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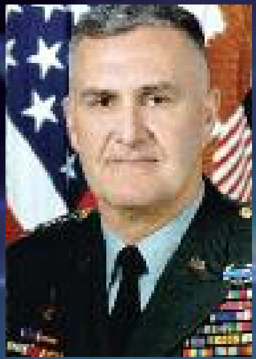

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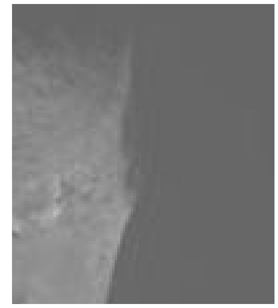


IMPACTS on Data Centers from the new ASHRAE 90.1-2010 Energy Standard

by Dennis Julian, PE, ATD, DCEP
Wayne Drooks, PE

The American Society of Heating, Refrigerating and Air-Conditioning Engineers' (ASHRAE) goal for the 2010 edition was to reduce energy costs by 30% compared to the 2004 version. Capital costs and return on investment (ROI) were not considered during the process.

Previous editions of this standard have been interpreted to exclude data center equipment from the energy efficiency requirements since they were considered to be process loads. The new 2010 version specifically includes data centers and introduces additional specific requirements on total system efficiencies and individual equipment efficiencies. Many features routinely incorporated into other project types are now required to be provided in data centers.

These new requirements will improve data center efficiencies and result in operational savings. But they will also most likely increase the initial cost of the systems. System designs will change as a result of these requirements but those changes will need to be carefully designed so as to not reduce the reliability and availability of the data center operations.

ANSI/ASHRAE/IES Standard 90.1-2010 is a consensus document. It represents a best practices approach to energy efficient systems. It is not a code or a specific requirement until it is adopted as such by the Authority Having Jurisdiction (AHJ). This can be at the local state or federal level. This is commonly done through the adoption of energy codes such as the International Energy Conservation Code (IECC). The present IECC-2009 is based on the ASHRAE 90.1-2007 standard. The IECC-2012 code is presently being revised and will incorporate many provisions of the ASHRAE 90.1-2010 standard. As this energy code is adopted by various AHJs, the requirements for data centers will become enforceable.

Other standards that may eventually adopt the new version are certification programs for energy efficiency and sustainability such as LEED. The current draft for the updated LEED 2012 includes a mandatory requirement to comply with ASHRAE 90.1-2010.

There are multiple sections of the standard that may impact the data center. This article will review these in general and more specifically some of the electrical and mechanical systems most affected.

Architectural – Building Envelope

There have been changes and additions to this section that will minimally affect the data center. The envelope requirements always applied to the buildings where data centers were located. One of the changes includes a mandatory requirement for a continuous air barrier for all buildings. This requirement is beneficial to the operation of the data center. Other changes will affect support spaces such as offices but will not be of consequence to the data center itself.

Lighting

The allowable lighting watts per square foot have been reduced for interior and exterior spaces and the control requirements have been expanded.

Exterior spaces have been broken out into five zones. The zones are based on the areas surrounding the data center and vary from rural undeveloped areas to major metropolitan areas. The exterior lighting power allowances vary based on the zone where the facility is located.

This could be an area of concern for providing adequate security lighting in rural and less developed areas. Lighting fixture types will need to be selected based on lumens per watt and may increase the use of advanced lamps and technology including LED fixtures.

Interior lighting power levels have been reduced from 10-18% depending on the classification of the data center areas. Designs will need to ensure that adequate lighting levels are maintained with these reduced power levels.

Transformers including PDUs

Minimum energy efficiency requirements for transformers 600V and below have been added to the standard. Transformers need to comply with the provisions of the Energy Policy Act of 2005. Efficiencies are to be measured per the testing requirements of NEMA TP-1 2002. Essentially the testing emphasizes efficiencies at part load (approximately) 35% since that is a typical loading for general use transformers. This also tends to be true in data centers with redundant transformers (PDUs). Efficiencies as measured by NEMA TP-1-2002 are generally required to be over 98% as indicated in the standard.

THREE-PHASE TRANSFORMER EFFICIENCY

kVA	Efficiency	kVA	Efficiency
15	97.0	225	98.5
30	97.5	300	98.6
45	97.7	500	98.7
75	98.0	750	98.8
112.5	98.2	1000	98.9
150	98.3		

Source: Table 4-2 of National Electrical Manufacturers Association (NEMA®) Standard TP-1-2002, 'Guide for Determining the Energy Efficiency for Distribution Transformers'.

EPACT 2005 federal law is not identical to the NEMA Standard TP-1. A major difference is that the federal energy efficiency mandate does not exclude K-factor rated transformers or harmonic mitigating transformers, which NEMA TP-1 does exclude from its scope. The federal law also does not specifically exclude retrofit or replacement transformers from its scope, as NEMA TP-1 does.

NEMA TP-1 certified transformers are typically more expensive than non-certified units.

Heating, Ventilating and Air Conditioning (HVAC) Systems

Most equipment efficiencies have been increased from the previous standard and economizers are required in more climates. Many of these requirements applied to other project types but are now specifically required in data centers.

Piping

Variable flow piping systems. The standard requires piping systems to be variable flow. Constant flow piping systems are not allowed. Variable pumping systems controlled by differential pressure and exceeding 10 hp, shall have the sensor located at the most remote heat exchanger or at the location requiring the greatest differential pressure. The maximum pressure set point shall not exceed 110% of the required differential pressure to achieve design flow. Where DDC controls are used the differential set point shall be reset downward based on valve positions until one valve is nearly wide open. Exceptions are provided for systems that include no more than three valves and where the minimum flow is less than that required by equipment manufacturers, such as chillers, where total pump system power is 75 hp or less.

This requirement will require the monitoring of all the chilled water valves by the DDC system and a control sequence to calculate the required differential pressure in the system based on the position of all the chilled water valves.

Piping shall be insulated per Table 6.8.3B except where the design operating temperatures range between 60F and 105F or where heat gain or loss will not increase energy usage.

It is common to not insulate dry cooler piping which could range from 40F to 110F. This may lead to increased costs for insulation.

The standard has developed a minimum pipe size requirement. It is a general requirement based on standard weight steel piping. The minimum pipe sizes do not apply to piping that is not in the critical circuit at design conditions for more than 30% of the operating hours.

Therefore, piping that experiences higher flows during maintenance or abnormal conditions is not required to be sized based on the standard.

The table includes the piping sizing requirement from the standard and some typical industry values that have been developed based on comparison of initial cost, pumping energy, noise generation and system erosion due to fluid velocity. As can be seen from the chart there is not a lot of difference in the smaller sizes but as pipe increases to 6 inch or larger the differences can be substantial.

ASHRAE 90.1-2010			Clear Water		Glycol and Water Mix	
Nominal Pipe Size (inches)	Variable Flow System (gpm)	Maximum velocity (fps)	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	4.56	40-65	2.7-4.4	30-50	2.0-3.4
3	110	4.77	65-115	2.8-5.0	50-90	2.2-3.9
4	210	5.29	115-240	2.9-6.1	90-190	2.3-4.8
5	250	4.01	240-440	3.9-7.1	190-340	3.1-5.5
6	440	4.89	440-700	4.9-7.8	340-550	3.8-6.1
8	700	4.49	700-1450	4.5-9.3	550-1100	3.5-7.1
10	1000	4.07	1450-2400	5.9-9.8	1100-2000	4.5-8.1
12	1500	4.26	2400-3500	6.9-10.0	2000-3200	5.7-9.2
Pipes over 12 inches		5.0		8.3-12.8		7.3-11.2

The pipe sizing in the standard should lead to a reduction in pipe friction losses and therefore reduced pressure requirements (head) for the pump thereby reducing operating costs. The larger pipe sizes will result in increased costs for piping, valves, supports and installation.

Maximum flow rates are based on variable flow piping systems operating over 4400 hours per year.

Controls

System controls shall not permit reheat or simultaneous heating and cooling for humidity control. This is a common occurrence in computer room system designs that will no longer be permitted.

If the new ASHRAE TC9.9 temperature and humidity requirements are followed this should have minor effect on computer room design and operation. It could be a concern on tightly controlled humidity levels and in rooms with high humidity and low internal heat loads leading to overcooling.

Additional more sophisticated controls may be required to prevent this condition.

Equipment

One of the mandatory provisions is minimum equipment efficiencies. In addition to the previous tables for equipment efficiencies, Table 6.8.1K has been added that lists minimum efficiencies for Air Conditioners and Condensing Units Serving Computer Rooms.

Equipment efficiencies must be verified through a certification program or the equipment manufacturer shall install a permanent label stating that the equipment complies with the requirements of Standard 90.1.

CRAH units cannot be single speed constant volume. Per the standard, air handling and fan coil units with chilled water cooling coils and supply fans 5 hp or greater shall have two speed or variable speed motors. As of January 2012 this requirement also includes units with direct expansion cooling and a cooling capacity of 110,000 Btu/h (9.1 tons).

Economizers

Each cooling system that has a fan shall include either an air or water side economizer. Climate zones are the same as the IECC 2006 standard. Exceptions are listed for the following:

a. **Exception a: Individual fan-cooling units for the following (from Table 6.5.1B):**

1. No economizer requirement for data centers in climate zones 1a, 1b, 2a, 3a, 4a (essentially southeast US and mid-Atlantic areas)

2. Cooling systems under 135,000 Btu/h (11.25 tons) in zones 2b, 5a, 6a, 7 and 8 (essentially the Northeast, eastern side of the Midwest and Alaska and some southern areas of Texas and New Mexico)

3. Cooling systems under 65,000 Btu/h (5.4 tons) in zones (essentially the West coast and the western side of the Mid-west).

b. **Exception c: Spaces humidified to satisfy process needs, but it is stated that this exception does not include computer rooms.**

c. **Exception j: Systems primarily serving computer rooms where:**

1. The total design cooling load of all computer rooms in the building is less than 250 tons and the building is not served by a centralized chilled water plant, or

2. The room total design cooling load is less than 50 tons and the building is served by a centralized chilled water plant, or

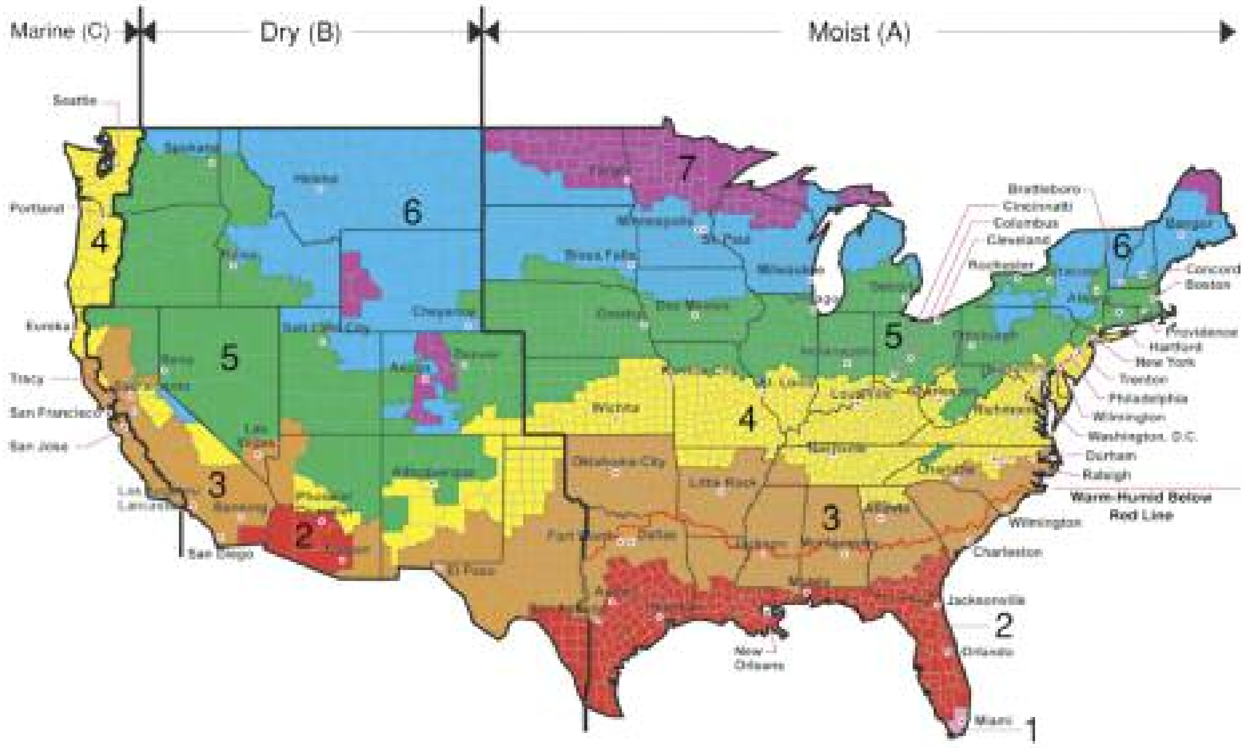
3. The local water authority does not allow cooling towers, or

4. Less than 50 tons of computer room capacity is being added to an existing building.

d. **Exception k: Dedicated systems for computer rooms where a minimum of 75% of the design load serves:**

1. Those spaces classified as an essential facility.

CLIMATE ZONES



All of Alaska in Zone 7 except for the following Boroughs in Zone 8: Bethel, Dellingham, Fairbanks, N. Star, Nome North Slope, Northwest Arctic, Southeast Fairbanks, Wade Hampton, and Yukon-Koyukuk

Zone 1 includes: Hawaii, Guam, Puerto Rico, and the Virgin Islands

2. Those spaces having a mechanical cooling design of Tier IV as defined by ANSI/TIA-942.

3. Those spaces classified under NFPA 70 (NEC) Article 708 – Critical Operations Power Systems (COPS).

4. Those spaces where core clearing and settlement services are performed such that their failure to settle pending financial transactions could present systemic risk as described in "The Interagency Paper on Sound Practices to Strengthen the Resilience of the US Financial System, April 7, 2003".

Using exception k to eliminate the need for economizers could impose a host of additional requirements for mechanical and electrical systems to comply with the definition of Tier IV, essential facility or a COPS facility including structural and architectural considerations for robustness, survivability after an event and compartmentalization.

Water economizers: system shall be capable of cooling supply air by indirect evaporation and providing up to 100% of the expected system cooling load at outdoor air temperatures of 50F dry bulb / 45F wet bulb and below. Exceptions:

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 using 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 drops for the economizer system are restricted to reduce additional load on the pumps during non-economizer system operation.

Integrated economizer controls are required to allow partial cooling even when additional cooling is required to meet the load.

This requires series installed economizers in lieu of the more common parallel economizers.

Many water cooled chiller systems have been installed with plate and frame heat exchangers that are designed and operated as a chiller replacement when the outdoor ambient conditions are appropriate. This implies the heat exchanger is installed in parallel with the chillers and the water is typically bypassed around the chiller. Therefore, the heat exchanger is an all or nothing operation.

This standard will require the heat exchanger to be in series with the chiller at all times so it can provide partial cooling.

Humidification

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.

Fan System Power Limitation

Fan cooling systems exceeding 5 hp must be variable speed and the motor size must not exceed the next larger standard size greater than the brake horsepower (bhp). The bhp must be identified on the design documents for verification by the AHJ.

System Commissioning

The standard requires that HVAC control systems be tested to ensure that controls are calibrated, adjusted and are working properly. For projects larger than 50,000 sf of conditioned space, detailed instructions for commissioning the HVAC systems shall be provided by the designer in the plans and specifications.

Energy Cost Budget Alternative

Section 11 of the standard outlines the requirements to evaluate compliance of the proposed design with the prescriptive requirements of the standard. There are still some mandatory requirements that need to be met. Once these are satisfied, alternative designs can be evaluated to show compliance with the standard.

Conclusion

Following ASHRAE 90.1-2010 will provide additional energy savings during operation. It may also lead to higher initial costs for equipment installation and structure. Designers will need to be creative in incorporating these energy saving features while keeping initial costs under control and maintaining the required level of reliability and availability of the data center.

Dennis Julian, PE, ATD, DCEP, is Principal of Integrated Design Group. He can be reached at djulian@idgroupae.com and Wayne Drooks, PE, Senior Mechanical is the engineer at Integrated Design Group. He can be reached at wdrooks@idgroupae.com