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The Impacts of ASHRAE 90.1-2010 on Data Center Design

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Integrated Design Group is a design firm that employees architects, project managers, and mechanical and electrical engineers. We specialize in the design of data centers and other mission critical facilities. From feasibility and due diligence studies and design renovations to fit-outs, expansions, and new buildings, our concentration is on Data Center design and workplace support spaces for Financial, Corporate, Academic/Institutional, and Public Sector clients. Our team promotes a unique integration of architecture and engineering. Our team has provided our clients with knowledgeable service, and functional, cost-effective facilities of the highest design quality.

Introduction

Dennis Julian, PE, ATD, DCEP
Principal
Integrated Design Group
djulian@idgroupae.com

7x24 Magazine: "Impacts on Data Centers from the new ASHRAE 90.1-2010 Energy Standard
http://www.idgroupae.com/documents/11-17-117x24FallExcerptArticle_002.pdf

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Dennis, a Principal at Integrated Design Group, is in charge of coordinating the management of the architectural and engineering disciplines. His focus includes maintaining adherence to quality, innovative design, project schedules and budgets, interfacing with clients to provide performance reports and in select cases, being the primary contact for inquiries made by the client. Dennis has over 25 years of experience and has managed and engineered a wide variety of data center projects for retail, governmental, educational, process, advanced technology, commercial, health care and financial clients. He is a principal-in-charge for all Digital Realty projects.

ASHRAE 90.1 Significance

- ASHRAE 90.1-2010 goal was to improve building energy efficiency by 30% compared to the 2004 version
- "Consensus Document" – Design guideline until adopted by AHJ, local or state
- International Energy Conservation Code (IECC) – 2012 version will incorporate many provisions of ASHRAE 90.1-2010
- DOE will require all buildings to comply with ASHRAE 90.1-2010 by August 2013. State or local codes may require earlier compliance.
- ANSI/ASHRAE/USGBC/IES Standard 189.1-2011, Standard for the Design of High-Performance Green Buildings. References ASHRAE 90.1-2010.
- LEED 2013 uses ASHRAE 90.1-2010 as a base requirement
- International Green Construction Code (IGCC) references ASHRAE 90.1-2010

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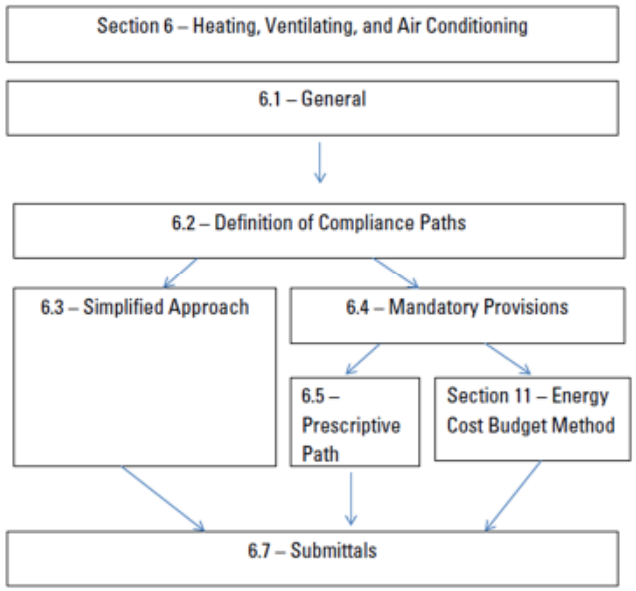
Goal of standard was to increase energy savings. No consideration of cost.

Most states are on a 3 year code cycle. Last cycle was 2009. Present Adoption:

- Illinois adopts IECC 2012 January 1, 2013
- Texas requires compliance with IECC 2012 for all state buildings September 2012
- Massachusetts goal was to adopt IECC 2012 in Fall of 2012.
- Virginia schedule to adopt January 2013 requires compliance January 2014.

Compliance Paths



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In most cases requirements can be met following prescriptive requirements or by modeling to show an equivalent energy savings

Application to New and Existing Buildings

- **New Buildings:** all comply
- **Additions to Existing Buildings:** extension/increase in floor area or height of a building outside of the existing building envelope
- **Alterations of Existing Buildings:** all comply
- **Replacement of Portions of Existing Buildings:** portions of a building envelope… that are being replaced are considered as alterations of existing buildings.
- **Changes in Space Conditioning:** unconditioned or semi heated spaces converted to conditioned spaces

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Impact on Data Center Design

- Scope expanded to include receptacle loads and Data Centers which are defined by the standard as “process”
- 2010 version now has language specific to data centers requiring compliance with specific sections
- Architectural – Building Transmission Performance
- Lighting
- Transformer efficiency
- HVAC
- Commissioning

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Interpretations of previous versions of ASHRAE 90.1 determined that data centers were “process loads” and therefore exempt from the requirements. The 2010 version specifically includes data centers as a covered use.

Building envelope (opaque elements and fenestration) requirements are more stringent.

Hot water heater minimum efficiencies have increased.

Service water pressure booster systems now have minimum requirements.

Most interior light power densities reduced. Additional controls added. Five zone exterior lighting power density table added.

Most equipment efficiencies are higher. Energy recovery required in more applications. Economizers required in more climates. More energy-conserving controls required.

Architectural

- Building envelope
- Continuous air barrier
- Roofing
- Support & office spaces
- Elevator

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- Entire Air leakage section has been modified including requirements for building envelope, ducts and plenums.
- Continuous air barrier extend over all surfaces of the building envelope (at the lowest floor, exterior walls, and ceilings or roof. Includes building assemblies used as ducts or plenums. List of acceptable materials is provided. Maximum air leakage is specified.

- Cool/high albedo (ratio of light reflected to light received) roof requirements added. In climate zones 1 – 3 shall have on of the following:
  - Minimum 3 yr solar reflectance of 0.55
  - Minimum 3 yr aged thermal emittance of 0.75
  - Minimum 3 yr solar reflectance index of 64 using a convection coefficient of 2.1 BTU/h-ft^2
  - Increased roof insulation levels.
- Insulation values have increased for some building types

- New elevator requirements for lighting efficiency, standby mode (occupancy sensor to turn off lighting and ventilation)
- Motorized damper for stair and elevator shaft vents

Transformers

Three-phase kVA	Standard efficiency level (%)	TP-1-2002 efficiency level (%)
30	96.5	97.5
45	96.6	97.7
75	96.7	98.0
112.5	96.9	98.2
150	97.1	98.3
225	97.3	98.5
300	97.4	98.6

- January 1, 2007: must comply with provisions of Energy Policy Act of 2005.
- Efficiencies shall be measured per testing requirements of NEMA TP-1-2002.

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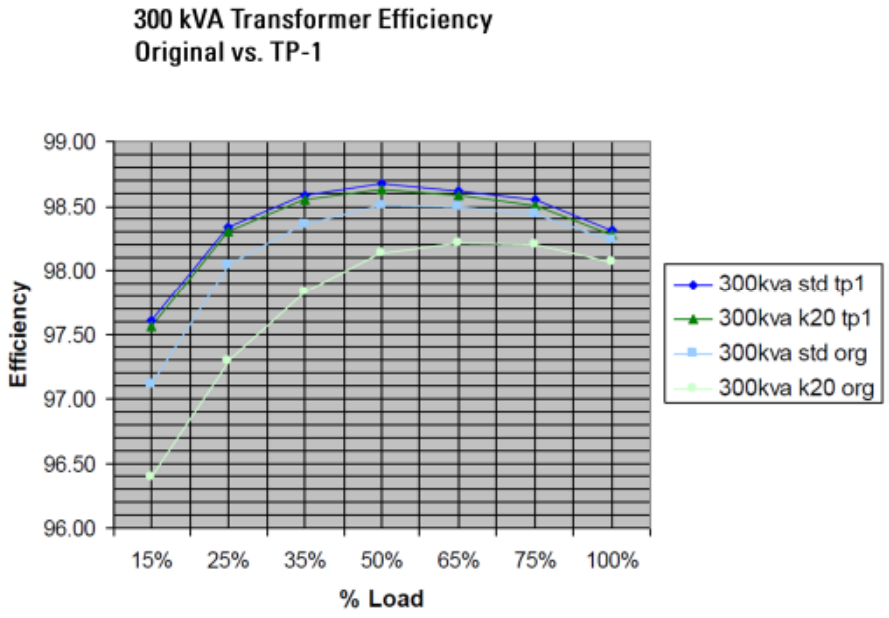
EPACT 2005 federal law is not identical to NEMA standard TP-1. A major difference is that the federal energy efficiency mandate does not exclude K rated transformers or harmonic mitigating transformers which NEMA does exclude from its scope.

Power Distribution Units



- Testing emphasizes efficiencies at part load (approx. 35%)
- All dry-type transformers including K-rated and PDUs.

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Generally larger and more expensive than non energy efficient transformers.

Electrical – Affected Equipment/Systems

- Voltage drop requirements – size for maximum voltage drop at design loads:
  - 2% for feeders
  - 3% for branch circuits
- Automatic Receptacle control for at least 50% of all receptacles, including those in modular partitions, installed in the following space types:
  - Private offices
  - Open offices
  - Automatic control device based on on of the following: scheduled basis, occupant sensor (30 min) or remote signal.
  - Motor efficiencies in accordance with the Energy Independence and Security Act of 2007

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Automatic control of receptacles not required for:

1. Equipment requiring 24 hour operation
2. Where it would endanger safety or security of the room or building occupants.

General Lighting

- Allowable lighting watts per SF reduced for interior and exterior spaces.
- Automatic control requirements now include all building sizes.
- Occupancy sensors required in more locations
- Five Exterior lighting zones with different lighting levels.
- Functional testing required

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Any automatic control device required shall be either manual on or shall only turn on no more than 50% of the lighting except full auto on is allowed for: public corridors and stairwells, restrooms, primary building entrance areas and lobbies and areas where manual on would endanger the safety or security of the room or occupants.

Space control – the controlled lighting shall have at least one control step between 30% and 70% (inclusive) of full lighting power in addition to on and off.

More areas require occupant sensor control including conference, meeting and training rooms, employee lunch and break rooms, storage areas, copy rooms, office spaces up to 250sf, restrooms, dressing and locker rooms.

Stairwell lighting shall have one or more control devices to automatically reduce lighting by at least 50% within 30 min of being unoccupied.

Maximum override time for automatic controls is 2 hours.

Commissioning – Lighting systems shall be functionally tested and certified by a

third party not involved with design or construction.

Interior Lighting

Building Area Type	90.1-2007 LPD (W/ft^2)	90.1-2010 LPD (W/ft^2)
Manufacturing facility	1.3	1.11
Office	1.0	0.90
Warehouse	0.8	0.66

- Interior lighting power levels reduced by 10-18% depending on area.

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Based on a whole building approach. Generally space by space allows less W/sf.

Office – 10% reduction in W/sf

Manufacturing (classification typically used for computer room) – 15% reduction

Warehouse (typically storage areas or unoccupied areas)– 18% reduction

May no longer get a 35% reduction allowance in LEED which may be a loss of one point.

LEED points for reductions of 15%, 25% and 35%.

Interior Lighting: 10,000 Sq. Ft space

T8 - 32 watt lamp = 92.18 LPW

LED lamp = 84.4 LPW

Layout of space = 85 fixtures

Using T8 lamps with 3-lamps per fixture = 0.8 w/sf (28% reduction)

Using LED lamps - 2 Led strips per fixture = 0.7 w/sf (37% reduction)

Exterior Lighting

Exterior Lighting Zones

Lighting Zone	Description	Allowed W/SF
0	Undeveloped areas within national parks, state parks, forest land, rural areas, and other undeveloped areas as defined by the *authority having jurisdiction.*	0
1	Developed areas of national parks, state parks, forest land, and rural areas.	0.04
2	Areas predominantly consisting of residential zoning, neighborhood business districts, light industrial with limited nighttime use and residential mixed use areas.	0.06
3	All other areas.	0.1
4	High activity commercial districts in major metropolitan areas as designated by the local jurisdiction.	0.13

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Exterior lighting control:

Building façade and landscape lighting shall be automatically shut off between midnight or business closing, whichever is later and 6am or time established with the AHJ.

Other exterior lighting shall be controlled to automatically reduce by 30% for at least one of the following conditions:

from 12 midnight or within one hour of the end of business operations, whichever is later and 6am or

during any period when no activity is detected for a time no longer than 15 minutes.

Typical Site Lighting

LED 0.04 w/sf, LED lamp = 74.7 LPW

250 Metal Halide: 0.07 w/sf, Lamp = 88 LPW

HVAC – Affected Equipment/Systems

- Equipment efficiency
- Piping
- Insulation
- Fan power
- Economizers
- Controls
- Commissioning

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It is not uncommon to not insulate some piping like dry cooler piping which could range from 40F to 120F. This may lead to additional costs for insulation.

HVAC Equipment Efficiency Unitary AC Units

TABLE 6.8.1A Electronically Operated Unitary Air Conditioners and Condensing Units—Minimum Efficiency Requirements

Equipment Type	Size Category	Heating Section Type	Subcategory or Rating Condition	Minimum Efficiency[a]	Test Procedure[b]
Air conditioners, air cooled	<65,000 Btu/h[c]	All	Split system	13.0 SEER	AHRI 210/240
			Single package	13.0 SEER	
Through-the-wall (air cooled)	≤30,000 Btu/h[c]	All	Split system	12.0 SEER	
			Single package	12.0 SEER	
Small-duct high-velocity (air cooled)	<65,000 Btu/h[c]	All	Split system	10.0 SEER	
Air conditioners, air cooled	≥65,000 Btu/h and <135,000 Btu/h	Electric resistance (or none)	Split system and single package	11.2 EER 11.4 IEER	AHRI 340/360
		All other	Split system and single package	11.0 EER 11.2 IEER	
	≥135,000 Btu/h and <240,000 Btu/h	Electric resistance (or none)	Split system and single package	11.0 EER 11.2 IEER	
		All other	Split system and single package	10.8 EER 11.0 IEER	
	≥240,000 Btu/h and <760,000 Btu/h	Electric resistance (or none)	Split system and single package	10.0 EER 10.1 IEER	
		All other	Split system and single package	9.8 EER 9.9 IEER	
	≥760,000 Btu/h	Electric resistance (or none)	Split system and single package	9.7 EER 9.8 IEER	
		All other	Split system and single package	9.5 EER 9.6 IEER	
	<65,000 Btu/h	All	Split system and single package	12.1 EER 12.3 IEER	AHRI 210/240
	≥65,000 Btu/h and <135,000 Btu/h	Electric resistance (or none)	Split system and single package	11.5 EER (before 6/1/2011) 12.1 EER (as of 6/1/2001) 11.7 IEER (before 6/1/2011) 12.3 IEER (as of 6/1/2011)	
				11.3 EER(before 6/1/2011)	

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- Typical air-cooled equipment

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HVAC Equipment Efficiency Chillers

TABLE 6.8.1C Water Chilling Packages—Efficiency Requirements[a]

Equipment Type	Size Category	Path A	Path B	Test Procedure[c]
Air-Cooled Chillers	<150 tons	≥9.562 EER ≥12.500 IPLV	NA[d]	
	≥150 tons	≥9.562EER ≥12.750 IPLV	NA[d]	
Air-Cooled without Condenser, Electrical 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 water-cooled positive displacement efficiency requirements		
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	
Air-Cooled Absorption, Single Effect	All Capacities	≥0.600 COP	NA[d]	AHRI 560
Water-Cooled Absorption, Single Effect	All Capacities	≥0.700 COP	NA[d]	
Absorption Double-Effect, Indirect-Fired	All Capacities	≥1.000 COP ≥1.050 IPLV	NA[d]	
Absorption Double-Effect, Direct-Fired	All Capacities	≥1.000 COP ≥1.000 IPLV	NA[d]	

- Typical water-cooled equipment

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HVAC Piping

ASHRAE 90.1-2010			Clear Water		Glycol and Water Mix	
Nominal Pipe Size (inches)	Constant Flow System (gpm)	Variable Flow System (gpm)	Industry Design Flow for water (gpm)	Typical Industry Design velocity for water (fps)	Typical Industry Design Flow for glycol (gpm)	Typical Industry Design velocity for glycol (fps)
2 1/2	68	110	40-65	2.7-4.4	30-50	2.0-3.4
3	110	170	65-115	2.8-5.0	50-90	2.2-3.9
4	210	320	115-240	2.9-6.1	90-190	2.3-4.8
5	250	440	240-440	3.9-7.1	190-340	3.1-5.5
6	370	700	440-700	4.9-7.8	340-550	3.8-6.1
8	680	1100	700-1450	4.5-9.3	550-1100	3.5-7.1
10	1000	1600	1450-2400	5.9-9.8	1100-2000	4.5-8.1
12	1500	2300	2400-3500	6.9-10.0	2000-3200	5.7-9.2
Pipes over 12 inches	5.0	7.5		8.3-12.8		7.3 - 11.2

- Constant volume (CV) vs. variable volume (VV) system sizing.
- For systems operating more than 4400 hrs/yr
- Typical flows:
- 1125kW IT UPS (8" to 10")
  - Pri - 1220 gpm
  - Sec – 1170 gpm
- 2250kW IT UPS (10" to 12")
  - Pri – 2440 gpm
  - Sec - 2100 gpm
- 3375kW UPS (12" to 14/12")
  - Pri – 3660 gpm
  - Sec - 3060 gpm

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Larger pipe sizing effects valving, fittings, space and PPS enclosure size.

4400 hrs/yr is 50% of available hours per year.

For 1125kW UPS – 7 CRAHs at 140 gpm each = 980 gpm. Remaining requirement is for other loads – Electrical room, Battery room, etc.

For 2250kW UPS – 14 CRAHs at 140 gpm each = 1960 gpm. Remaining requirement is for other loads – Electrical room, Battery room, etc.

For 3375lW UPS – 21 CRAHs at 140 gpm each = 2940 gpm. Remaining requirement is for other loads – Electrical room, Battery room, etc.

Fan Power

- All fan cooling systems >/= 5 HP must be variable speed
- Motor size can not exceed next larger standard size than the required BHP
- This also applies to DX CRACs > 9 tons

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Economizers

City	Airside Economizer with A1 Recommended Temperatures (hr)	Airside Economizer with A1 Allowable Temperatures (hr)
Boston	7,099	7,834
New York	6,734	7,448
Wash, DC	6,124	6,941
Atlanta	5,331	6,356
Miami	1,541	2,516
Chicago	6,846	7,523
St Louis	5,979	6,796
Dallas	4,561	5,515
Houston	3,172	3,922
Austin	3,907	4,863
Denver	8,145	8,643
Las Vegas	5,880	7,170
Phoenix	5,065	6,699
Seattle	8,606	8,755
San Francisco	8,657	8,758
Los Angeles	6,816	8,370
		Average

- Each cooling system that has a fan requires either an air- or water-side economizer.

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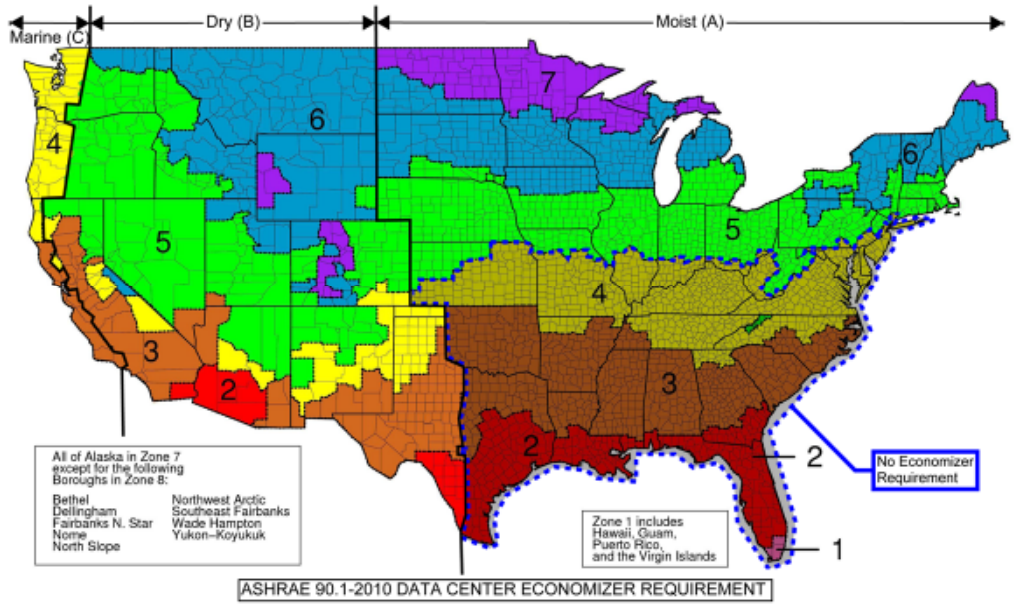
Economizer Climate Zones Map



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Economizers: Air vs. Water

- Air-side utilizes outside air (OA) to supply to space when conditions permit
- Water-side utilizes outside air (OA) to cool chilled water (directly or indirectly)
- Systems with hydronic cooling and humidification systems designed to maintain a minimum dew point of 35F shall use a water side economizer if an economizer is required.

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Specific design parameters for sizing economizers are provided so that the system will provide 100% cooling at outdoor air temperatures of 50F dry bulb / 45F wet bulb and below. Three exceptions provided:

1. Evaporative water economizers for systems primarily serving computer rooms: 40F dry bulb / 35F wet bulb.

2. Dry cooler economizers for systems primarily serving computer rooms: 35F dry bulb.

3. Systems where dehumidification requirements cannot be met with outdoor air temperatures of 50F dry bulb / 45F wet bulb and where 100% of the expected system cooling at 45F dry bulb / 40F wet bulb is met with evaporative water economizers.

Pressure drop across the economizer system is restricted to reduce additional load on the pumps.

Integrated water side economizer control shall require partial cooling even when additional cooling is required to satisfy the load.

This requires series heat exchangers (HX) in lieu of the more common parallel HX.

Controls

- Simultaneous cooling & heating not allowed
- Chilled water optimization systems with reset
- Monitor chilled water system control valves
- DDC controls required to perform these functions

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System controls shall not permit reheat or any other form of simultaneous heating or cooling for humidity control.

The standard requires the differential set point to be reset downward based on unit valve positions until one valve is nearly wide open.

This requires the monitoring of all chilled water control valves and a control sequence to calculate the required differential pressure setting to control the pumps.

Commissioning

- Required for projects > 50,000 SF
- Detailed instructions provided by designer in plans & specs

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Conclusions

- Energy savings
- Higher costs
- Reliability/Availability

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