Data Centers

Data Center CASE Scope
Existing Title 24 2008 Scope

- Current scope (§100 T24-2008) exempts "process space" from many of the requirements, however
- Process space as defined doesn't fit data centers (§101 T24-2008)
- ***PROCESS SPACE*** *is a space that is thermostatically controlled to maintain a process environment temperature less than 55ºF or to maintain a process environment temperature greater than 90ºF 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.*

Data Center CASE Scope
Existing Title 24 2008 Scope

- Process Loads (§101 T24-2008) are exempt from many of the requirements
  - Ventilation minimums (§121)
  - Performance method budget (§141(c))
  - Fan power (§144(c))
  - Reheat/Recool (Exception 4 to §144(d))
  - Economizers (Exceptions 2 and 4 to §144(e)1)
    - exception 4: “where it can be shown to the satisfaction of the enforcing agency that the use of outdoor air is detrimental to … computer room or telecommunications equipment room.”
  - SAT Reset (Exception 3 to §144(f))
  - Pipe insulation (Exception 3 to §123)
  - Thermostatic controls (Exception to §122)
- ***PROCESS LOAD*** *is a load resulting from a process.* (§101)

Data Center CASE Scope
Title 24 2011 Scope Proposal

- Create separate definitions for Exempt and Covered Processes
- Covered Processes to include:
  - Datacom (or computer room) equipment
  - Laboratory exhaust
  - Garage exhaust
  - Kitchen ventilation
  - Refrigerated warehouses
  - Refrigerated casework

Data Center CASE Scope
New Definition

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

Data Center CASE Economizers

Data Centers

- **144 (m) Additional Requirements for Computer Rooms.**
- 1. **Economizers .** Each individual cooling fan 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.

Data Center CASE Economizers

Data Centers

- **EXCEPTION 1 to Section 144(m)1:** Individual computer rooms under 5 tons in a building that does not have any economizers.
- **EXCEPTION 2 to Section 144(m)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 144(m)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.

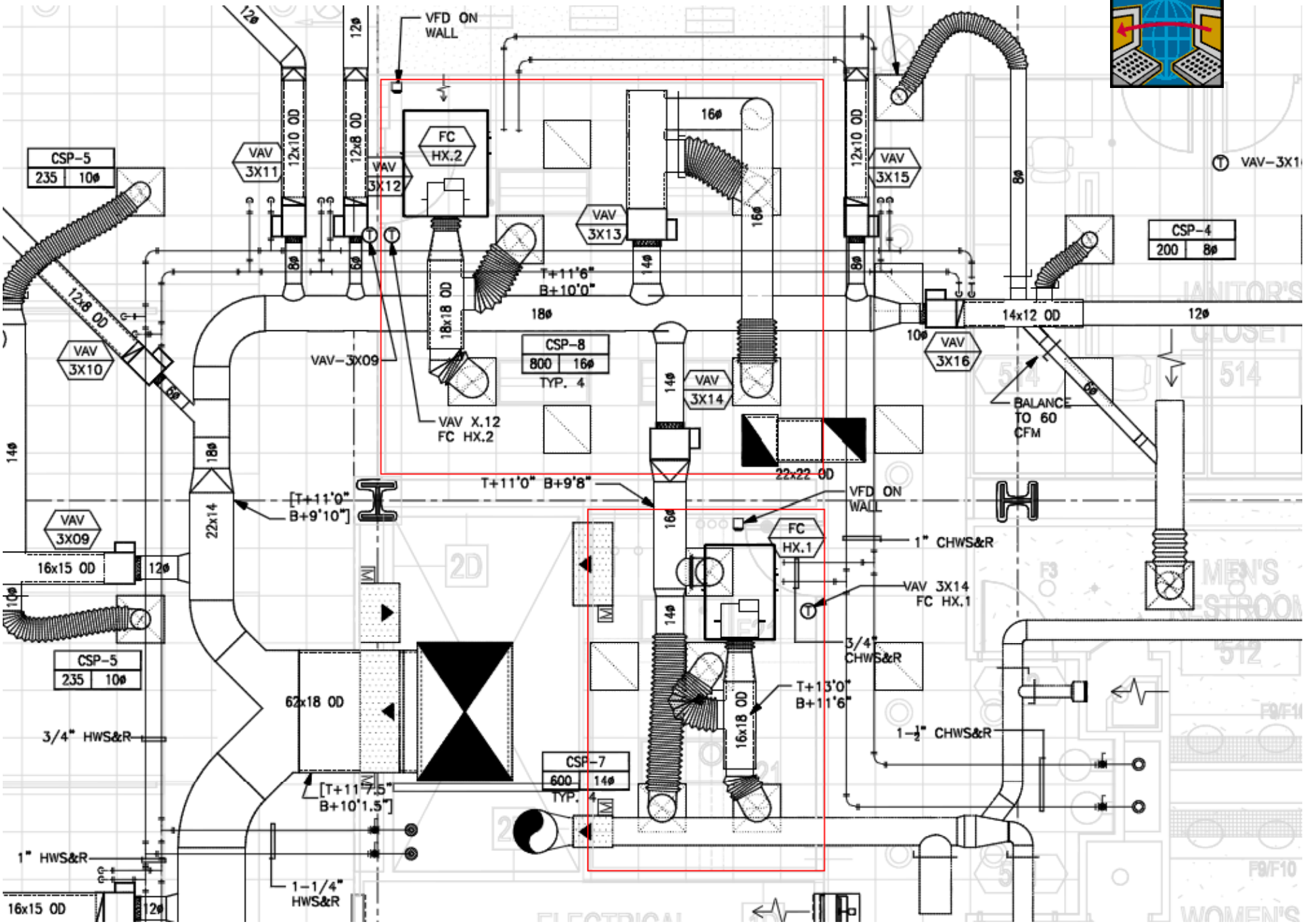
Data Centers

Data Center CASE Economizers

- **EXCEPTION 4 to Section 144(m)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:
  - 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% of their design load.
  - the economizer system has the ability to serve only the computer room(s), e.g. shut off flow to non-computer rooms when unoccupied.
  - the non-economizer system does not operate when the cooling load of the non-computer room(s) served by the economizer system is less than 50% of design load.

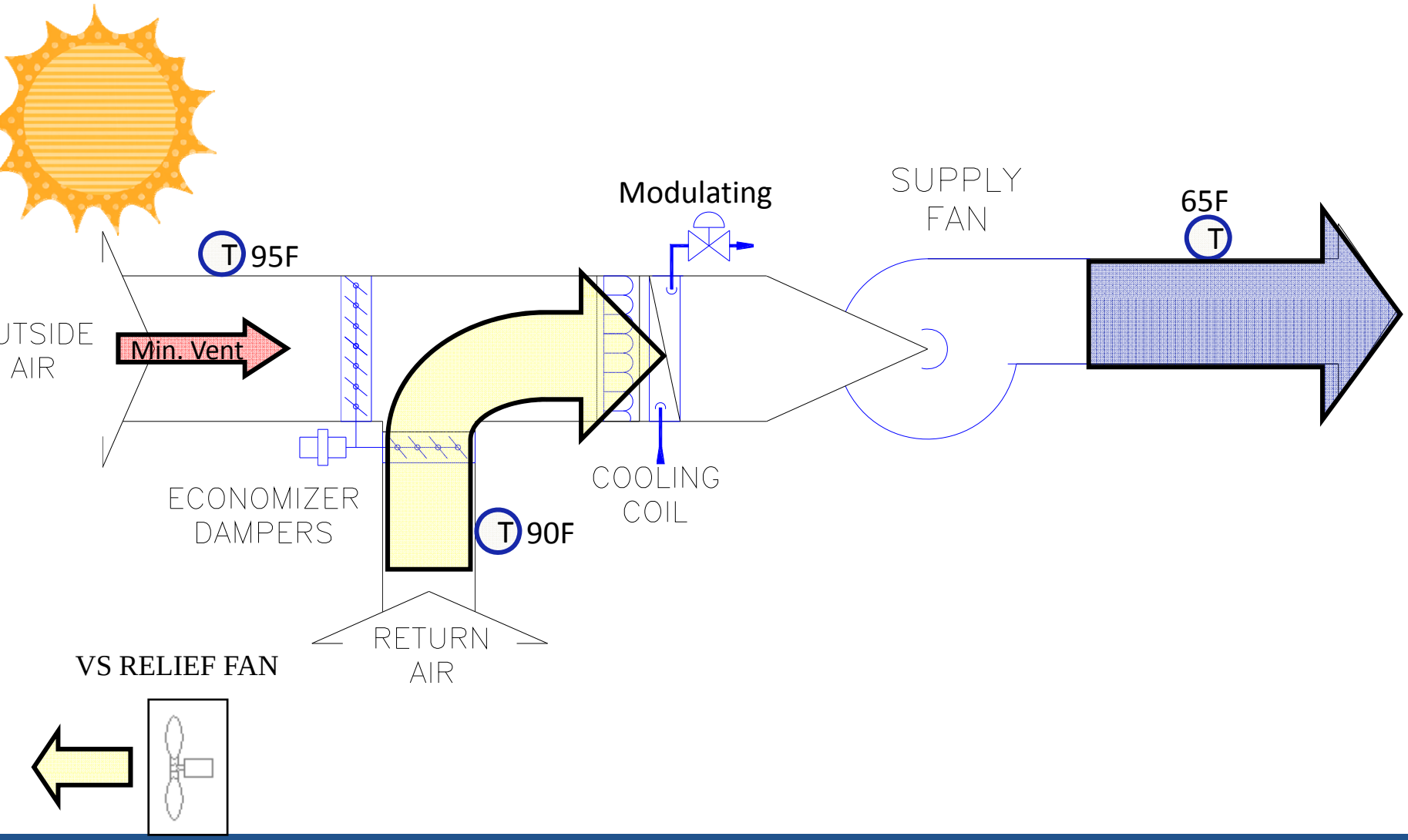
Two Computer Rooms Served by VAV Boxes and Fan Coils

Data Centers



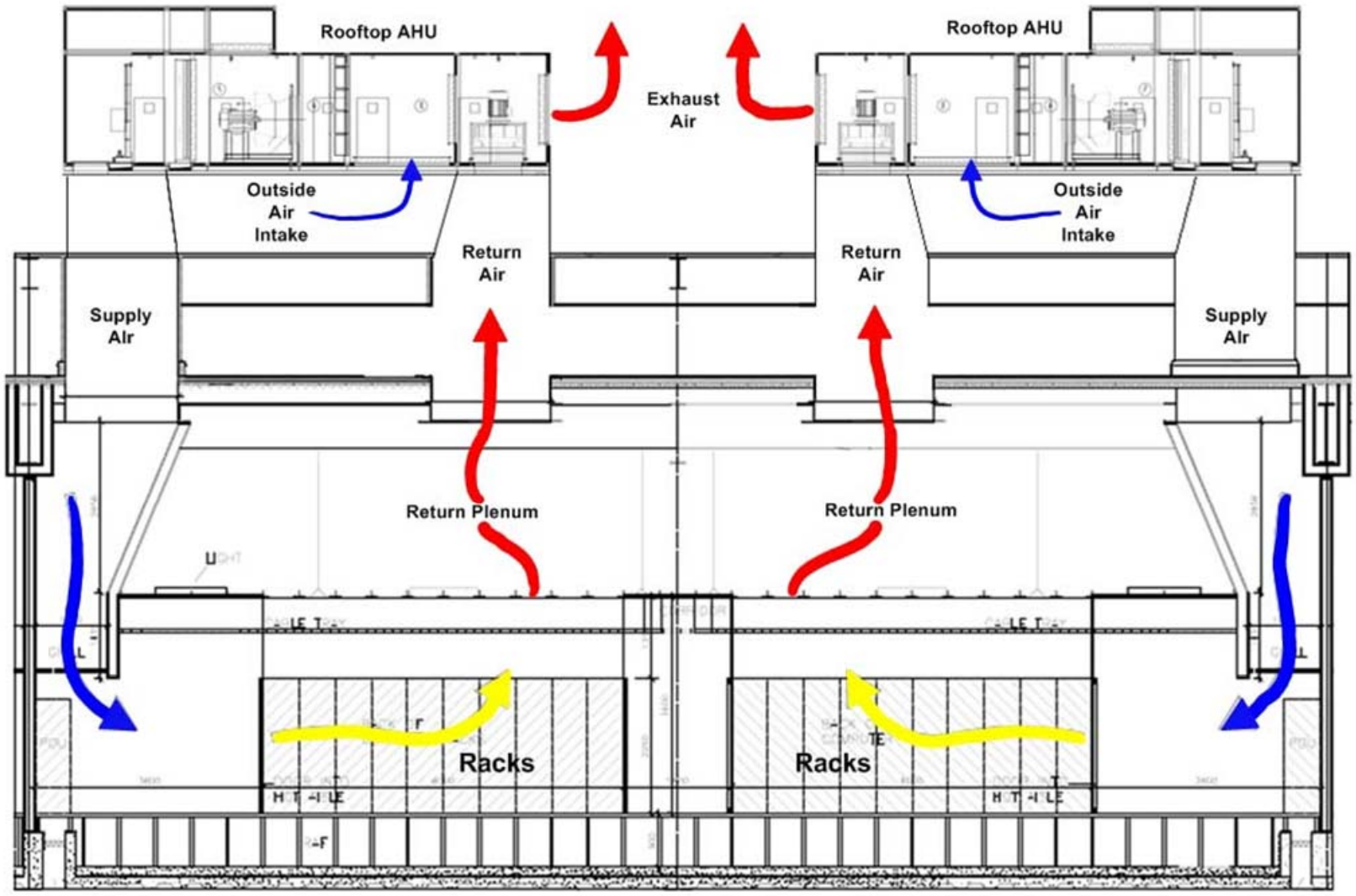
Data Center CASE Economizers
Air-side economizer

Data Centers



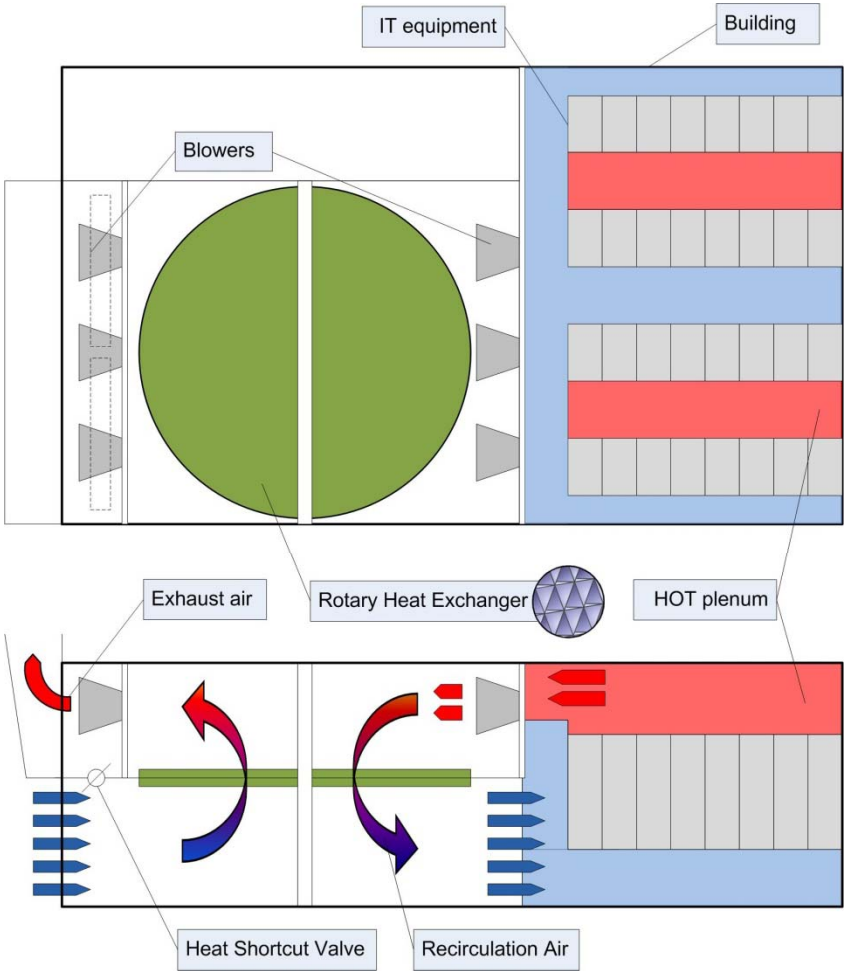
Data Center CASE Economizers
Air-side economizer

Data Centers



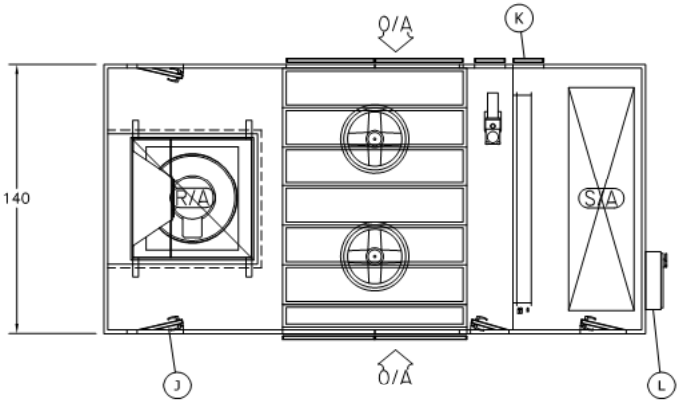
Data Center CASE Economizers
Heat Wheel Economizer

Data Centers



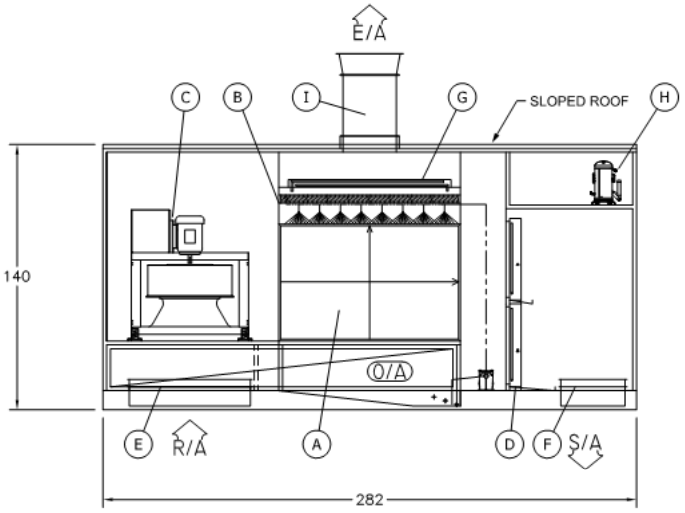
Data Center CASE Economizers
Indirect Evaporative Cooler Economizer

Data Centers



PLAN VIEW

ROOF REMOVED



ELEVATION VIEW

WALL REMOVED

MAJOR COMPONENTS:

A. POLYMER TUBE HEAT EXCHANGER
B. WATER SPRAYS / MIST ELIMINATOR
C. S/A FAN WITH MOTOR AND DRIVES
D. COOLING COIL (DX TYPE)
E. R/A ISOLATION DAMPER
F. S/A ISOLATION DAMPER
G. CONDENSER COIL
H. COMPRESSORS
I. SCAVENGER E/A FAN
J. UNIT HINGED ACCESS DOOR (TYPICAL)
K. UNIT BOLT-ON ACCESS PANEL (TYPICAL)
L. UNIT ELECTRICAL / CONTROL PANELS

NOTES:

1. MINIMUM 3'-0" CLEARANCE REQUIRED FOR SERVICE ACCESS (COILS MAY REQUIRED MORE ACCESS FOR REMOVAL).
2. WEATHER HOODS MAY BE SHIPPED IN PIECES FOR ASSEMBLY AND INSTALLATION BY OTHERS.
3. ATTENUATION OF FAN SOUND POWER LEVELS, IF REQUIRED, IS BY OTHERS.
4. ESTIMATED WEIGHT: 20,000 LBS (SHIPPING)
   21,500 LBS (OPERATING)

PRELIMINARY DRAWING

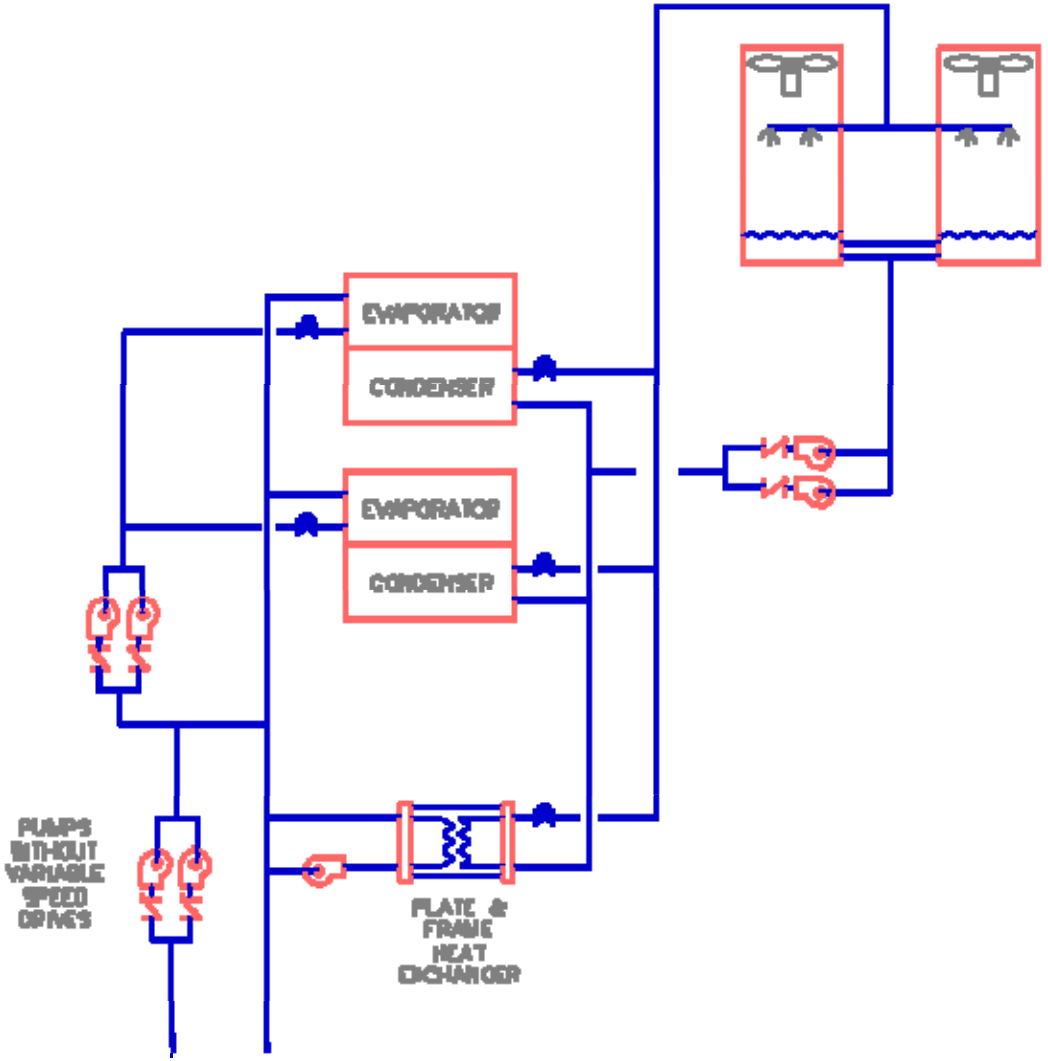
THIS DRAWING IS INTENDED FOR PRELIMINARY DESIGN PURPOSES ONLY. THE RECIPIENT OF THIS DRAWING IS CAUTIONED AGAINST USING THIS DRAWING FOR FINAL ENGINEERING PURPOSES, AS THE WEIGHTS AND DIMENSIONS INDICATED HEREIN MAY CHANGE DURING THE FORMAL SUBMITTAL PROCESS.

AIR FLOW KEY:
O/A: OUTSIDE AIR
S/A: SUPPLY AIR
R/A: RETURN AIR
E/A: EXHAUST AIR

ORDER NO. XXXXX		Munters	
		ORDER NAME: DATA CENTER	
APPROVALS	DATE	UNIT TYPE: PVT-300	
DRAWN: MF	10/07/10	TITLE: MECHANICAL LAYOUT	
CHKD:		SIZE: A	DWG NO. XXXXX-M-XXXX
APPD:			
SHEET 1 OF 1	SCALE: NTS	MODEL: PV-MZP-8730-PVT	

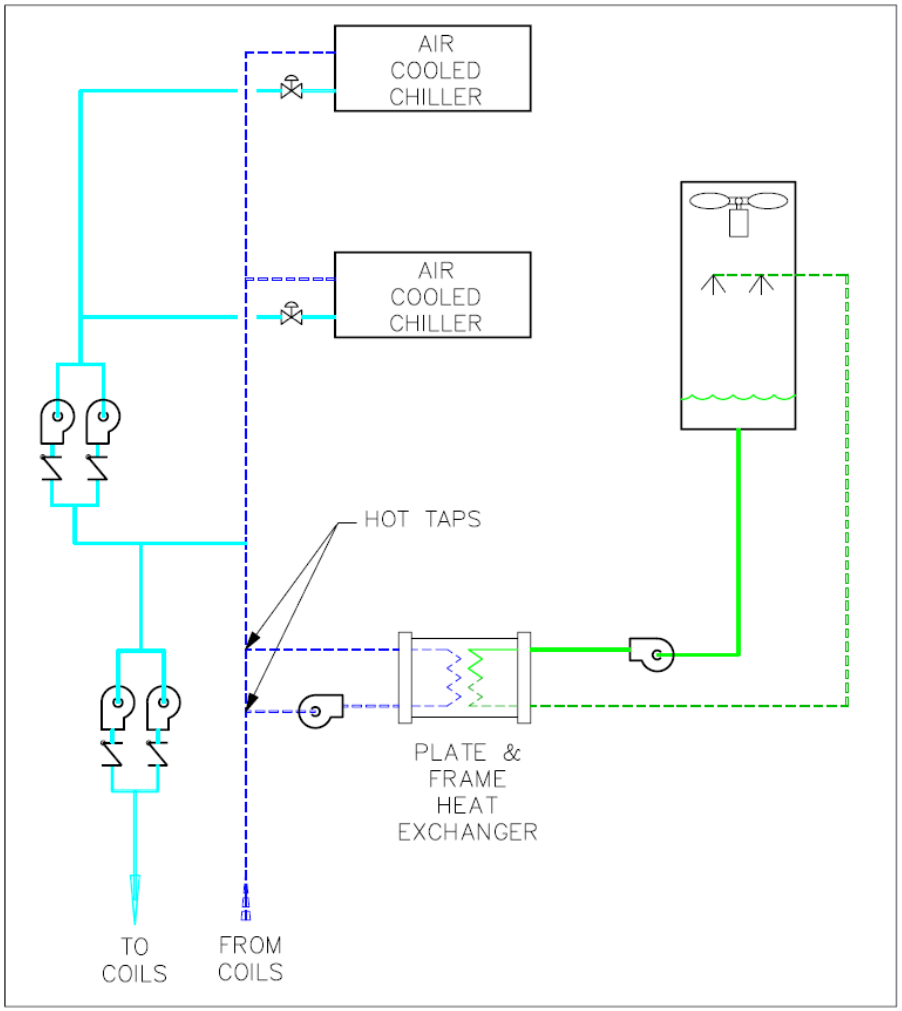
Data Center CASE Economizers
Integrated water-side economizer

Data Centers



Data Center CASE Economizers
Integrated WSE with air-cooled chillers

Data Centers



Data Center CASE Economizers
Water-Side Economizer Sizing Criteria

- Current Title 24 wording:
  - 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/45°F wet-bulb and below.
- Proposed wording for computer rooms:
- 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 **40°F** dry-bulb/**35°F** wet-bulb and below.

Data Center 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 (proposed)	<5 tons/room in building w/o economizer	<50 tons	<20 tons
ASHRAE 90.1-2010	1. Southeast 2. < 6t West, <12t N,NE 3. <250t w/o CHW plant 4. <50t w/CHW plant 5. Mission critical (5%)	<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 may be used instead of air economizers and even fewer scenarios where no economizer is required.

Water economizer does not require larger tower – Example:

- Design supply air temperature: 60°F
- Design CHW supply temperature: 45°F
- CHWST at 35°F WB: 47°F
  - Can account for reductions in ventilation and envelope load
  - Can account for redundancy in air handlers
- Heat exchanger approach: 3°F
- Tower approach at design: 5°F
- Tower approach at 35°F WB: 9°F → CWST: 44°F → +3°F HX → CHWST: 47°F
  - Accounting for reduced ventilation and envelope load, load diversity, and elimination of chiller heat.
  - Chiller heat alone is typically 15-18% of design tower load

Data Center CASE Humidity Controls Proposal

Data Centers

- **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.

Data Center CASE Humidity Controls Rationale

- There is no published research supporting the need for humidity control in data centers
- 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 Data Centers, Are They Necessary?” by Mark Hydeman and Dave Swenson: http://tinyurl.com/22otv8g

Data Center CASE Proposed prescriptive fan power limit

- Title 24 §144(c) has fan-power limitations (in watts/cfm) based on built-up ducted overhead systems with terminal units
- Computer rooms typically have less pressure drop and operate longer hours
- Proposed fan power limit is 27 watts per kBtuh of net sensible cooling capacity.
  - Based on 20ºF dT, 2.5" total pressure, 55% fan efficiency and 90% motor/drive efficiency. It can also be met at 3" total pressure and 65% fan efficiency
  - User's Manual will explain: this calculation can account for redundancy. A CRAC unit may be designed for 30 W/kBtuh but will operate at 20 W/kBtuh at peak load because it will not be running at full speed

Data Center CASE Fan Power Analysis – Survey of Existing Projects

	BHP	kW	CFM	TSP	fan effic	dT	sens. Btuh	W/kBtuh	Complies?
Liebert DH380A	10.0	7.45	15,200	2.55	61%	20.0	334,400	22	YES
Liebert DH380A with econo coil	10.0	7.45	14,250	2.78	62%	20.0	313,500	24	YES
Liebert DH380A with econo coil	13.8	10.29	15,200	3.45	60%	20.0	334,400	31	NO
Liebert DH267W	4.7	3.53	10,200	1.63	55%	20.0	224,400	16	YES
Liebert DH267W with econo-coil	7.5	5.59	10,200	2.5	54%	20.0	224,400	25	YES
Liebert CHW - FC fan	11.4	8.52	17,100	2.46	58%	20.0	376,200	23	YES
Liebert CHW - EC fan	9.7	7.20	17,100	2.46	69%	20.9	393,881	18	YES
Huntair CHW	8.3	6.16	16,700	1.8	57%	22.6	414,244	15	YES
Stulz CHW	7.6	5.66	18,000	1.38	51%	21.8	432,036	13	YES
APC CHW - InRow		0.92	2,900				60,000	15	YES
Energy Labs - CHW ducted upflow	1.3	0.94	4,425	1.23	68%	21.1	102,850	9	YES
Energy Labs - CHW downflow	7.4	5.53	17,700	1.63	61%	21.1	411,401	13	YES
Team Air - InRow	0.8	0.63	6,150	0.6	69%		139919	4	YES

Data Center CASE Fan Control
Existing Prescriptive VAV Requirement

- Title 24-2008:
  - Effective 1/1/2012, DX and chilled water (CHW) units ≥ 10 tons shall be VAV
    - (have VFD or 2 speed supply fans to reduce speed below 2/3 of full speed at low load)
- Data centers will be covered by this requirement effective 1/1/2013 (when Title 24-2011 scope change goes into effect)

Data Center CASE Fan Control
Proposed Prescriptive VAV Requirement

- **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.

Currently Available VAV DX Equipment

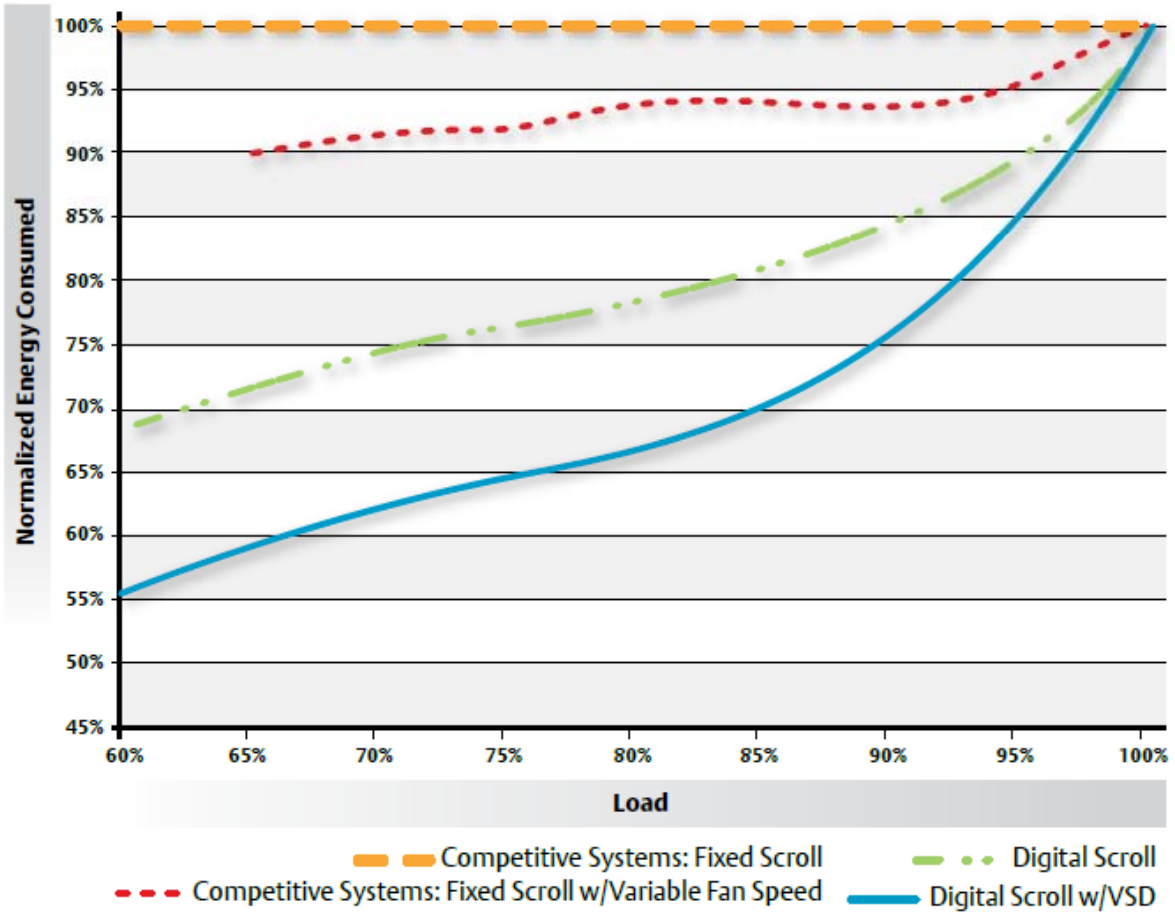
Data Centers

Make/Model	Size range	Fan	Compressors	Comment
Liebert/DS	8t – 30t	Forward curve (beta testing EC fan)	Semi-hermetic with four-step or digital scrolls	$1800 for factory VFD.
Stulz CyberTwo	6t – 30t	EC fan optional (~$1700 add)	(2) scrolls	2 speed fan control?
Data Aire gforce	6t – 30t	EC fan standard	(2) scrolls (face split coil, not row split) (investigating variable speed compressor)	Currently accepts external speed signal (default min = 80%)
APC InRoom	5t – 20t	EC	(2) compressors above 8 tons	
Aaon	3t – 140t		Digital scroll	No cost add for VAV
Carrier	4-5t		Digital scroll	
VRF (Daikin, Mitsubishi, etc)	2t – 10t		variable speed	
JCI	3-5t		Variable speed scroll	Available in 2011/2012

Data Center CASE Fan Control
Proposed Prescriptive VAV Requirement

- Liebert Literature

The example below shows the energy required to operate a floor-mount Liebert DS cooling unit.



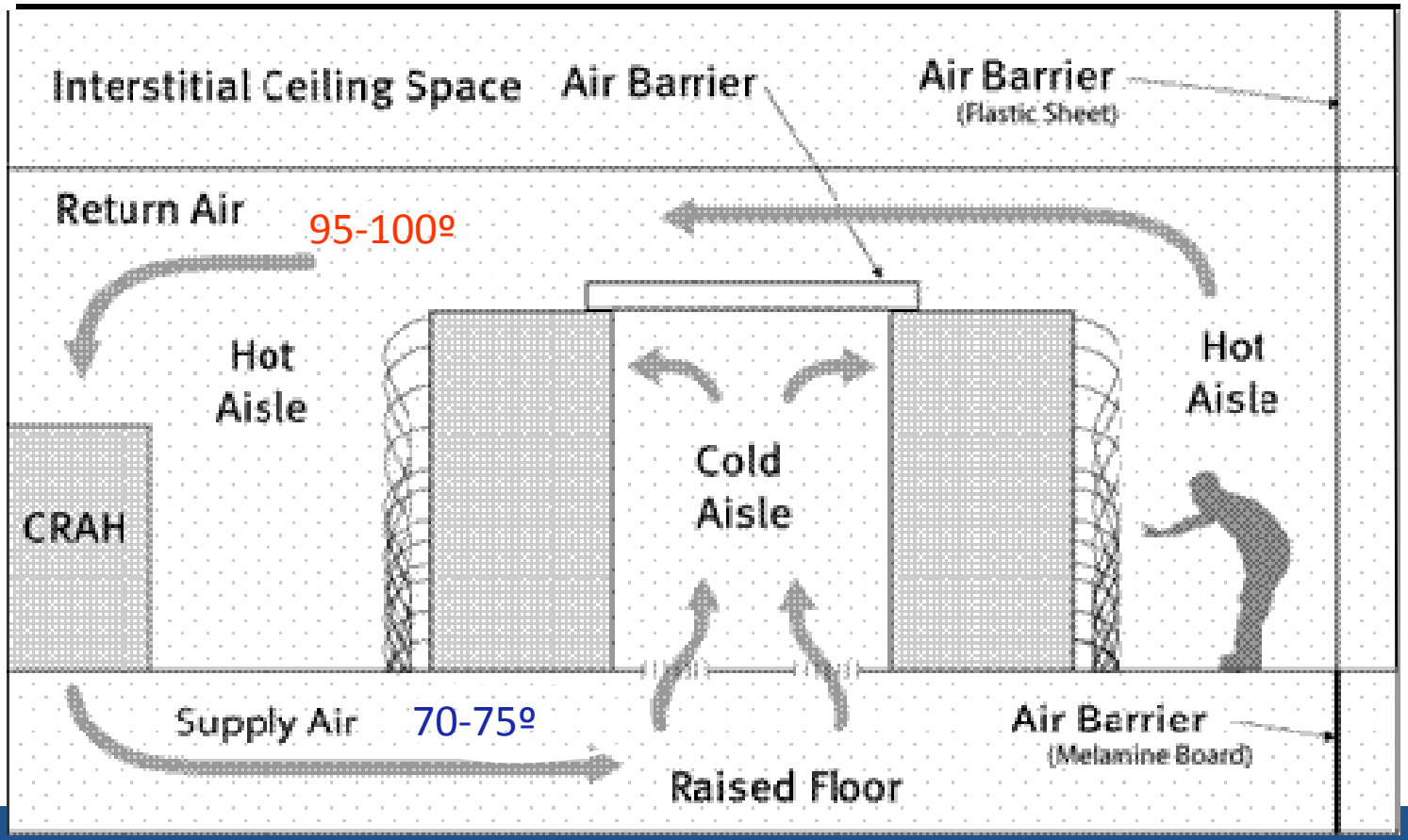
Data Center CASE Containment
Proposed requirement

- **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 144(m)6:** Expansions of existing computer rooms.
- **EXCEPTION 2 to Section 144(m)6:** Computer racks with a design load less than 1 kW/rack.
- **EXCEPTION 3 to Section 144(m)6:** Equivalent energy performance based on computational fluid dynamics or other analysis.

Data Center CASE Containment
Cold aisle containment, UF supply

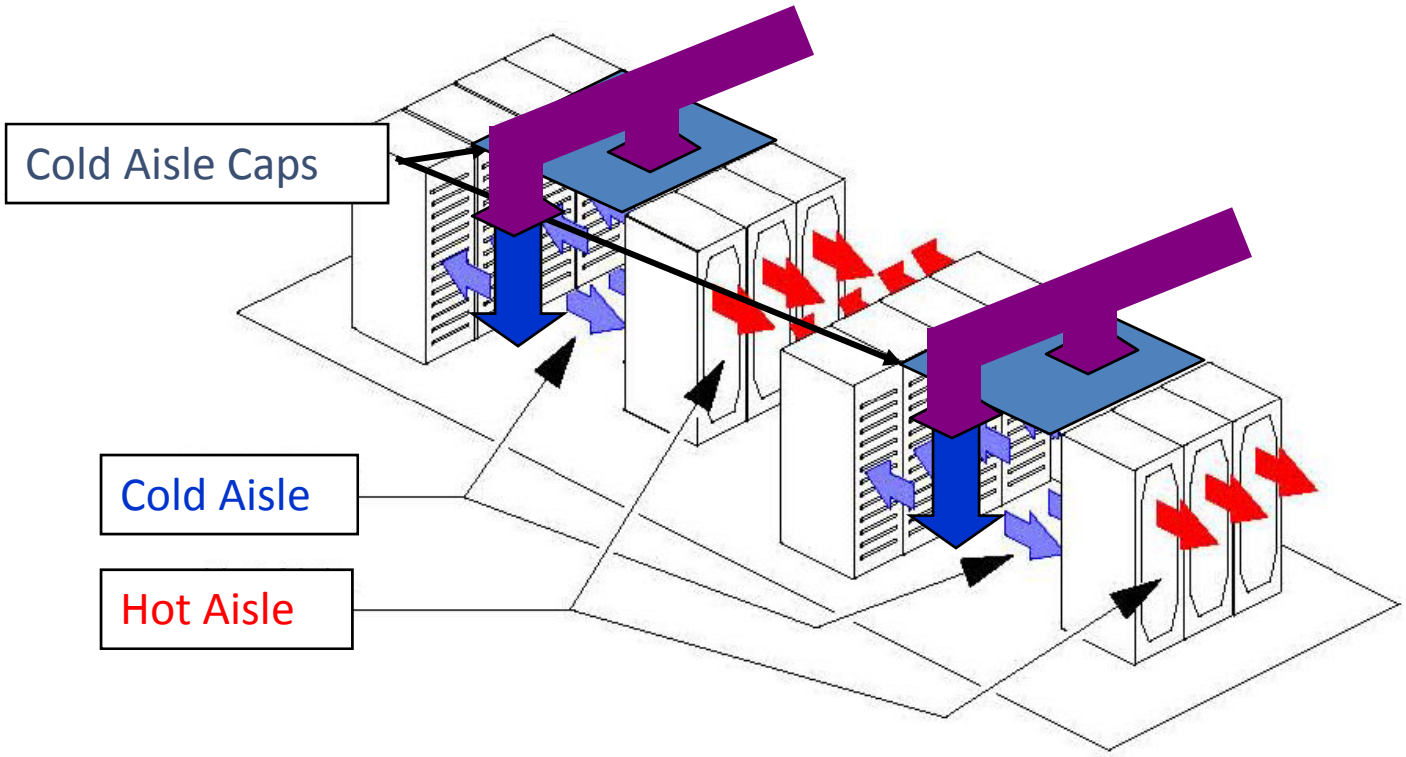
Data Centers

Cold aisle top caps and end caps



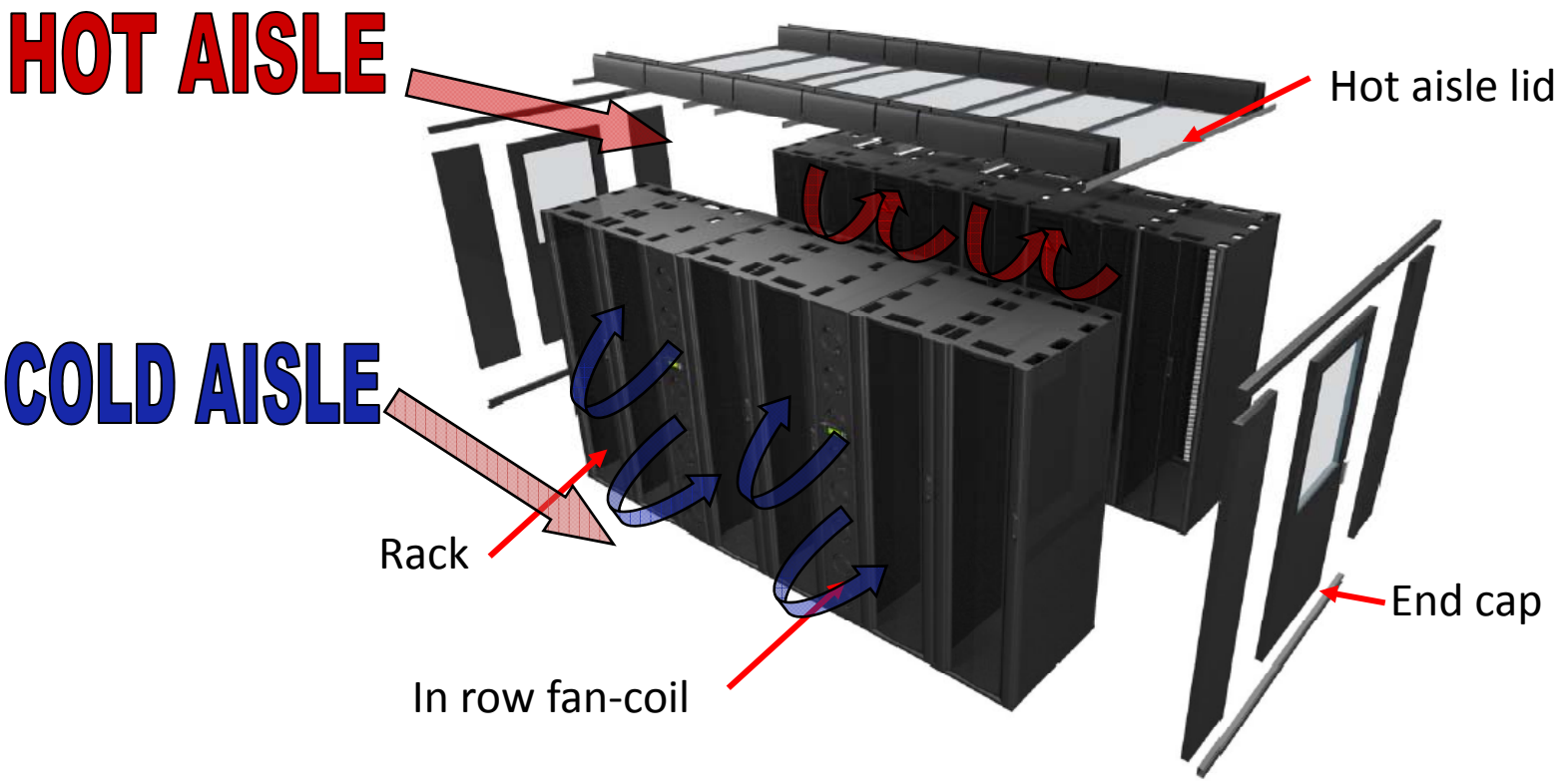
Data Center CASE Containment
Cold aisle containment, OH supply

Cold aisle top caps and end caps



Data Center CASE Containment
Hot aisle containment with in row cooling

Data Centers



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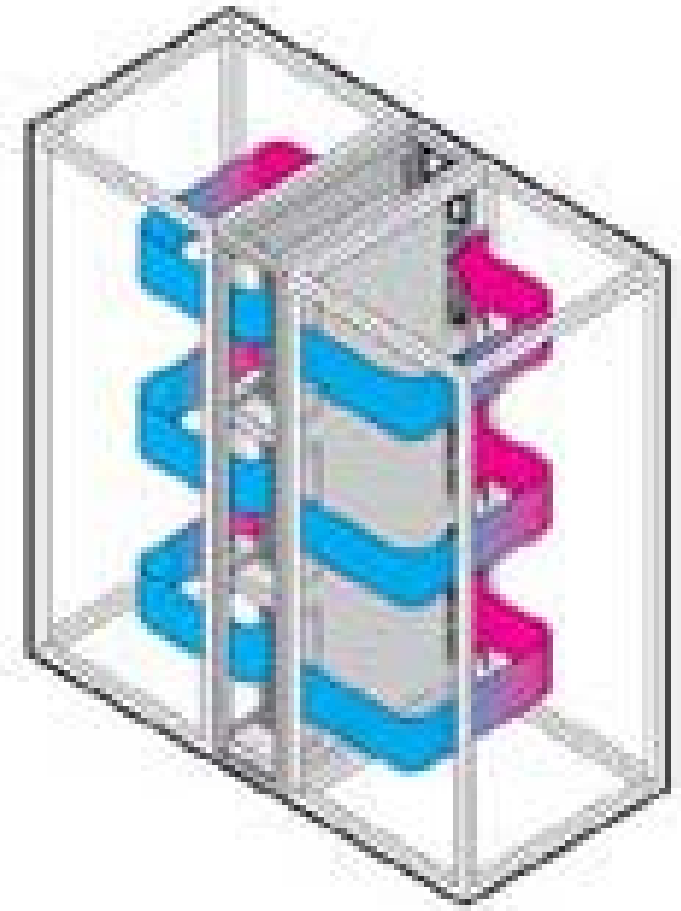
Data Center CASE Containment
In-Row Cooling

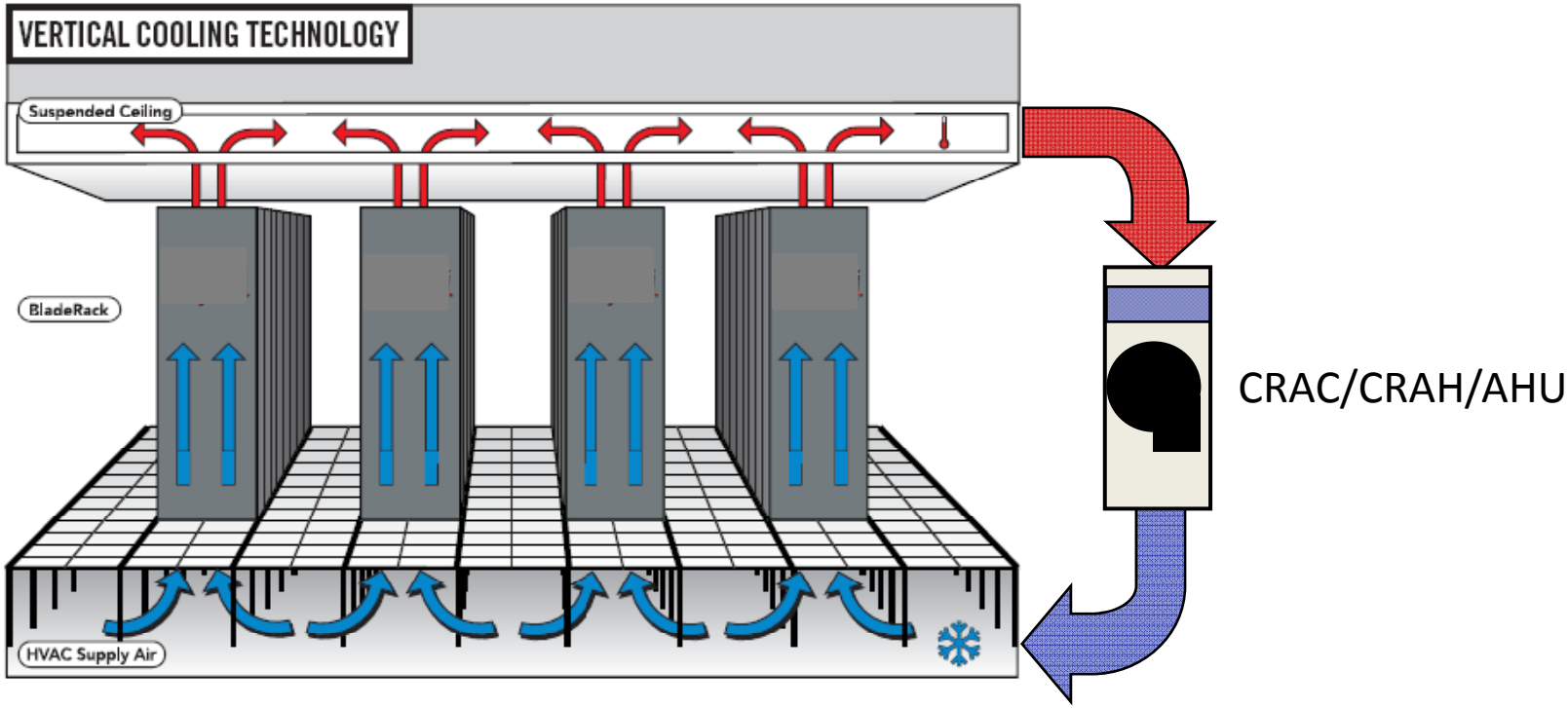
This complies both on the cold and hot aisles



Data Center CASE Containment
Combined hot and cold aisle containment

Data Centers

Supply air enters from the bottom of the rack
Return air is ducted to the ceiling



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Data Center CASE Containment Space Supply

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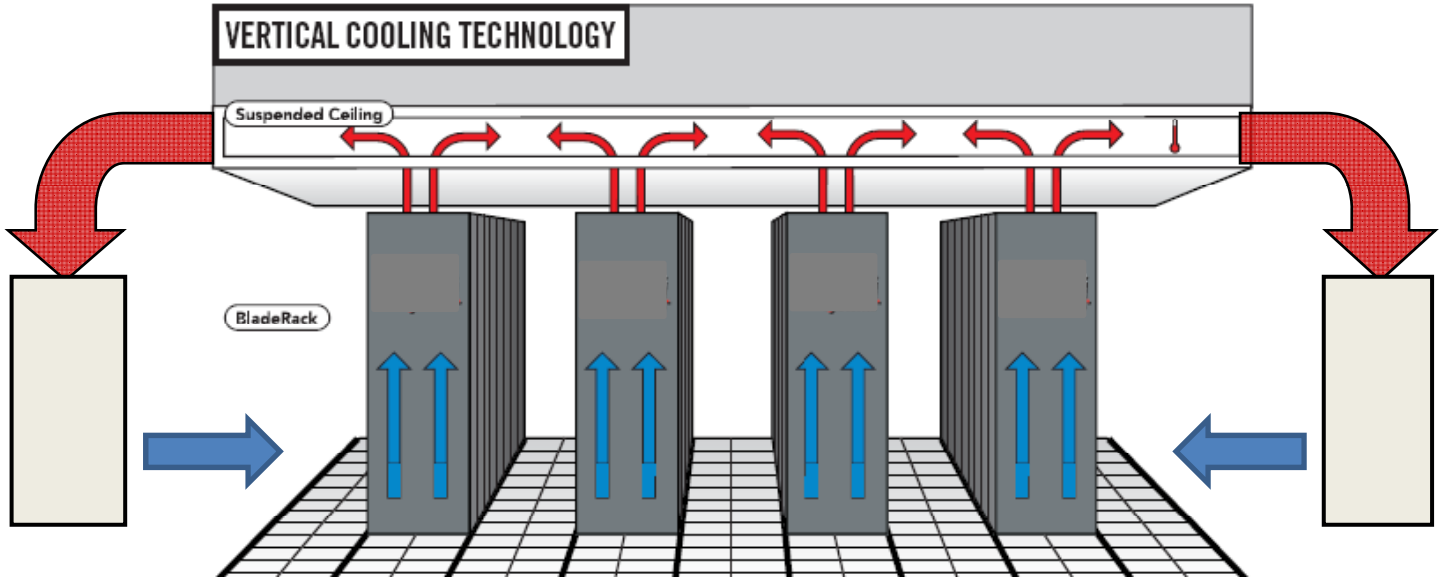
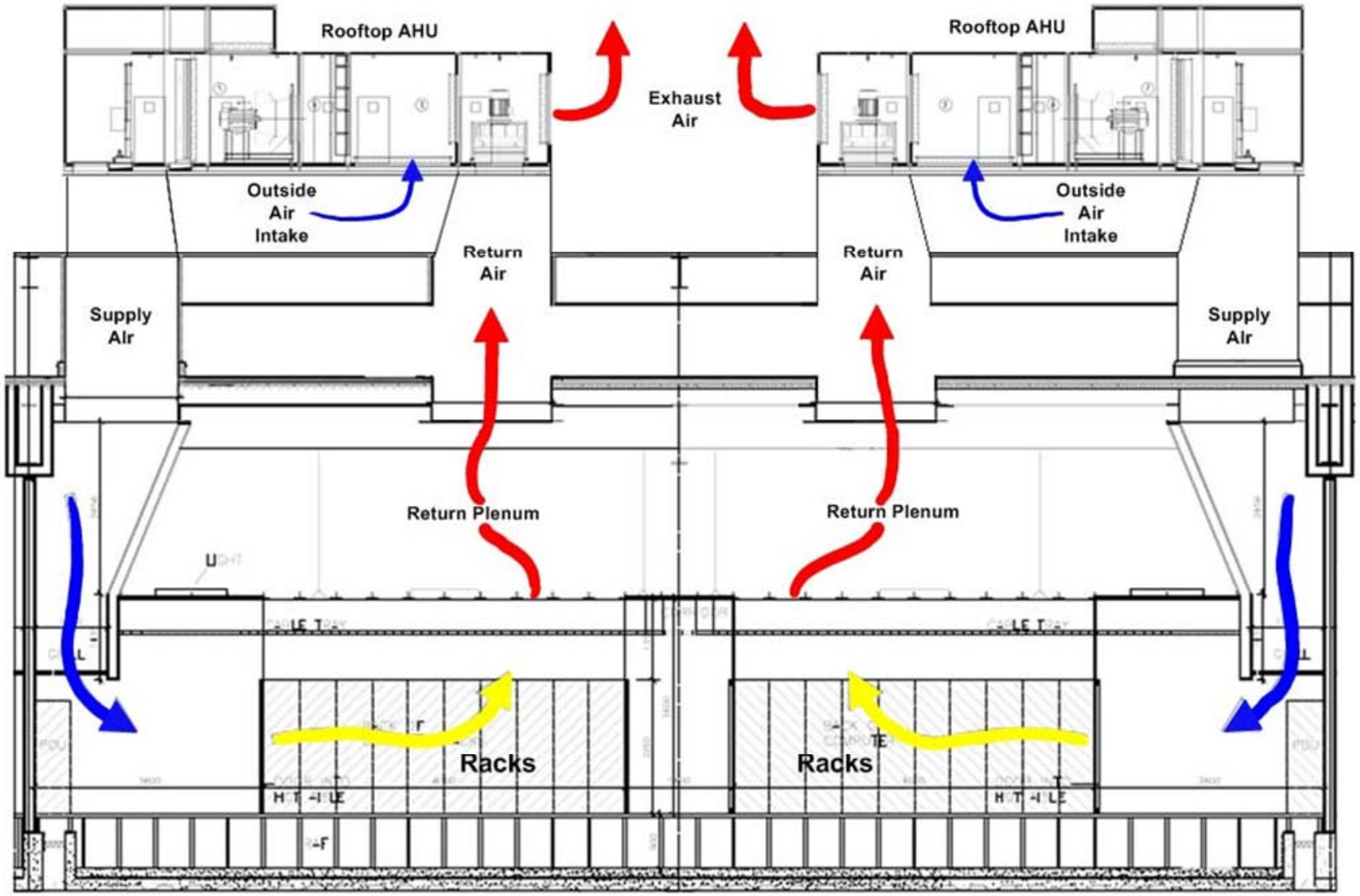
Containment allows you to get rid of the raised floor!



Containment Examples



Containment Examples

Containment Examples

Containment Examples

Data Centers

Data Center CASE – 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

Data Center CASE – 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
- If more than 75% of the proposed building cooling capacity serves computer rooms then the entire building is modeled as System 6 or System 7. If less than 75% of the proposed building cooling capacity serves computer rooms but there are any computer rooms with a cooling capacity exceeding 120,000 Btuh then the computer rooms shall be modeled with a separate system than the non-computer rooms

Data Centers

System 6 (CHW) Baseline

- Design airside ΔT: 20ºF
- Design return air setpoint: 80ºF
- One fan system per room
- CFM sized 110% of the calculated load
- Supply fan power: 0.49 W/cfm (based on 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

Data Centers

- Equipment power density: input by user
- Equipment schedules: cycle monthly between 25%, 50%, 75%, 100% (same as 90.1 addendum cj)
- Lighting power density: 0.8 W/ft2
- Ventilation: 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 ratio at part load = speed ratio ^3 (e.g. 12.5% of design power at 50% speed).
  - Supply air temperature setpoint shall be linearly reset from 60°F at 50% cooling load and above to space temperature at 0% cooling load.

System 7 (DX) Baseline

Data Centers

- 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
- Supply fan power: 0.49 W/cfm (based on supply fan effic: 60%, supply fan total static: 2.5")
- Airside economizer, when required prescriptively - differential drybulb control
- No humidification
- No reheat

System 7 (DX) Baseline

Data Centers

- Equipment power density: input by user
- Equipment schedules: cycle monthly between 25%, 50%, 75%, 100% (same as 90.1 addendum cj)
- Lighting power density: 0.8 W/ft2
- Ventilation: 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 ratio at part load = speed ratio ^3 (e.g. 12.5% of design 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.

Electrical System Baseline Tracks Proposed

Data Centers

- 2.4.1.5 Process Loads
- Process load is the internal energy of a building resulting from an activity or treatment not related to the space conditioning, lighting, service water heating, or ventilating of a building as it relates to human occupancy. Process load may include sensible and/or latent components. Process loads for data centers includes transformers, UPS, PDU, server fans and power supplies, etc.

Questions