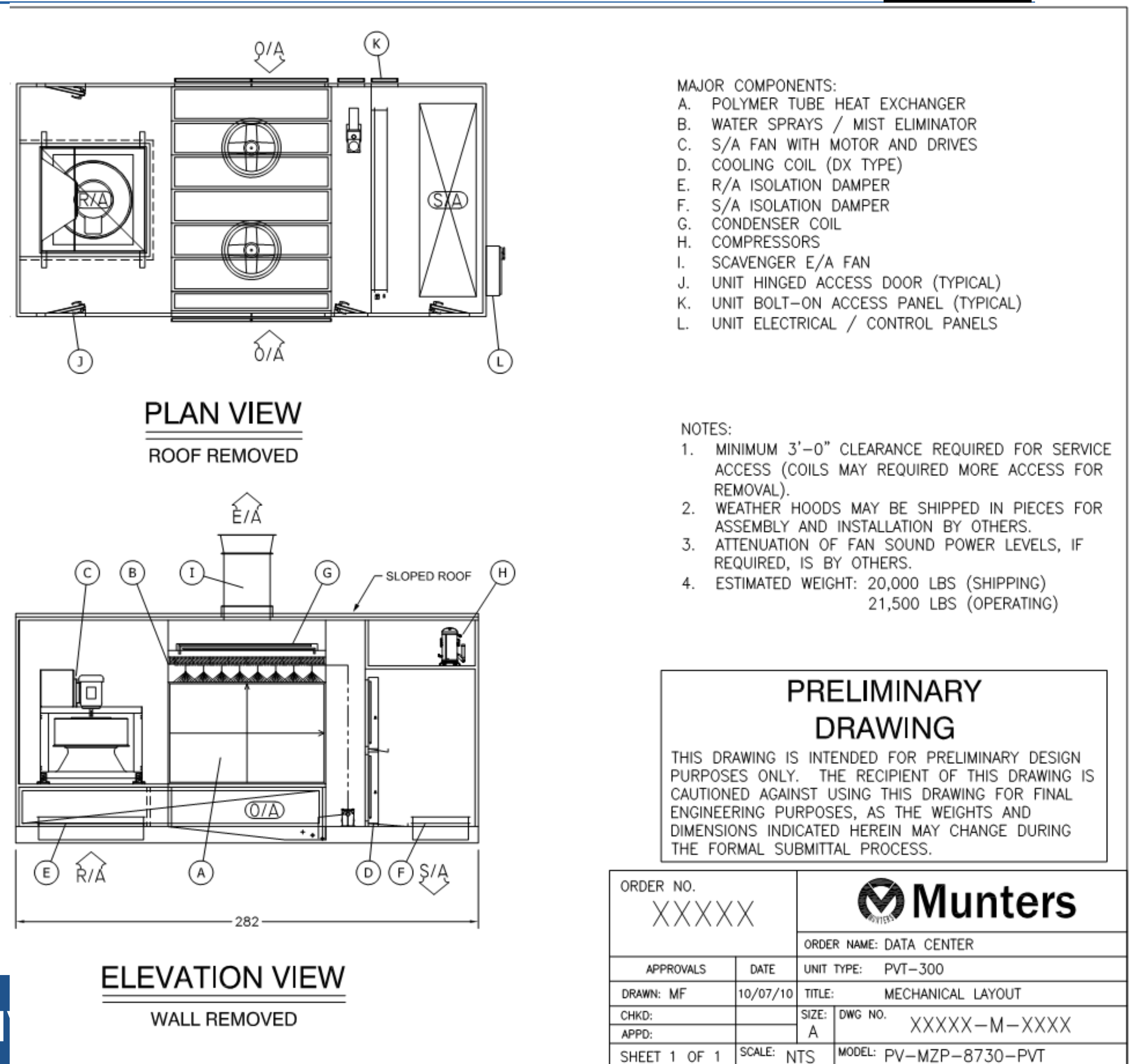


Computer Room Economizers
Indirect Evaporative Cooler Economizer

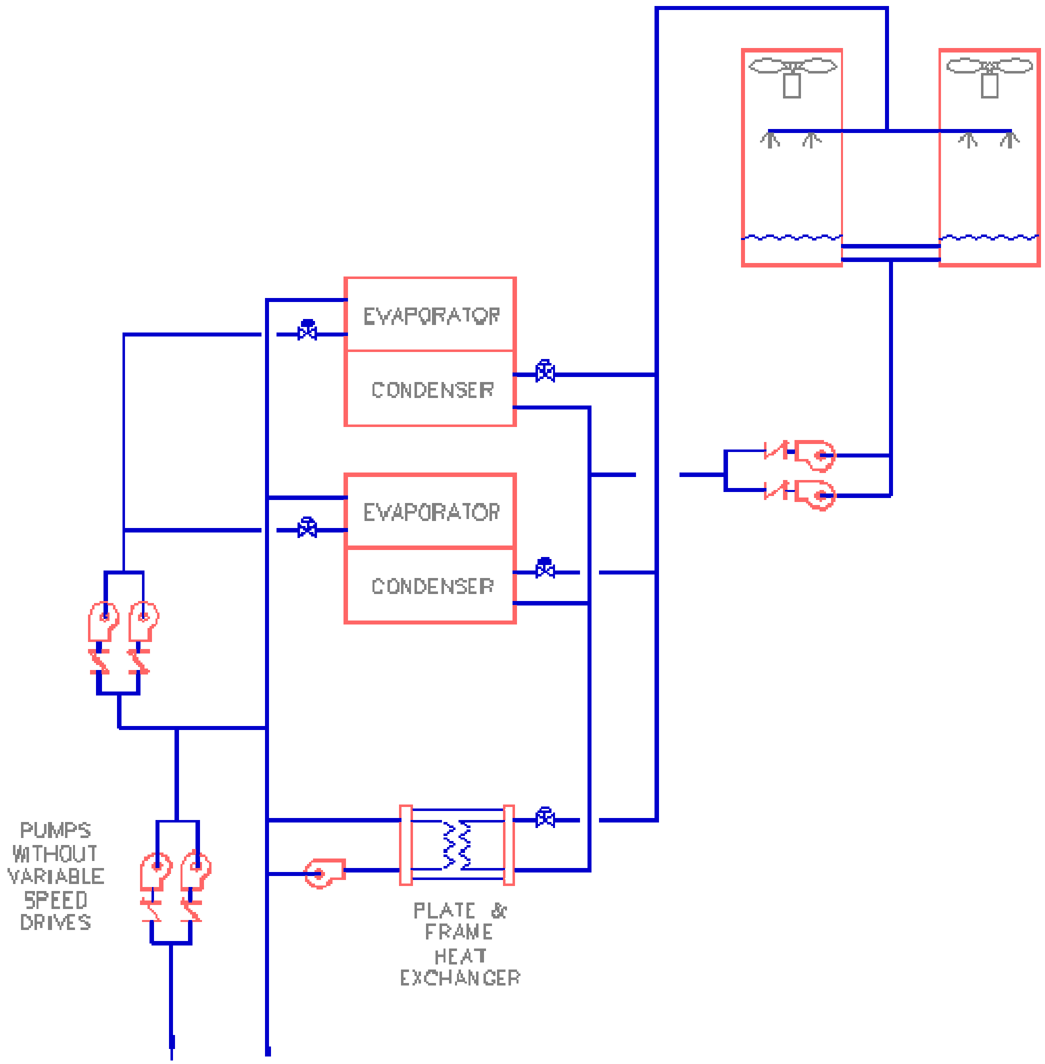


State Points at Design Conditions (Water Sprays on)

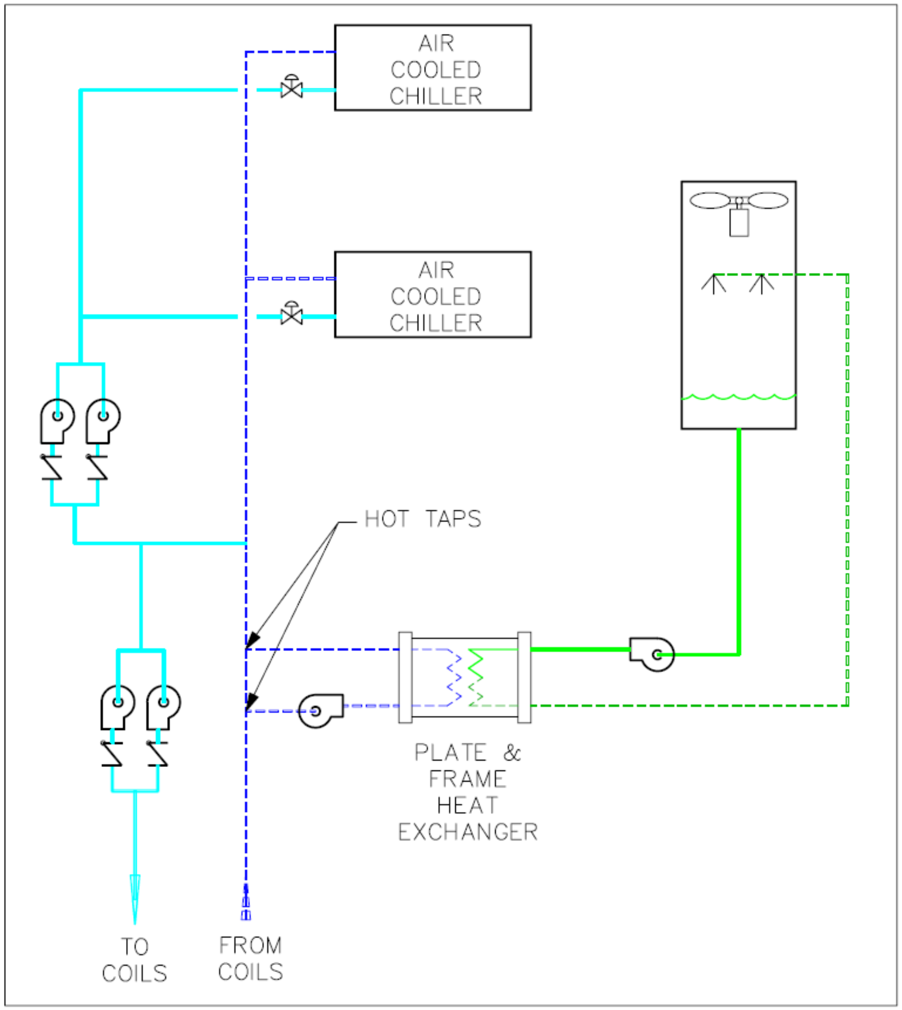
	DB (°F)	WB (°F)	ACFM
1 (R/A)	100.0	70.2	42,214
2	102.2	70.9	42,380
3	86.8	66.3	41,222
4 (S/A)	75.0	62.4	40,329
5 (O/A)	96.0	81.9	42,682
6	87.5	84.9	42,379
7 (E/A)	101.9	87.8	43,492



Computer Room Economizers
Integrated water-side economizer



Computer Room Economizers
Integrated WSE with air-cooled chillers



Computer Room Economizers (140.9(a))

1. **Economizers.** Each individual cooling system primarily serving computer room(s) shall include either:

   A. An integrated air economizer capable of providing 100 percent of the expected system cooling load as calculated in accordance with a method approved by the Commission, at outside air temperatures of 55°F dry-bulb/50°F wet-bulb and below; or

   B. An integrated water economizer capable of providing 100 percent of the expected system cooling load as calculated in accordance with a method approved by the Commission, at outside air temperatures of 40°F dry-bulb/35°F wet-bulb and below.

   EXCEPTION 1 to Section 140.9(a)1: Individual computer rooms under 5 tons in a building that does not have any economizers.

   EXCEPTION 2 to Section 140.9(a)1: New cooling systems serving an existing computer room in an existing building up to a total of 50 tons of new cooling equipment per building.

   EXCEPTION 3 to Section 140.9(a)1: New cooling systems serving a new computer room in an existing building up to a total of 20 tons of new cooling equipment per building.

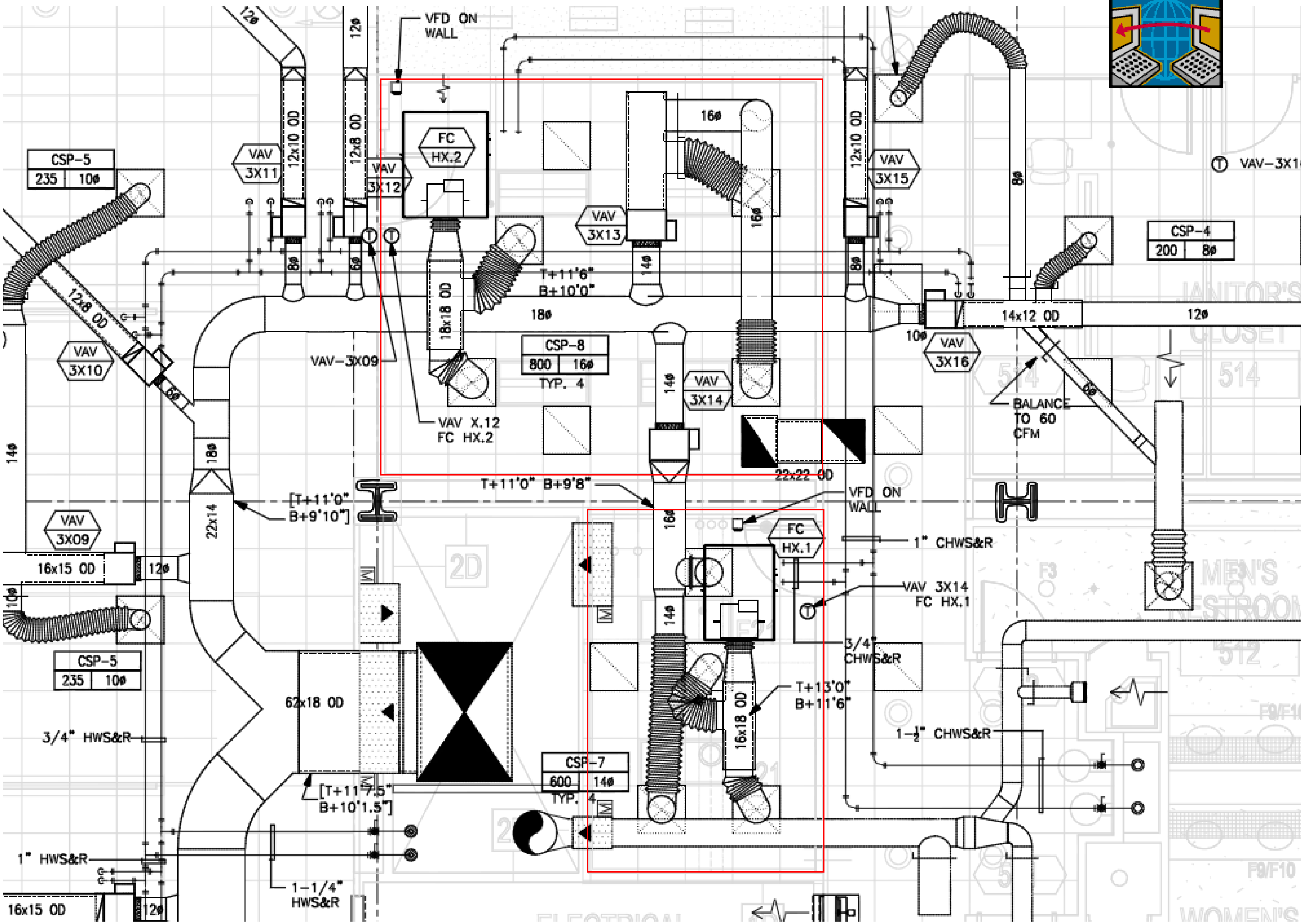
   EXCEPTION 4 to Section 140.9(a)1: A computer room may be served by a fan system without an economizer if it is also served by a fan system with an economizer that also serves noncomputer room(s) provided that all of the following are met:

   i. The economizer system is sized to meet the design cooling load of the computer room(s) when the noncomputer room(s) are at 50 percent of their design load; and

   ii. The economizer system has the ability to serve only the computer room(s), e.g. shut off flow to noncomputer rooms when unoccupied; and

   iii. The noneconomizer system does not operate when the outside air drybulb temperatures is below 60°F and, the cooling load of the noncomputer room(s) served by the economizer system is less than 50 percent of design load.

Two Computer Rooms Served by VAV Boxes and Fan Coils



Computer Room Economizers – Comparison to Other Codes

Exceptions to Prescriptive Computer Room Economizer Requirement

	New Construction	Existing Computer Room	New Computer Room in Existing Bldg
Title 24-2013	<5 tons/room in building w/o economizer	<50 tons	<20 tons
ASHRAE 90.1-2010	1. <250t w/o CHW plant 2. <50t w/CHW plant 3. Mission critical (<5% of Computer Rooms)	<50 tons	<50 tons
Oregon 2010	<4.5 tons up to 20t/bldg	<50 tons	<20 tons
Washington 2009*	<20 ton/bldg or <10% of bldg air economizer capacity and not using ASHRAE-127 units and efficiency is 15% better than minimum and 2-speed or modulating compressors	<3 tons/unit up to 6t/bldg if not using ASHRAE-127 units and efficiency is 15% better than minimum	<3 tons/unit up to 6t/bldg if not using ASHRAE-127 units and efficiency is 15% better than minimum

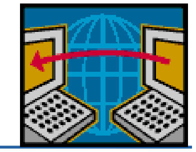
*This is a simplification of a fairly complex code. Washington essentially prescriptively requires air economizers in almost all computer rooms. There are a couple small scenarios where water economizer December be used instead of air economizers and even fewer scenarios where no economizer is required.

Computer Room Humidity Control (140.9(a)2&3)

Reheat. Each computer room zone shall have controls that prevent reheating, recooling, and simultaneous provisions of heating and cooling to the same zone, such as mixing or simultaneous supply of air that has been previously mechanically heated and air that has been previously cooled, either by cooling equipment or by economizer systems.

Humidification. Non-adiabatic humidification (e.g. steam, infrared) is prohibited. Only adiabatic humidification (e.g. direct evaporative, ultrasonic) is permitted.

Computer Room Humidity Controls Rationale



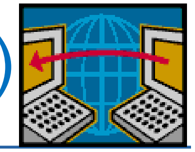
- There is no published research supporting the need for humidity control in Computer Rooms
- NEBS (for telecom central offices) has no lower humidity limit
- IT Equipment is already protected for ESD under IEC61000-4-2.
- ANSI/ESDA 20.20-2007 does not allow humidification as a primary control for ESD
- See March 2010 ASHRAE Journal Article, “Humidity Controls for Computer Rooms, Are They Necessary?” by Mark Hydeman and Dave Swenson: http://tinyurl.com/22otv8g

ASHRAE RP 1499

Using ESD-mitigating flooring and footwear, the risk of ESD upset and damage can be reduced to an insignificant level, even if the humidity is allowed to drop to low values, such as 8%. In addition to using conductive footwear and flooring, other precautions should be taken, especially under low -humidity conditions, to avoid rapid removal of non-conductive plastic wrapping. Furthermore, all office chairs and carts selected for use in data centers should have ESD-mitigating properties.

The low increase in the ESD risk with reduced humidity indicates that a data center with a low incident rate of ESD-induced damage operating at 25% RH will maintain a low incident rate if the humidity is reduced to 8%. The increase in ESD-induced incident rates will range from 1.5-3. The concerns raised prior to the study regarding the increase in ESD-induced risk with reduced humidity are not justified. A standard set of ESD-mitigation procedures will ensure a very low ESD incident rate at all humidity levels tested.

Other Computer Room Requirements (140.9(a)4-6)



Power Consumption of Fans. The total fan power at design conditions of each fan system shall not exceed 27 W/kBtu·h of net sensible cooling capacity.

Fan Control. Each unitary air conditioner with mechanical cooling capacity exceeding 60,000 Btu/hr and each chilled water fan system shall be designed to vary the airflow rate as a function of actual load and shall have controls and/or devices (such as two-speed or variable speed control) that will result in fan motor demand of no more than 50 percent of design wattage at 66 percent of design fan speed.

Containment. Computer rooms with air-cooled computers in racks and with a design load exceeding 175 kW/room shall include air barriers such that there is no significant air path for computer discharge air to recirculate back to computer inlets without passing through a cooling system.

EXCEPTION 1 to Section 140.9(a)6: Expansions of existing computer rooms.

EXCEPTION 2 to Section 140.9(a)6: Computer racks with a design load less than 1 kW/rack.

EXCEPTION 3 to Section 140.9(a)6: Equivalent energy performance based on computational fluid dynamics or other analysis.

Computer Room – Modeling Baseline

- Current Title 24 baseline

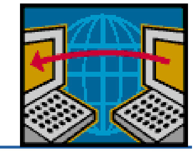
Table N2-13 – Standard Design HVAC System Selection

Building Type	System Type	Proposed Design Heating Source	System
Low-Rise Nonresidential (three or fewer stories above grade)	Single Zone	Fossil	System 1 – Packaged Single Zone, Gas/Electric
		Electric	System 2 – Packaged Single Zone, Heat Pump
	Multiple Zone	Any	System 3 – Packaged VAV, Gas Boiler with Reheat
High Rise Nonresidential (four or more stories)	Single Zone	Any	System 5 – Built-up Single Zone System with Central Plant
	Multiple Zone	Any	System 4 – Central VAV, Gas Boiler with Reheat
All Residential including Hotel/Motel Guest Room	Hydronic	Any	System 5 – Four Pipe Fan Coil System with Central Plant
	Other	Fossil	System 1 (No economizer) – Packaged Single Zone, Gas/Electric
		Electric	System 2 (No economizer) – Packaged Single Zone, Heat Pump

Computer Room – Modeling Baseline – Proposal

- Two new system types:
  - System 6 – CHW CRAH units – if total computer room design load is over 250 tons or if the rest of the baseline building is CHW (System 4 or 5).
  - System 7 – DX CRAC units – if the computer room is not system 6 then it is system 7

System 6 (CHW) Baseline



- Design airside ΔT: 20°F
- Design return air setpoint: 80°F
- One fan system per room
- CFM sized 110% of the calculated load
- Supply fan effic: 60%
- Supply fan total static: 2.5”
- Relief fans are not modeled per ACM
- Airside economizer - differential drybulb control
- No humidification
- No reheat
- CHW plant shall follow System 4 rules

System 6 (CHW) Baseline

- Equipment power density: input by user
- Equipment schedules: cycle monthly between 25%, 50%, 75%, 100% (same as 90.1 addendum cj)
- Lighting schedules and occupant density and schedules shall follow "General Commercial and Industrial Work, Precision" category
- Lighting power density per new computer room prescriptive limit
- Ventilation: per T24 (0.15 cfm/ft^2) only during occupied hours
- Supply Air Temperature and Fan Control
  - Minimum fan volume setpoint shall be 50%.
  - Fan volume shall be linearly reset from 100% air flow at 100% cooling load to minimum air flow at 50% cooling load and below.
  - Fan power shall follow ACM VSD curve (e.g. 20% power at 50% speed)
  - Supply air temperature setpoint shall be linearly reset from 60^{o}F at 50% cooling load and above to space temperature at 0% cooling load.

System 7 (DX) Baseline

- Design airside ΔT: 20ºF
- Design return air setpoint: 80ºF
- One fan system per room
- CFM and cooling capacity sized at 120% of calculated load
- DX cooling efficiency: Minimum Title 24 efficiency based on the calculated capacity of each room.
  - If capacity > 20 tons then use 10t min efficiency
  - If capacity <20 tons then use capacity/2 min efficiency
- Fan effic: 60%
- Fan total static: 2.5” with economizer, 2.0” without economizer
- Airside economizer, when required prescriptively - differential drybulb control
- No humidification
- No reheat

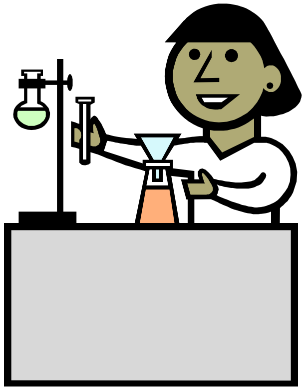
System 7 (DX) Baseline

- Equipment power density: input by user
- Equipment schedules: cycle monthly between 25%, 50%, 75%, 100% (same as 90.1 addendum cj)
- Lighting schedules and occupant density and schedules shall follow “General Commercial and Industrial Work, Precision” category
- Lighting power density per new computer room prescriptive limit
- Ventilation: per T24 (0.15 cfm/ft^2) only during occupied hours
- Fan control
  - Constant volume if total cooling capacity for the room < = 5 tons
  - Variable volume otherwise
- Supply Air Temperature and Fan Control for Variable Volume
  - Minimum fan volume setpoint shall be 50%.
  - Fan volume shall be linearly reset from 100% air flow at 100% cooling load to minimum air flow at 50% cooling load and below.
  - Fan power shall follow ACM VSD curve (e.g. 20% power at 50% speed)
  - Supply air temperature setpoint shall be linearly reset from 60^{o}F at 50% cooling load and above to space temperature at 0% cooling load.

Break

Labs

Laboratory Exhaust



Labs

Laboratory Exhaust (140.9(c)

(c) **Prescriptive Requirements for Laboratory exhaust systems.** For buildings with laboratory exhaust systems where the minimum circulation rate to comply with code or accreditation standards is 10 ACH or less, the design exhaust airflow shall be capable of reducing zone exhaust and makeup airflow rates to the regulated minimum circulation rate, or the minimum required to maintain pressurization requirements, whichever is larger. Variable exhaust and makeup airflow shall be coordinated to achieve the required space pressurization at varied levels of demand and fan system capacity.

EXCEPTION 1 to Section 140.9(c): Laboratory exhaust systems serving zones where constant volume is required by the Authority Having Jurisdiction, facility Environmental Health & Safety department or other applicable code.

EXCEPTION 2 to Section 140.9(c): New zones on an existing constant volume exhaust system.

Labs

Typical Practice

- 6-12 ACH ventilation
- 100% OSA constant volume reheat systems
- 3,000 fpm exhaust at the stack
- 4”-6” pressure on the supply and exhaust fans
- Supply air temperature reset?
- Constant volume fume hoods

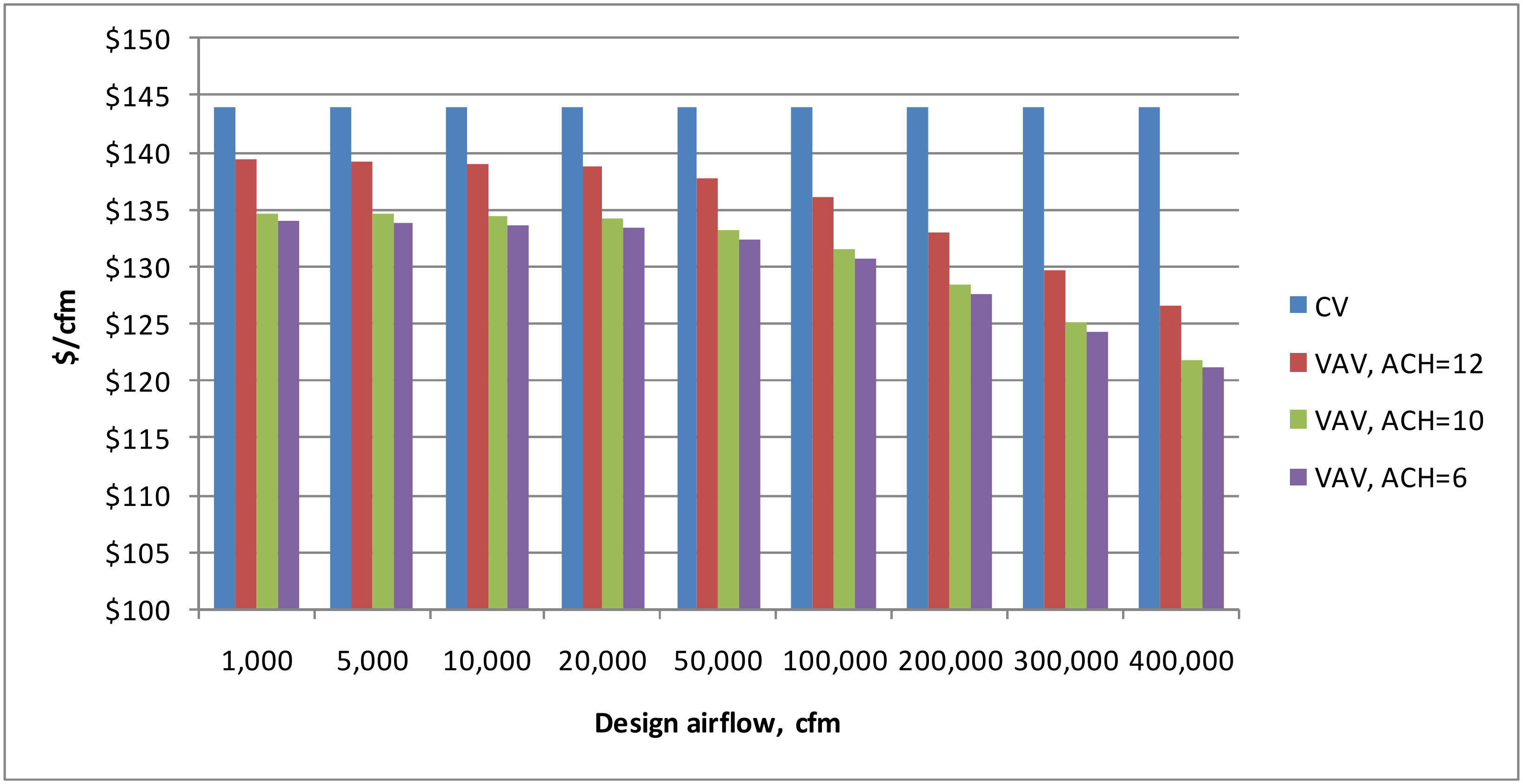
Labs

VAV Fume Exhaust

- Standard off the shelf technologies
- Saves fan energy (supply and exhaust)
- Reduces reheat, heating and cooling
- Improves comfort
- Safer during remodels and retrofits
- Not possible on all hoods

Cost Effectiveness - VAV

- Preliminary simulation results, 15-year LCC (CZ03)



Prescriptive Requirements for Commercial Kitchens

Kitchen Ventilation

Current Code Requirements

- No Current Kitchen Ventilation Requirements in T24
- ASHRAE 90.1-2007:
  - Kitchen Hoods. Individual kitchen exhaust hoods larger than 5000 cfm shall be provided with makeup air sized for at least 50% of exhaust air volume that is
    - unheated or heated to no more than 60˚F and
    - uncooled or cooled without the use of mechanical cooling.
- ASHRAE 90.1-2010:
  - Major changes from 90.1-2007
  - The proposed requirements on the following slides are the same as 90.1-2010 with minor changes

Prescriptive Requirements for Commercial Kitchens- Scope and Definitions

Scope

- Make it clear that kitchen ventilation cannot use the process exception

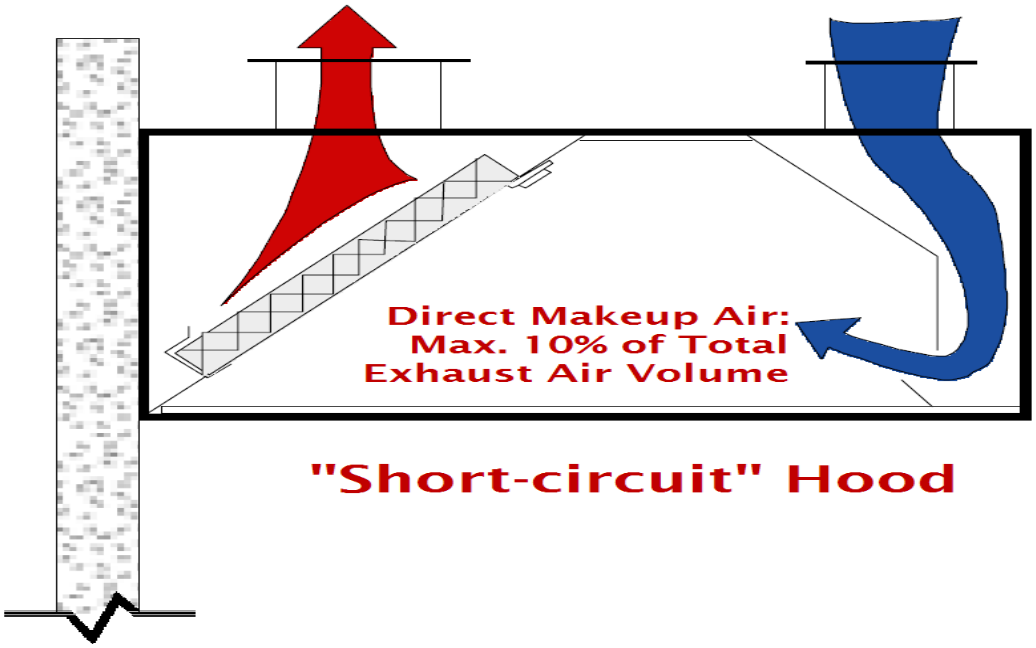
Nonresidential Standard Section 3.2 Definitions

Add new terms:

- Makeup Air = direct OA into kitchen
- Transfer Air = air from nearby zone (e.g. dining)
- Replacement Air = makeup + transfer + infiltration
- Other necessary terms listed in ASHRAE Standard 154

Kitchen Ventilation

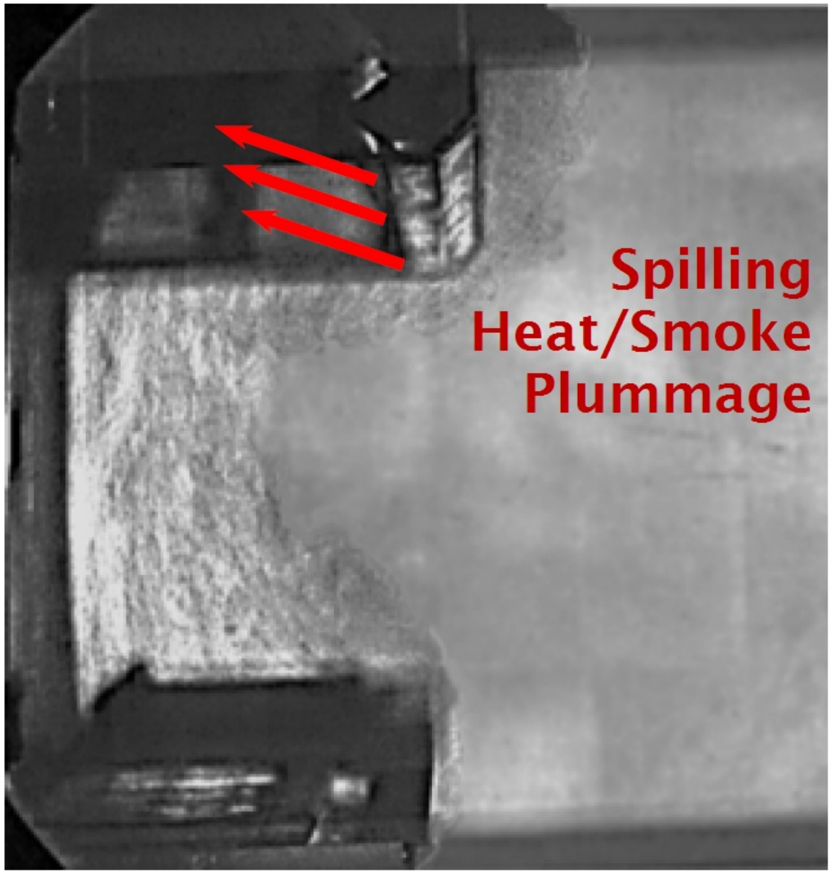
Short Circuit Hood Limitation (140.9(b)1A)



A. Replacement air introduced directly into the hood cavity of kitchen exhaust hoods shall not exceed 10percent of the hood exhaust airflow rate.

Rationale for Short Circuit Hood Limitation (140.9(b)1A)

- AGA and CEC have shown direct supply greater than 10% of hood exhaust in Short-circuit Hoods significantly reduces Capture and Containment (C&C)
- Poor C&C does not remove cooking heat and smoke from kitchen
- Exhaust rates generally higher to offset poor C&C
  - Higher exhaust fan energy
- Higher Exhaust rates increase Room Makeup Air rates
  - Higher MUA fan and conditioning energy



Rationale for Short Circuit Hood Limitation (140.9(b)1A)

- Short-circuit Hoods represent approximately:
  - 20% of U.S. Market
  - 1% of California Market

Conditioned Makeup Air Limitations (140.9(b)2A)

Kitchen ventilation.

A. Mechanically cooled or heated makeup air delivered to any space with a kitchen hood shall not exceed the greater of:

i. The supply flow required to meet the space heating and cooling load; or

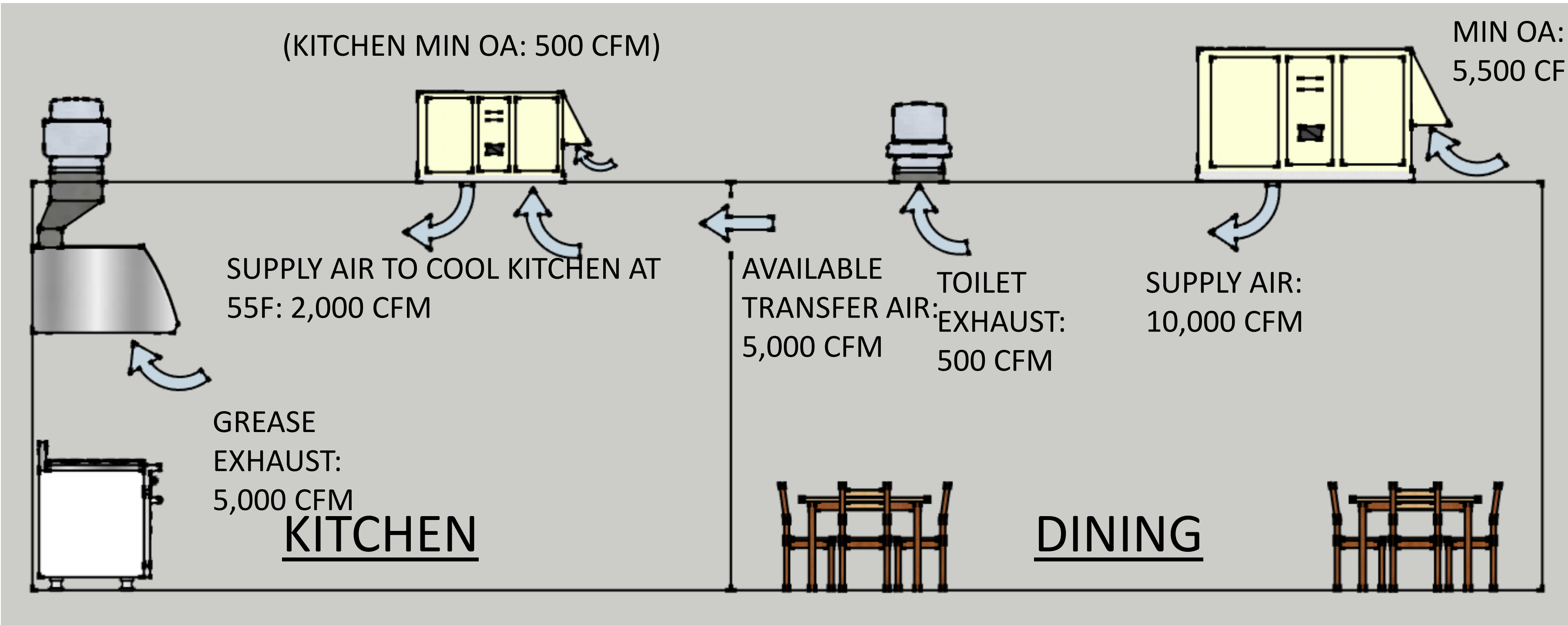
ii. The hood exhaust flow minus the available transfer air from adjacent spaces. Available transfer air is that portion of outdoor ventilation air serving adjacent spaces not required to satisfy other exhaust needs, such as restrooms, not required to maintain pressurization of adjacent spaces, and that would otherwise be relieved from the building.

EXCEPTION to Section 140.9(b)2A: Existing kitchen makeup air units not being replaced as part of an addition or alteration.

Conditioned Makeup Air Limitations: Rationale (140.9(b)2A)

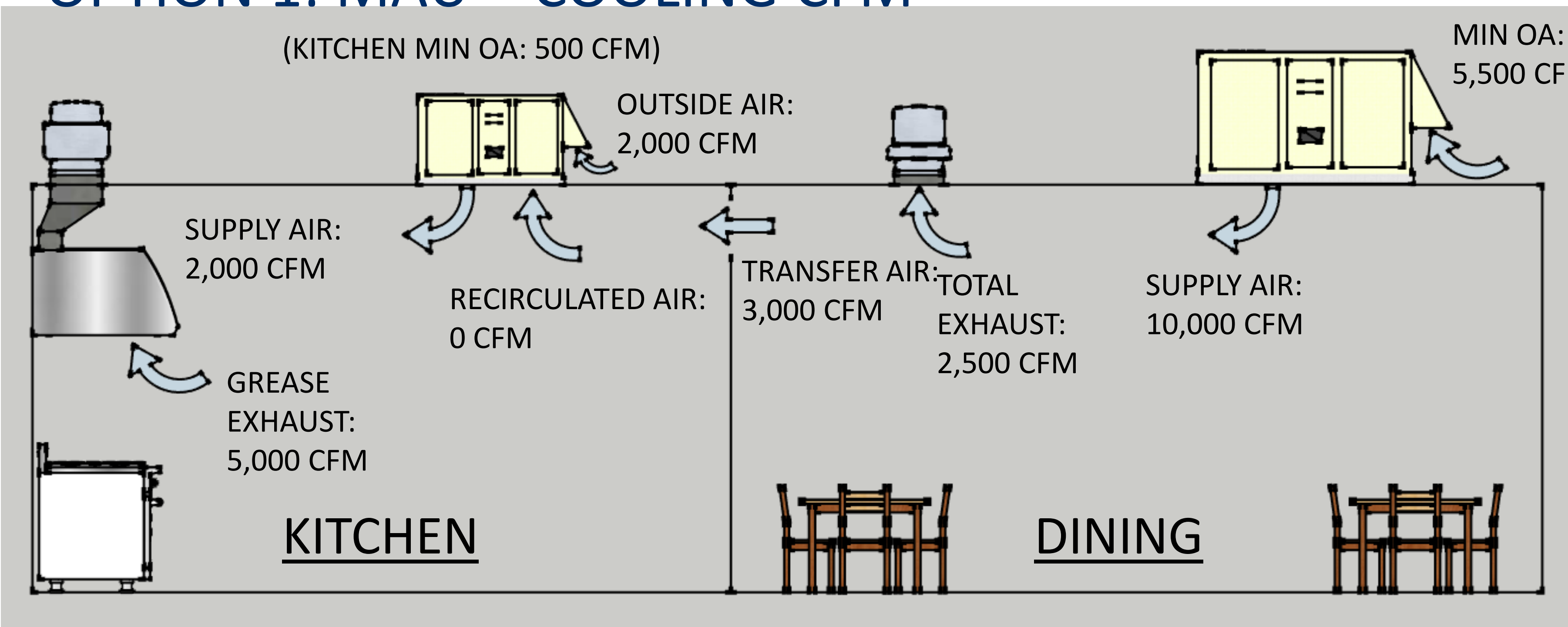
- Supplying conditioned makeup air when transfer air is available is a wasteful design practice and should be prohibited.
- Using available transfer air saves energy and reduces the first cost of the kitchen makeup unit and the exhaust system in the adjacent spaces.
- Note that the dining room is exempt from the DCV requirement per:
  - EXCEPTION 2 to Section 121(c)3: Where space exhaust is greater than the design ventilation rate specified in Section 121(b)2B minus 0.2 cfm per ft2 of conditioned area.
- We will clarify in the users manual that "space exhaust" includes kitchen hood exhaust in adjacent spaces.

Conditioned Makeup Air Limitations: Example (140.9(b)2A)



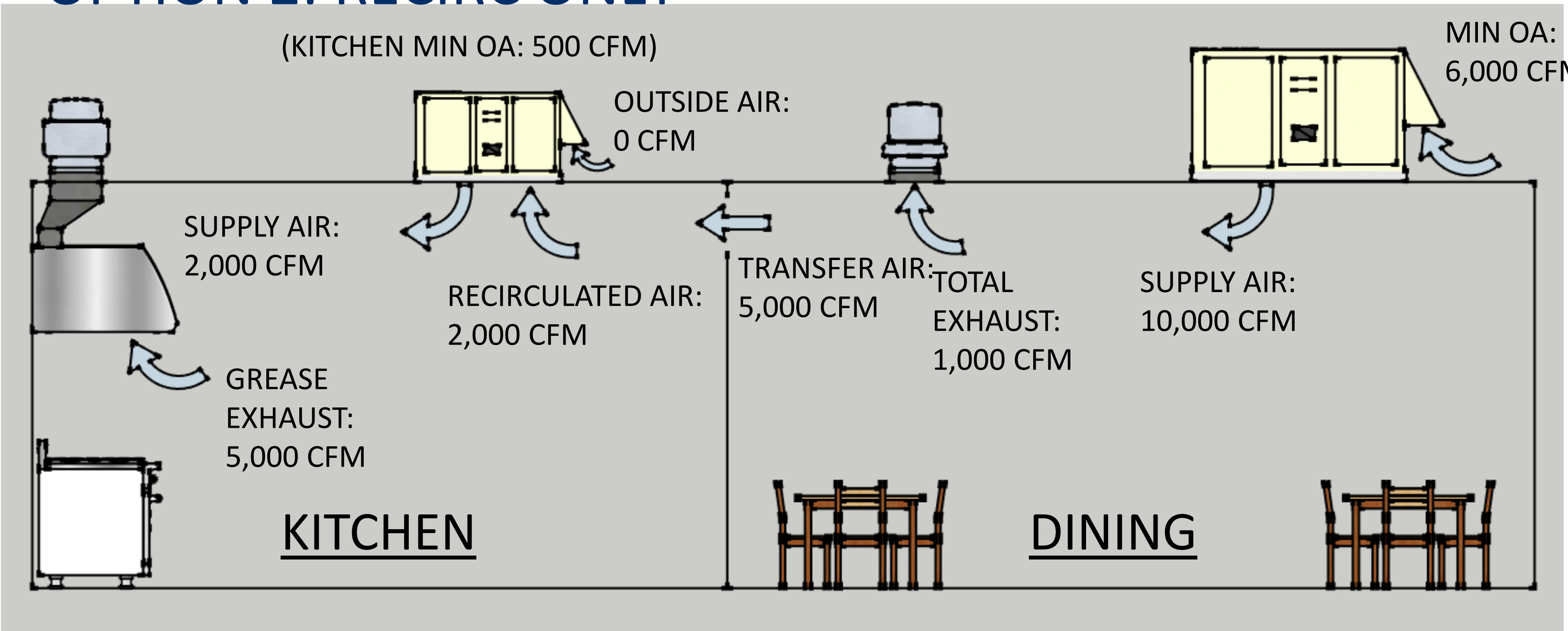
Conditioned Makeup Air Limitations: Example (140.9(b)2A)

OPTION 1: MAU = COOLING CFM



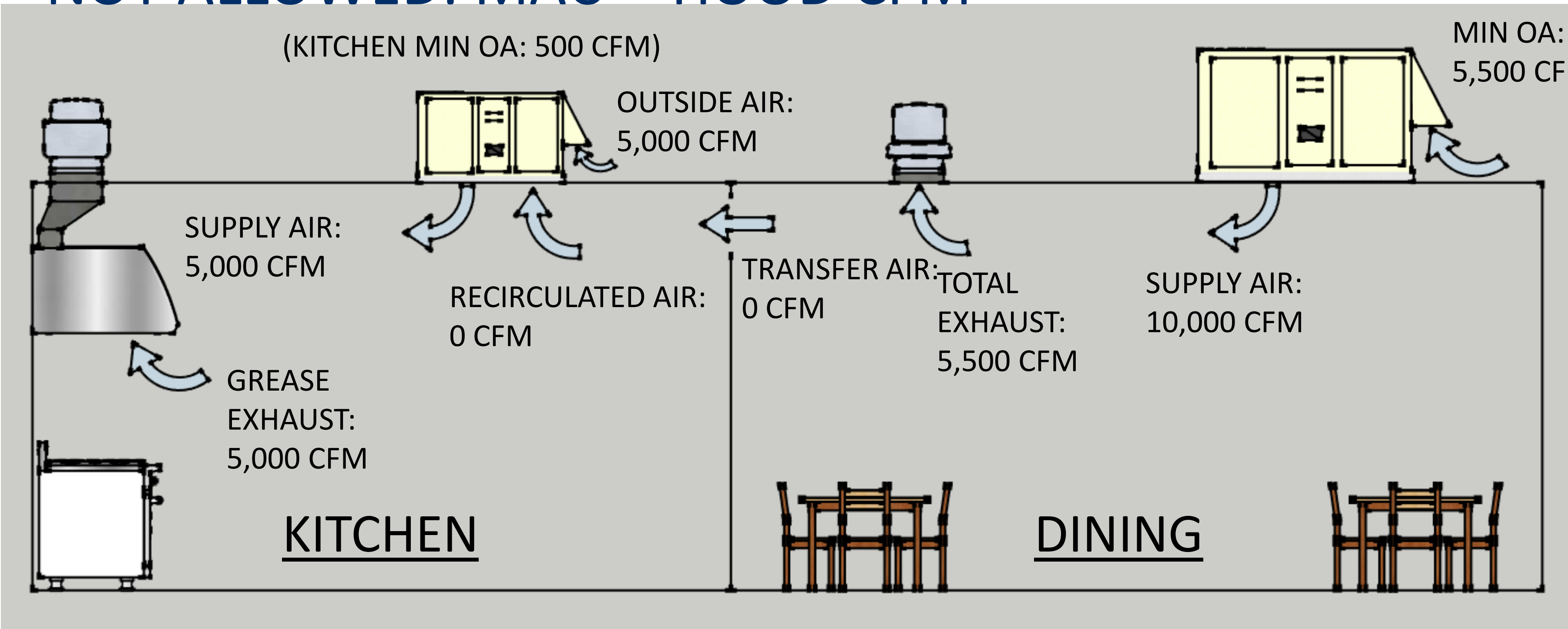
Conditioned Makeup Air Limitations: Example (140.9(b)2A)

OPTION 2: RECIRC ONLY



Conditioned Makeup Air Limitations: Example (140.9(b)2A)

NOT ALLOWED: MAU = HOOD CFM



Exhaust Hood Airflow Limitations (140.9(b)1B)

B. For kitchen/dining facilities having total Type I and Type II kitchen hood exhaust airflow rates greater than 5,000 cfm, each Type I hood shall have an exhaust rate that complies with TABLE 140.9-A. If a single hood or hood section is installed over appliances with different duty ratings, then the maximum allowable flow rate for the hood or hood section shall not exceed the TABLE 140.9-A values for the highest appliance duty rating under the hood or hood section. Refer to ASHRAE Standard 154-2011 for definitions of hood type, appliance duty, and next exhaust flow rate.

EXCEPTION 1 to Section 140.9(b)1B: 75 percent of the total Type I and Type II exhaust replacement air is transfer air that would otherwise be exhausted.

EXCEPTION 2 to Section 140.9(b)1B: Existing hoods not being replaced as part of an addition or alteration.

TABLE 140.9-A MAXIMUM NET EXHAUST FLOW RATE, CFM PER LINEAR FOOT OF HOOD LENGTH

Type of Hood	Light Duty Equipment	Medium Duty Equipment	Heavy Duty Equipment	Extra Heavy Duty Equipment
Wall-mounted Canopy	140	210	280	385
Single Island	280	350	420	490
Double Island	175	210	280	385
Eyebrow	175	175	Not Allowed	Not Allowed
Backshelf / Passover	210	210	280	Not Allowed

Exhaust Hood Airflow Limitations: Rationale (140.9(b)1B)

- Exhaust airflow rates in Table 140.9-A are 30% below the minimum airflow rates in ASHRAE Standard 154-2003, which are for unlisted hoods
- Values in Table 140.9-A are supported by ASHRAE RP-1202 for listed hoods
- Intended to eliminate wasteful common practice of specifying excessive exhaust airflow by selecting hoods that are not listed or have not been subjected to a recognized performance test
- Should not increase first cost and in many cases will reduce first cost through downsizing of exhaust, supply and cooling equipment

ASHRAE-154

Appliance Description	Size	Type I Hoods			
		Light Duty	Medium Duty	Heavy Duty	Extra-Heavy Duty
Braising pan/tilting skillet, electric	All	•			
Oven, rotisserie, electric and gas	All	•			
Oven, combination, electric and gas	All	•			
Oven, convection, full-size, electric and gas	All	•			
Oven, convection, half-size, electric and gas (protein cooking)	All	•			
Oven, deck, electric and gas	All	•			
Oven, mini-revolving rack, electric and gas	All	•			
Oven, rapid cook, electric	All	•			
Oven, rotisserie, electric and gas	All	•			
Range, discrete element, electric (with or without oven)	All	•			
Salamander, electric and gas	All	•			
Braising pan/tilting skillet, gas	All		•		
Broiler, chain conveyor, electric	All		•		
Broiler, electric, under-fired	All		•		
Conveyor oven, electric	≥ 6 kW		•		
Conveyor oven, gas	All		•		
Fryer, doughnut, electric and gas	All		•		
Fryer, kettle, electric and gas	All		•		
Fryer, open deep-fat, electric and gas	All		•		
Fryer, pressure, electric and gas	All		•		
Griddle, double-sided, electric and gas	All		•		
Griddle, flat, electric and gas	All		•		
Range, cook-top, induction	All		•		
Range, open-burner, gas (with or without oven)	All		•		
Range, hot top, electric and gas	All		•		
Broiler, chain conveyor, gas	All			•	
Broiler, electric and gas, over-fired (upright)	All			•	
Broiler, gas, under-fired	All			•	
Range, wok, gas and electric	All			•	
Appliances using solid fuel (wood, charcoal, briquettes, or mesquite) to provide all or part of the heat source for cooking	All				•

Large Kitchen Efficiency Menu (140.9(b)2B)

A kitchen/dining facility having a total Type I and Type II kitchen hood exhaust airflow rate greater than 5,000 cfm shall have one of the following:

i. At least 50 percent of all replacement air is transfer air that would otherwise be exhausted; or

ii. Demand ventilation system(s) on at least 75 percent of the exhaust air. Such systems shall:

  a. Include controls necessary to modulate airflow in response to appliance operation and to maintain full capture and containment of smoke, effluent and combustion products during cooking and idle; and

  b. Include failsafe controls that result in full flow upon cooking sensor failure; and

  c. Include an adjustable timed override to allow occupants the ability to temporarily override the system to full flow; and

  d. Be capable of reducing exhaust and replacement air system airflow rates to the larger of:

    (i) 50 percent of the total design exhaust and replacement air system airflow rates; or

    (ii) The ventilation rate required per Section 120.1.

iii. Listed energy recovery devices with a sensible heat recovery effectiveness of not less than 40 percent on at least 50 percent of the total exhaust airflow; and

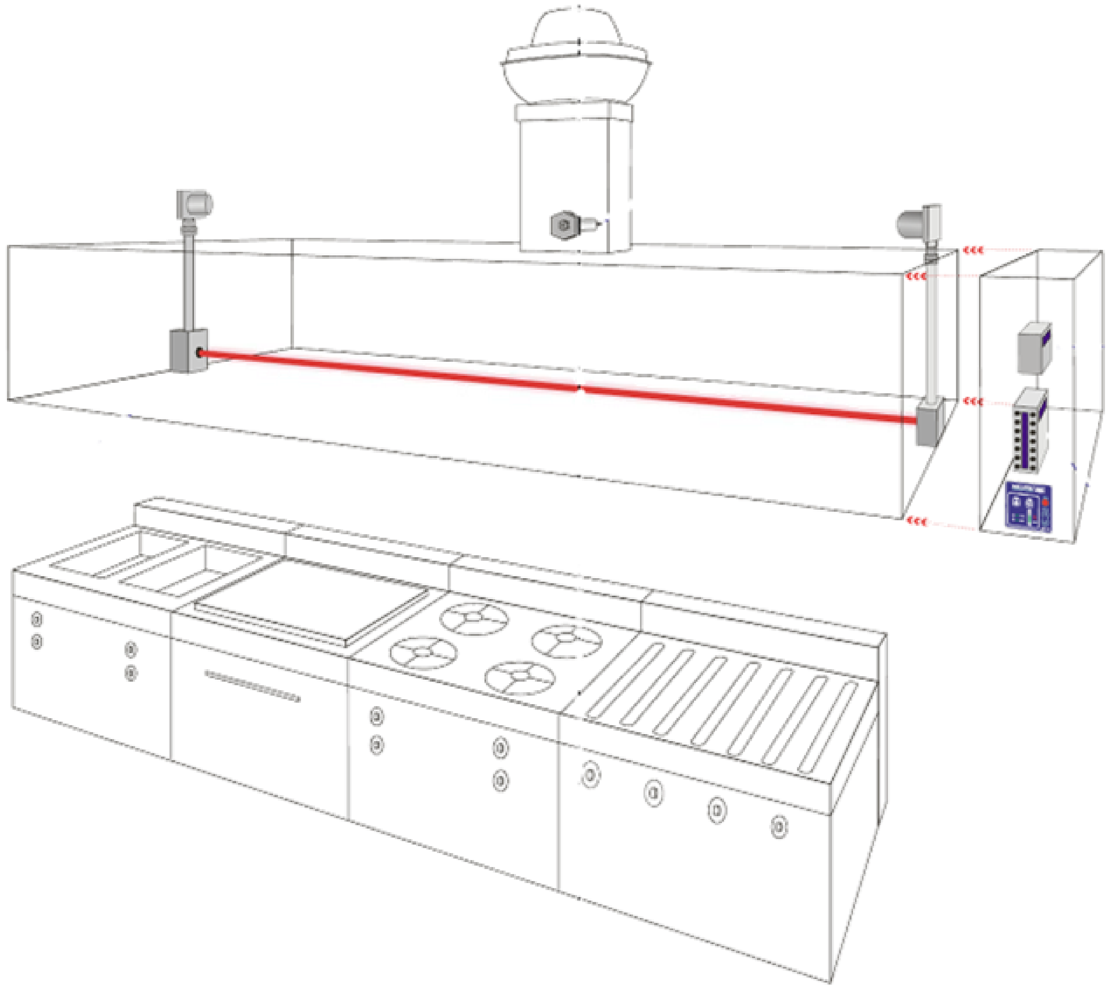
iv. A minimum of 75 percent of makeup air volume that is:

  a. Unheated or heated to no more than 60°F; and

  b. Uncooled or cooled without the use of mechanical cooling.

EXCEPTION to Section 140.9(b)2B: Existing hoods not being replaced as part of an addition or alteration.

Efficiency Menu: Demand Control Ventilation Systems (DCV) (140.9(b)2B)



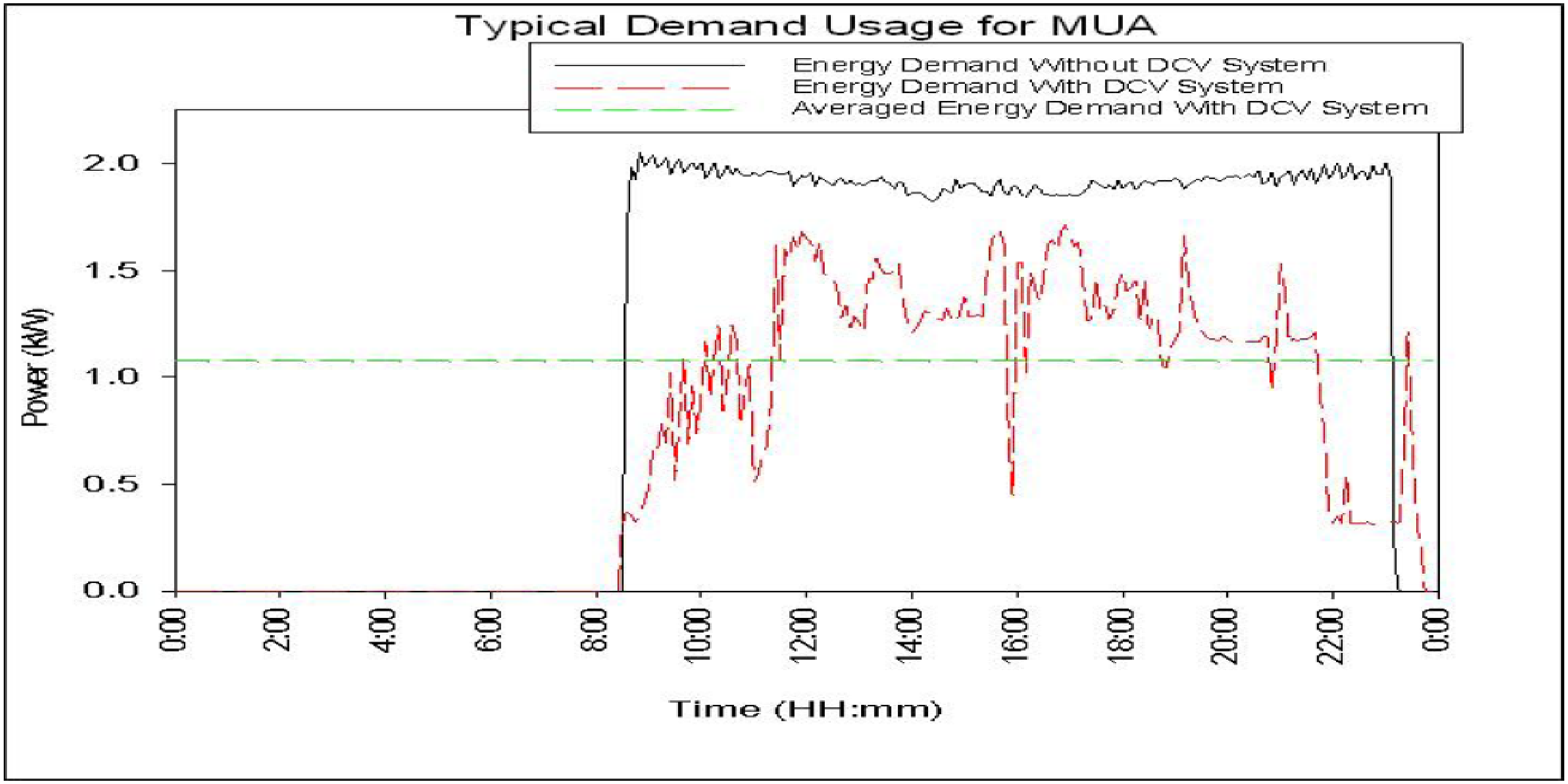
Kitchen Ventilation

Demand Control Ventilation Systems (DCV) (140.9(b)1B)

- **Common Kitchen Exhaust Systems**
- Typical control strategy: ON/OFF, Exhaust and Makeup Air fans full speed or off
- Reality:
  - Food not being cooked at all times
  - Peak exhaust requirements not necessary at all times
  - Fans often run 24/7 to avoid fire alarms when operators forget to turn on the hood
- **DCV Exhaust Systems (e.g. – Melink or Halton MARVEL)**
- Reduce exhaust and make up air fan speeds
- Use sensors to determine min. exhaust required for C&C
- In the event the operator forgets to turn the fan switch on in the morning, the system will automatically turn on as the duct temperature rises above 90F degrees. Similarly, the system will automatically turn off as the temperature drops below 75F.

DCV Example (140.9(b)1B)

- Exhaust Fan and Makeup Air Unit Electrical Demand Before and After the DCV Retrofit. No Heating/Cooling Savings.



DCV: Installation Costs and Fan Energy Savings Summary (does not include heating/cooling savings) (140.9(b)1B)

Site	Installation Costs ($)	Annual Fan Energy Saved kWh/year	Annual Fan Energy Cost Savings (Avg. $0.15/kWh)	Simple Payback (Years) (Excl Maintenance/Heating/Cooling)
El Pollo Loco	$15,500	9,871	$1,481	10.47
Panda Express (New Construction)	$8,000	15061	$2,259	3.54
Farmer Boys	$9,000	7884	$1,183	7.61
Desert Springs Marriot	28,000	150189	$22,528	1.24
Westin Mission Hills	$22,000	60,439	$9,066	2.43

Acceptance Tests (NA7.11)

NA7.11 Commercial Kitchen Exhaust System Acceptance Tests

NA7.11.1 Kitchen Exhaust Systems with Type I Hood Systems

The following acceptance tests apply to commercial kitchen exhaust systems with Type I exhaust hoods. All Type I exhaust hoods used in commercial kitchens shall be tested.

NA7.11.1.1 Construction Inspection

Step 1: Verify exhaust and replacement air systems are installed, power is installed and control systems such as demand control ventilation are calibrated.

Step 2: For kitchen/dining facilities having total Type 1 and Type II kitchen hood exhaust airflow rates greater than 5,000 cfm, calculate the maximum allowable exhaust rate for each Type 1 hood per Table 140.9-A.

NA7.11.1.2 Functional Testing at Full Load Conditions

The following acceptance test applies to systems with and without demand control ventilation exhaust systems. These tests shall be conducted at full load conditions.

Step 1: Operate all sources of outdoor air providing replacement air for the hoods.

Step 2: Operate all sources of recirculated air providing conditioning for the space in which the hoods are located.

Step 3: Operate all appliances under the hoods at operating temperatures.

Step 4: Verify that the thermal plume and smoke is completely captured and contained within each hood at full load conditions by observing smoke or steam produced by actual cooking operation and/or by visually seeding the thermal plume using devices such as smoke candles or smoke puffers. Smoke bombs shall not be used (note: smoke bombs typically create a large volume of effluent from a point source and do not necessarily confirm whether the cooking effluent is being captured). For some appliances (e.g., broilers, griddles, fryers), actual cooking at the normal production rate is a reliable method of generating smoke). Other appliances that typically generate hot moist air without smoke (e.g., ovens, steamers) need seeding of the thermal plume with artificial smoke to verify capture and containment.

...

Kitchen Ventilation – Baseline Modeling Rules

- Baseline Building total kitchen exhaust shall be either:
  - If the total exhaust is less than 5,000 cfm, the user entered total exhaust rate.
  - If the total exhaust rate is greater than or equal to 5,000 cfm, a total exhaust rate that is the sum of the Type I hoods based on the user input data and less than or equal to the maximum net exhaust flow rate in Table 144-C.
- Hood exhaust total static pressure shall be 2.5" and the fan efficiency shall be 50%.
- If the baseline total exhaust airflow rate is greater than 5,000 cfm then the kitchen exhaust shall be modeled as VAV with DCV (assumes one fan per hood)
- If the proposed case has more then one hood served by an exhaust fan (and does not have DCV control dampers at each hood) then add 0.1 to the fractional schedule for each additional hood beyond the first one up to a max fraction of 1.0
  - (e.g. if there is one hood then the fraction is 0.5 at 15:00, but if there are two DCV hoods served by the same fan then the fraction is 0.6. If there are 5 hoods then the fraction is 0.9 and 10 hoods the fraction is 1.0.)

Hour	Fraction	Hour	Fraction	Hour	Fraction
1	0.0	9	0.5	17	0.5
2	0.0	10	1.0	18	1.0
3	0.0	11	0.5	19	0.5
4	0.0	12	1.0	20	0.00
5	0.0	13	0.5	21	0.00
6	0.0	14	1.0	22	0.00
7	0.5	15	0.5	23	0.00
8	0.5	16	1.0	24	0.00

Kitchen Ventilation – Baseline Modeling Rules

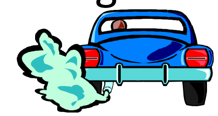
- Conditioning Systems
  - Each kitchen shall have a dedicated makeup air unit (MAU).
  - If the building has a chilled water plant then the MAU shall be chilled water. Otherwise the MAU shall be air-cooled DX.
  - MAU shall have an airside economizer capable of 100% OA and capable of using available transfer air.
    - available transfer shall be calculated from the building minimum outside airflow less any exhaust airflows (not including the kitchen exhausts) and 0.05 cfm/sf for exfiltration

Break

Garage Ventilation

Garage Ventilation (120.6(c))

Garage Exh.

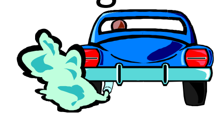


Mandatory Requirements for Enclosed Parking Garages. Mechanical ventilation systems for enclosed parking garages where the total design exhaust rate for the garage is greater than or equal to 10,000 cfm shall conform to all of the following:

1. Automatically detect contaminant levels and stage fans or modulate fan airflow rates to 50 percent or less of design capacity provided acceptable contaminant levels are maintained.
2. Have controls and/or devices that will result in fan motor demand of no more than 30 percent of design wattage at 50 percent of design airflow.
3. CO shall be monitored with at least one sensor per 5,000 ft^2, with the sensor located in the highest expected concentration locations, with at least two sensors per proximity zone. A proximity zone is defined as an area that is isolated from other areas either by floor or other impenetrable obstruction.
4. CO concentration at all sensors is maintained at 25 ppm or less at all times.
5. The ventilation rate shall be at least 0.15 cfm/ft^2 when the garage is scheduled to be occupied.
6. The system shall maintain the garage at negative or neutral pressure relative to other occupiable spaces when the garage is scheduled to be occupied.

Garage Ventilation (NA7.12)

Garage Exh.



NA7.12.2 Functional Testing

Conduct the following tests with garage ventilation system operating in occupied mode and with actual garage CO concentration well below setpoint.

Step 1: With all sensors active and all sensors reading below 25 ppm, observe that fans are at minimum speed and fan motor demand is no more than 30 percent of design wattage.

Step 2: Apply CO span gas with a concentration of 30 ppm, and a concentration accuracy of +/- 2%, one by one to 50% of the sensors but no more than 10 sensors per garage and to at least one sensor per proximity zone. For each sensor tested observe:

(a) CO reading is between 25 and 35 ppm.

(b) Ventilation system ramps to full speed when span gas is applied.

(c) Ventilation system ramps to minimum speed when span gas is removed.

Step 3: Temporarily override the programmed sensor calibration/replacement period to 5 minutes.

(d) Wait 5 minutes and observe that fans ramp to full speed and an alarm is received by the facility operators. Restore calibration/replacement period.

Step 4: Temporarily place the system in unoccupied mode and override the programmed unoccupied sensor alarm differential from 30% for 4 hours to 1% for 5 minutes. Wait 5 minutes and observe

…

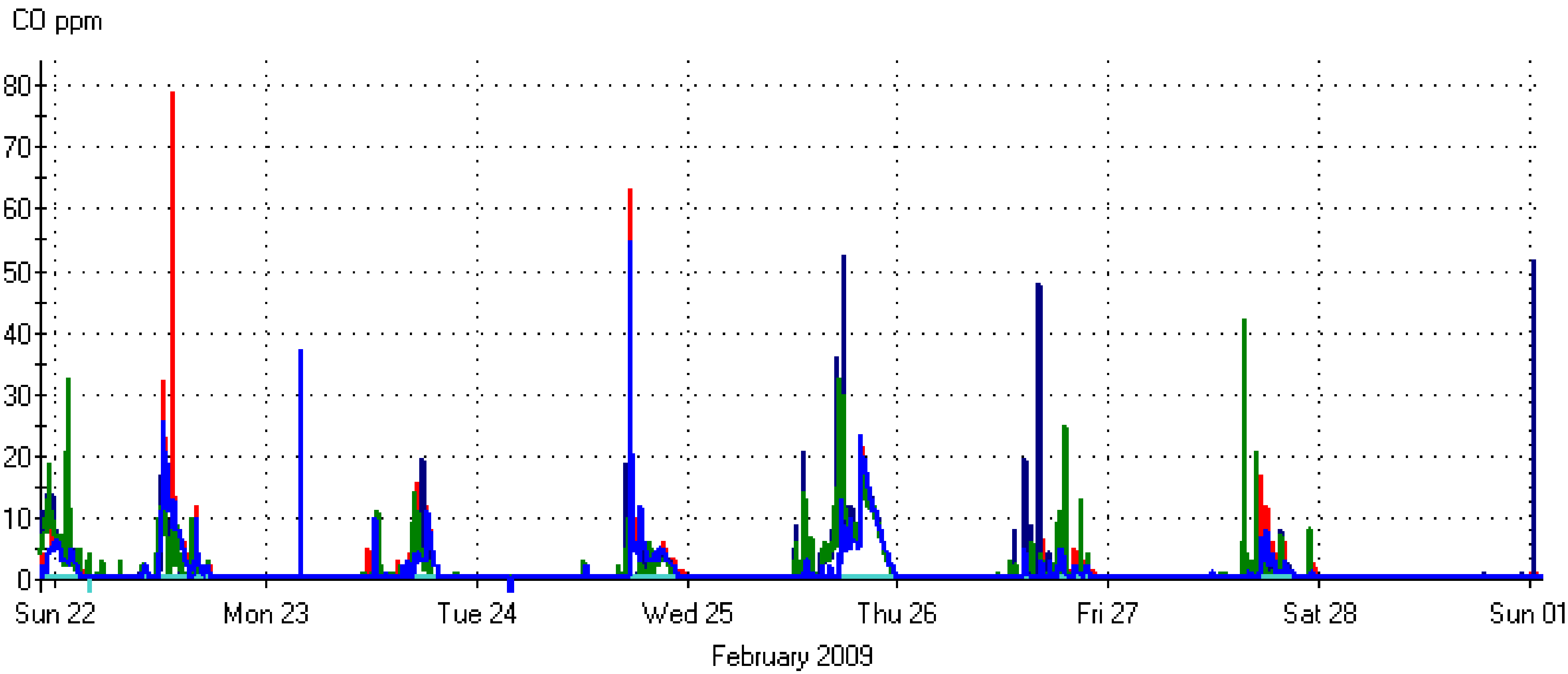
Typical Practice

Garage Exh.

- Most new garages have DCV with CO
  - Generally sold with a maintenance program
  - Some sensors turn themselves off after 2 years if not calibrated
- Many existing garages are constant volume
  - Many of these have arbitrary fan schedules
    - e.g. fans operate from 7am to 9am and from 4pm to 6pm
  - Note that when garage fans are turned off stack effect sucks garage air into the building above

Estimated Energy Savings

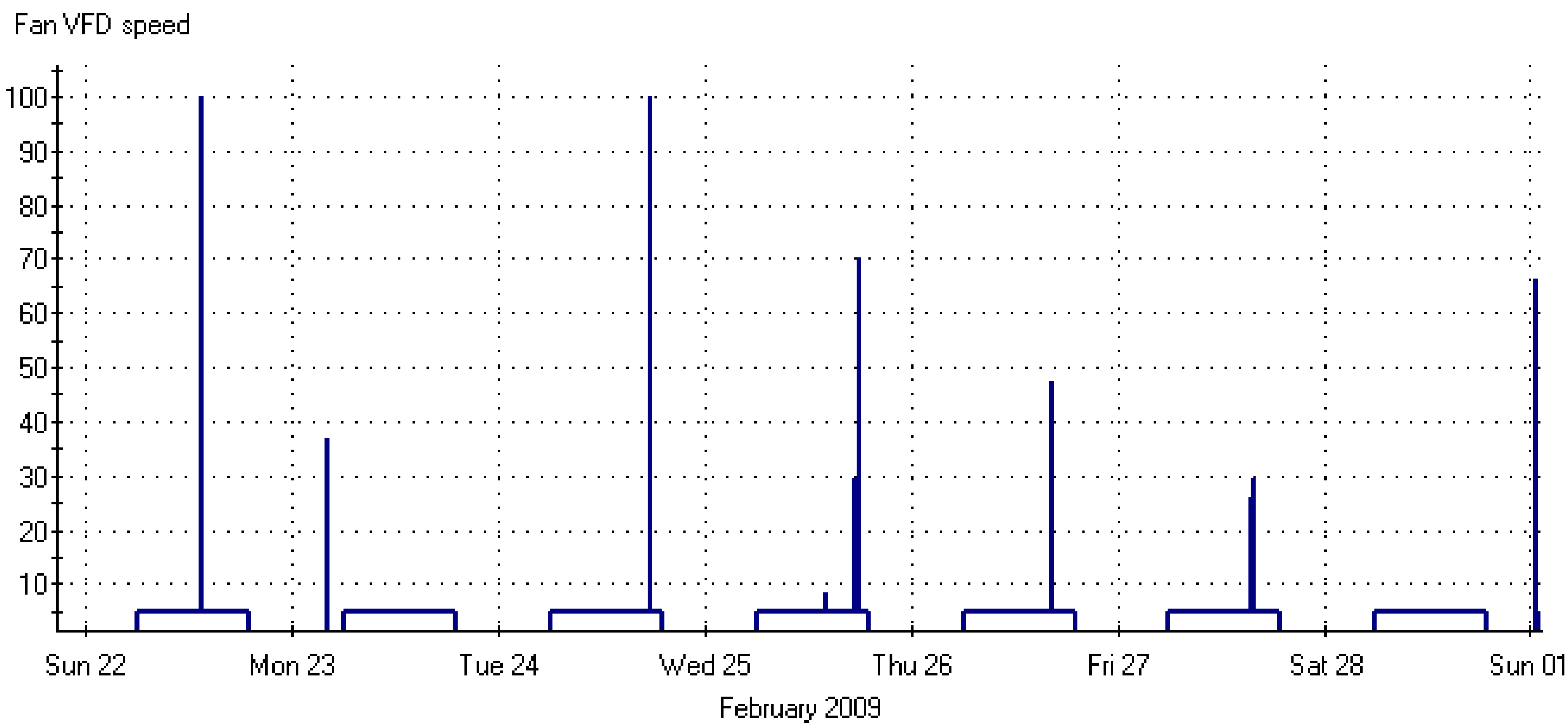
- Energy savings based on trend reviews of actual garages with CO monitoring systems



Estimated Energy Savings

Garage Exh.

- Trend reviews done on two garages with systems installed.
- Result: 80 – 90% fan energy savings



Mandatory Requirements for Process Boilers (120.6(d))

PROCESS is an activity or treatment that is not related to the space conditioning, lighting, service water heating, or ventilating of a building as it relates to human occupancy.

PROCESS BOILER is a type of boiler with a capacity (rated maximum input) of 300,000 Btus per hour (Btu/h) or more that serves a process.

Mandatory Requirements for Process Boilers (120.6(d))

Mandatory Requirements for Process Boilers

1. Combustion air positive shut-off shall be provided on all newly installed process boilers as follows:
   A. All process boilers with an input capacity of 2.5 MMBtu/h (2,500,000 Btu/h) and above, in which the boiler is designed to operate with a non-positive vent static pressure.
   B. All process boilers where one stack serves two or more boilers with a total combined input capacity per stack of 2.5 MMBtu/h (2,500,000 Btu/h).
2. Process boiler combustion air fans with motors 10 horsepower or larger shall meet one of the following for newly installed boilers:
   A. The fan motor shall be driven by a variable speed drive; or
   B. The fan motor shall include controls that limit the fan motor demand to no more than 30 percent of the total design wattage at 50 percent of design air volume.
3. Newly installed process boilers with an input capacity of 5 MMBtu/h (5,000,000 Btu/h) to 10 MMBtu/h (10,000,000 Btu/h) shall maintain excess (stack-gas) oxygen concentrations at less than or equal to 5.0 percent by volume on a dry basis over firing rates of 20 percent to 100 percent. Combustion air volume shall be controlled with respect to firing rate or measured flue gas oxygen concentration. Use of a common gas and combustion air control linkage or jack shaft is prohibited.
4. Newly installed process boilers with an input capacity greater than 10 MMBtu/h (10,000,000 Btu/h) shall maintain excess (stack-gas) oxygen concentrations at less than or equal to 3.0 percent by volume on a dry basis over firing rates of 20 percent to 100 percent. Combustion air volume shall be controlled with respect to measured flue gas oxygen concentration. Use of a common gas and combustion air control linkage or jack shaft is prohibited.

Mandatory Requirements for Commercial Boilers (120.9)

SECTION 120.9 – MANDATORY REQUIREMENTS FOR COMMERCIAL BOILERS.

(a) Combustion air positive shut-off shall be provided on all newly installed boilers as follows:

1. All boilers with an input capacity of 2.5 MMBtu/h (2,500,000 Btu/h) and above, in which the boiler is designed to operate with a non-positive vent static pressure.
2. All boilers where one stack serves two or more boilers with a total combined input capacity per stack of 2.5 MMBtu/h (2,500,000 Btu/h).

(b) Boiler combustion air fans with motors 10 horsepower or larger shall meet one of the following for newly installed boilers:

1. The fan motor shall be driven by a variable speed drive, or
2. The fan motor shall include controls that limit the fan motor demand to no more than 30 percent of the total design wattage at 50 percent of design air volume.

(c) Newly installed boilers with input capacity 5 MMBtu/h (5,000,000 Btu/h) and greater shall maintain excess (stack-gas) oxygen concentrations at less than or equal to 5.0 percent by volume on a dry basis over firing rates of 20 percent to 100 percent. Combustion air volume shall be controlled with respect to firing rate or flue gas oxygen concentration. Use of a common gas and combustion air control linkage or jack shaft is prohibited.

EXCEPTION to Section 120.9(c): Boilers with steady state full-load thermal efficiency 85-percent or higher.

Major Changes in the Modeling Rules (ACM)

- New philosophy: Exceedance, not Compliance
- Baseline is “Standard of Care”, not prescriptive requirements applied to proposed model
- System Map similar to 90.1 Appendix G
- Almost nothing tracks anymore, e.g:
  - Ventilation rate
  - Fan power
  - Wall type
  - Gas heat
- Realistic schedules
- Window switches in large commercial
  - Bonus if proposed has operable windows with switches
  - Penalty if proposed has operable windows without switches
- New rules to prevent cheating – e.g.:
  - If proposed fan or pump BHP is much less than MHP then software will increase the BHP in proposed model.
  - No custom curves for fans, pumps, towers, chillers?, DX?
  - Lab exhaust (e.g. 15 ACH) and minimum ventilation (e.g. 6 ACH) are stipulated
- New rules for labs, data centers, kitchens, garages

System Mapping (ACM)

Table 5 – Non-Residential Spaces (not including covered processes)

Building Area	Floors	Standard Design	Description
≤ 10,000 ft^2	1 floor	PSZ	Packaged Single Zone
	>1 floor	PVAV	Packaged VAV Unit
10,000 ft2 – 150,000 ft2	Any	PVAV	Packaged VAV Unit
>150,000 ft2	1 floor	SZVAV	Single-zone VAV Unit
	>1 floor	VAVS	Built-up VAV Unit

Table 6 –System Map for Covered Processes

Building Type or Space Type	Floors	Baseline System
Total computer room design cooling load is over 3,000,000 Btu/h Note: if the user chooses computer room for the space type and enters a receptacle load less than 20 W/ft^2 then the proposed and baseline shall use a receptacle load of 20 W/ft^2.	Any	System 10 – CRAH Unit
Computer rooms that do not meet the conditions for System 10, CRAH	Any	System 11 – CRAC Unit
Laboratory Space	Any	System 12 – LAB
Restaurant Kitchen	Any	System 13 – KITCH

Baseline Fan Power (ACM)

- Supply Fan
  - SZ
    - < 2,000 CFM: 2.5”, 50%
    - 2k-10k CFM: 3.0”, 60%
    - >10,000 CFM: 3.5”, 62%
  - MZ
    - Add 0.5” to SZ
    - Add 0.5” if > 6 stories (e.g. 4”, 62% for high rise MZ)
  - Lab AHU: see above
- Relief Fan (only if economizer)
  - <10,000 CFM: 0.75”, 40%
  - >10,000 CFM: 1.0”, 50%
- Toilet exhaust
  - <1,000 CFM: 0.75”, 45%
  - >1,000 CFM: 1.25”, 55%
  - Add 0.25” if > 6 stories
- Lab Exhaust: 4”, 62%
  - Add 0.5” if > 6 stories
- Kitchen exhaust: 2.5”, 50%
  - Add 0.5” if > 6 stories

Questions