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Engineers Newsletter

volume 49-4

HVAC-related changes in ASHRAE® Standard 90.1-2019

Jurisdictions have begun to adopt ASHRAE 90.1-2016. We now look to the 2019 version for ideas on how to save energy over the 2016 version—for participating in above-code programs, preparing for the future, or simply as a design preference for energy and energy cost saving. This *Engineers Newsletter* describes important changes affecting HVAC systems and related equipment.

Since 1975, ANSI/ASHRAE/IES Standard 90 and subsequently 90.1 have been the basis of many energy codes and continue to be adopted directly or by reference via the International Energy Conservation Code (IECC). ASHRAE Standard 90, was also the foundation for determining compliance with the Energy Policy Act of 1992.

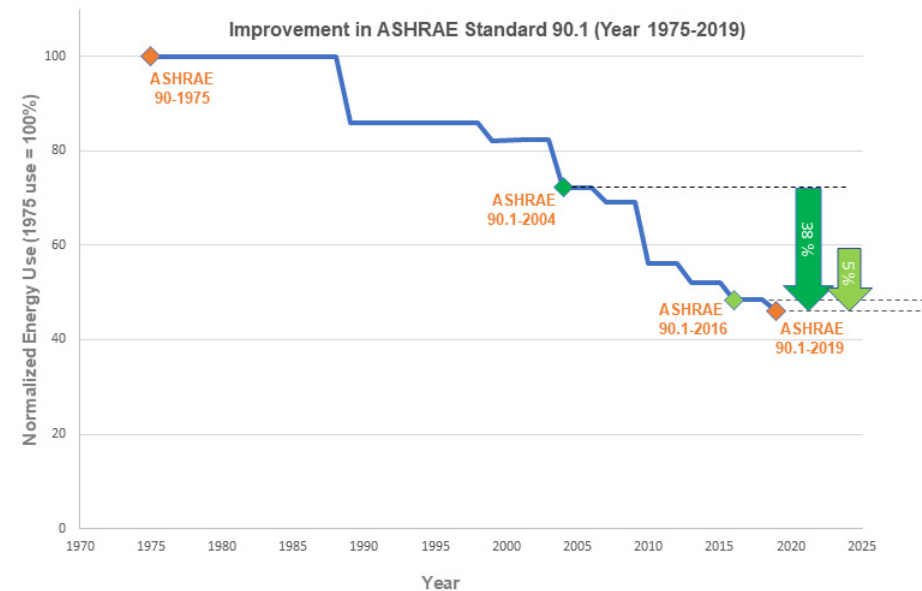
Purchase a copy of Standard 90.1, and the accompanying User's Manual, to better understand the requirements as they apply to specific systems, climates, buildings and design applications.

2019 Changes

Eighty-eight addenda were incorporated in the 2019 version of 90.1. These updates affect commissioning, building envelope, lighting and mechanical. Of those, 29 had energy savings which could be captured in the over 600 energy models created by the U.S. Department of Energy to determine energy saving impacts. Those whose savings weren't captured typically involve equipment not included in the energy models, or that are part of the optional compliance paths.

Figure 1 shows the normalized energy use from the first 1975 version through 90.1-2019. This is the energy consumed by the entire building, including equipment not regulated by 90.1. According to results of the 2019 model assessment, the 29 addenda save 38 percent energy over the 2004 version, or a weighted average of 5.0 percent as compared to the 2016 version. Before we review the HVAC related changes, let's review the non-mechanical changes first.

Figure 1. 90.1 energy use



Source: Pacific Northwest National Laboratory

New commissioning requirements.

Section 4.2.5, “Verification, Testing, and Commissioning,” was greatly expanded and requirements were outlined for commissioning in accordance with ANSI/ASHRAE/IES Standard 202 Commissioning Process for Buildings and Systems. A new Informative Appendix H provides additional information and guidance.

Building envelope. Requirements for Solar heat gain criteria and U-factor are upgraded across all climate zones. U-factors are lowered (more stringent) for most regions, and especially for assemblies using metal frames. They are now classified by type instead of materials. There are also new exceptions related to air curtains which also affect mechanical requirements.

Lighting. Lighting power allowances for the Space-by-Space Method and the Building Area Method are modified to reflect the outcomes of the fully reconstructed Standard 90.1 lighting model, which includes many updates and improvements. The model is more representative of real-world conditions with the inclusion of updated Illuminating Energy Society (IES) recommendations, room cavity ratios, additional surface reflectance categories, light loss factors, and a 100 percent LED technology baseline with updated efficacy values

Mechanical. Noteworthy mechanical changes are listed below. The 90.1-2019 section numbers and the corresponding 90.1-2016 addendum letters (e.g. cm, ce) are also shown for reference with those that contributed to energy savings shown in **bold red**.

- Clarified Humidification and Dehumidification control requirements (6.4.3.6, ae)
- Revised VAV Minimum Airflow Settings to align with Standard 62.1-2019 (**6.5.2.1, au and cm**)
- Revised Fan Motor Selection requirements, including exempting “Motors equipped with electronic speed control devices to vary the fan airflow as a function of load” (6.5.3.1.2, ce)

- Changed Fan Efficiency requirements to now use fan energy index (FEI) per AMCA 208 instead of the fan efficiency grade (FEG) used previously (**6.5.3.1.3, ao**)
- Changed exemptions for Supply Air Temperature Reset requirements in climate zones 0A, 1A, 2A and 3A (6.5.3.5, ap)
- New Occupied Standby Controls set requirements for controlling a zone to zero airflow when permitted by ASHRAE 62.1 (**6.5.3.8, g**)
- Revised Energy Recovery Ventilation requirements for non-transient dwelling units (**6.5.6.1, dn**)
- New Heat Recovery requirements for acute inpatient hospitals (**6.5.6.3, v**)
- New exemptions and trade-offs for renewable energy (6.5, 11.4.3, App G, by and s)
- Revised requirements for Data Centers in that IT loads greater than 10kW must now follow ASHRAE Standard 90.4 (6.6.1, bv)
- New Pump Efficiency requirements (**10.8.6-4, an**)
- Updated minimum equipment efficiency tables:

Unitary Air Conditioners and Heat Pumps (**6.8.1-1, bl and 6.8.1-2, bm**), Packaged Terminal Air Conditioners and Heat Pumps (**6.8.1-4, bn**) and Warm-Air Furnaces (**6.8.1-5, bo**) to align with DOE requirements taking affect 1/1/2023 including:

- Updated Boilers (**6.8.1.6, bp**), Heat Rejection Equipment including dry coolers and evaporative condensers (**6.8.1-7, bq**) along with Commercial Refrigerators, Freezers and Refrigeration (**6.8.1-11, br**).
- A new table was also added for Heat Pump and Heat Recovery Chiller packages (**6.8.1-16, bd**).

ASHRAE 90.1-2019 section updates

Airside Considerations.

Humidification and dehumidification controls. Section 6.4.3.6 is intended to limit the energy used to humidify or dehumidify a building. The language in this section was revised to clarify past confusion:

- The use of electricity, or fossil fuel, is permitted for the purpose of humidification, but cannot be used to raise the indoor humidity level to any higher than 30 percent relative humidity (RH) in the warmest zone served by the system (Figure 2).
- The use of “mechanical cooling” is permitted for the purpose of dehumidification, but cannot be used to lower the indoor humidity level to any lower than 55°F dew point—which enables the use of sensible-cooling equipment like chilled beams, radiant panels, and sensible-cooling terminal units—or lower than 60 percent RH in the coldest zone (Figure 2).

This section also clarifies that a lower humidity level is permitted if it results from operating mechanical cooling for temperature control. For example, a VAV system that is designed to supply air at 48°F dry bulb for temperature control may result in a space dew point below 55°F; and this is permitted.

- If a zone is served by a system with both humidification and dehumidification capabilities, the controls must prevent simultaneous operation of humidification and dehumidification equipment.

Systems serving zones where specific humidity levels are required by accreditation standards (such as museums and hospitals) are exempt from these limits, as long as the controls maintain a deadband of at least 10 percent RH between the humidification and dehumidification setpoints.

In addition, the standard also exempts any system serving zones in which applicable codes or accreditation standards requires humidity levels to be tightly controlled (within ± 5 percent RH).

VAV minimum airflow settings. The 2019 version of ASHRAE Standard 62.1 introduces a new “Simplified Procedure” for determining system ventilation efficiency (E_v) in a multiple-zone recirculating system, similar to a VAV system. In order to use this new procedure, the minimum primary airflow setpoint for each zone must be no lower than 1.5 times the design zone outdoor airflow (V_{OZ}).

To align with Standard 62.1, Section 6.5.2.1 in Standard 90.1 has also been revised. This section prevents reheating air that has been previously cooled, unless the zone controls first reduce airflow to the prescribed minimum thresholds. Previously, Exception 2 required airflow be reduced to 20 percent of the zone’s design supply airflow (see ~~strike-through~~ text below). This is now updated to require airflow be reduced to the minimum primary airflow rate required by the Simplified Procedure in Standard 62.1 (see underlined text below)—which, as explained previously, is 1.5 times the design zone outdoor airflow.

6.5.2.1 Zone Controls.

Zone thermostatic control shall prevent reheating ...

Exceptions to 6.5.2.1:

2. Zones with DDC that comply with all of the following:

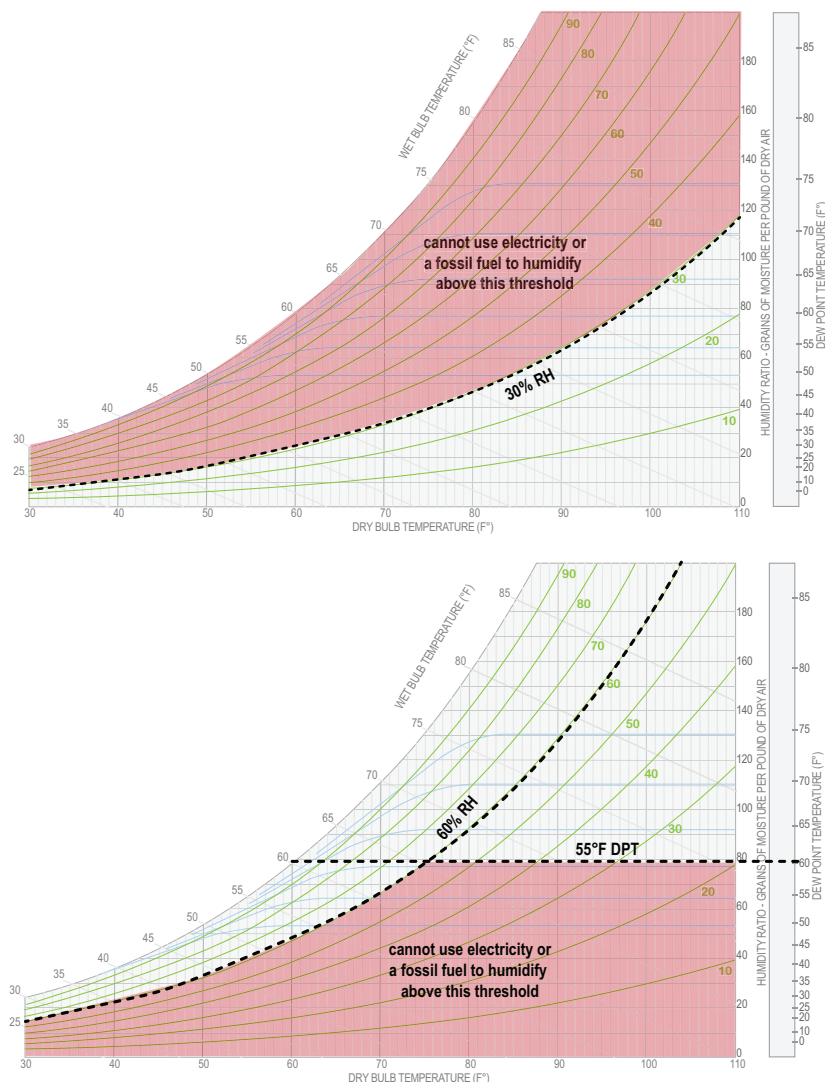
(a) The airflow rate in dead band between heating and cooling does not exceed the larger of the following:

~~(1) 20 percent of the zone design peak supply airflow~~

(1) The minimum primary airflow rate required to meet the Simplified Procedure ventilation requirements of ASHRAE Standard 62.1 for the zone...

The new Simplified Procedure in Standard 62.1 makes it easier to calculate the design intake flow rate for

Figure 2. Limits on humidification and dehumidification



a multiple-zone VAV system, and this change to Standard 90.1 makes it easier for the VAV box controls to be set up to comply with both standards.

See page 5 of ADM-APN075-EN for more on this topic.

Fan motor selection. Section 6.5.3.1.2 includes requirements related to the selection of fan motors. This section is revised to accommodate new motor and drive technologies, while also simplifying motor selection criteria:

- For a fan less than 6 bhp, the fan motor must be no larger than the first available size with a nameplate rating greater than 1.5 times the bhp. For example, if the design brake horsepower of a fan is 4.4 bhp, the selected motor must be the next available size that has a nameplate rating greater than 6.6 (1.5×4.4 bhp).

- For a fan 6 bhp and larger, the fan motor must be no larger than the first available size with a nameplate rating greater than 1.3 times the bhp.
- Fans with a motor nameplate less than 1 hp, or a nameplate electrical input power less than 0.89 kW, are exempt from these limits.

A major change to this section is that “motors equipped with electronic speed control devices to vary the fan airflow as a function of load” are also exempt. Therefore, a fan that is equipped with a variable-speed drive, or a motorized impeller (a direct-drive fan that incorporates an electronically commutated motor, or ECM), are no longer subject to these fan motor size limitations. However, it is still important to ensure that the fan and motor combination is capable of turning down as required by the application.

In the foreword to addendum CE, the Standard 90.1 committee explained that “alternating-current (AC) induction motors operated with variable-frequency drives maintain high efficiency at part load; and permanent magnet fan motors maintain even higher efficiency,” therefore, “the restriction of [fan motor] selections provides no benefit.”

Fan Efficiency. In section 6.5.3.1.3 fan efficiency requirements are now based on the fan energy index (FEI) per AMCA 208 instead of fan efficiency grade (FEG). In general, FEI ensures a good fan or fan array selection, whereas FEG simply required a good fan at peak efficiency.

As defined by the standard, FEI is “a ratio of the electrical input power of a reference fan to the electrical input power of the actual fan for which the FEI is calculated, both calculated at the same duty point. FEI can be calculated for each point on a fan curve.” From this it follows that fans with higher FEI values will consume less power for a given airflow and pressure than fans with lower FEI values.

90.1 requires each fan and fan array to have an FEI of 1.00 or higher and VAV systems are required to have an FEI of 0.95 or higher. Certain small fans and ceiling fans are exempt. Embedded

fans that are part of the equipment listed under Section 6.4.1.1 (such as packaged rooftops, condensing units, water-source heat pumps, air-cooled chillers, PTAC’s, furnaces, cooling towers, and VRF systems) or included in equipment bearing a third-party-certified seal for air performance (such as cataloged air handlers, blower coils, fan-coils, and unit ventilators) are also exempt. Products that are still subject to the FEI requirements include custom air handlers for example. Figure 3 demonstrates the broader operating ranges associated with higher FEI fans.

The reference and actual fan electrical input power are wire-to-air metrics and include efficiency losses from the impeller, the motor, the motor drive (i.e. V-belt for fixed speed fans) and the motor controller for fans with speed control.

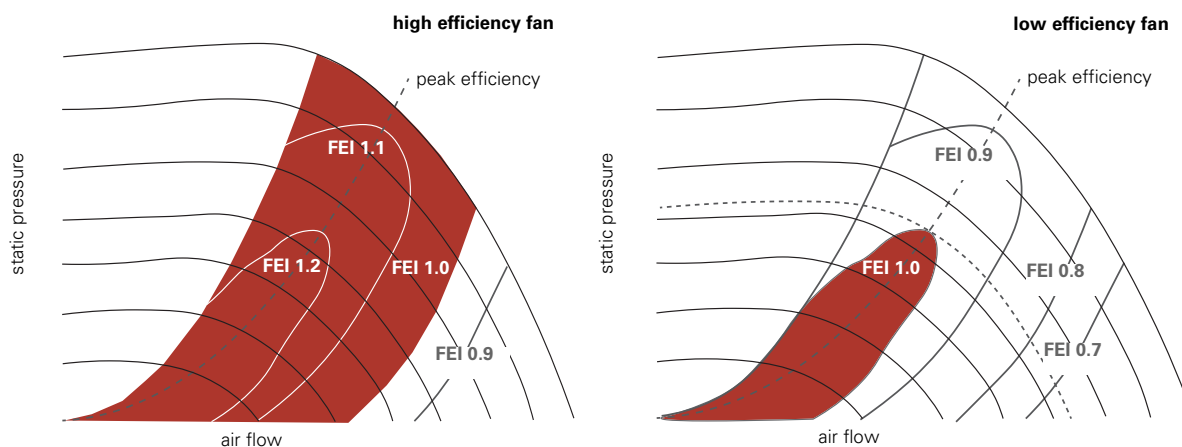
Supply-air temperature (SAT) reset control. Section 6.5.3.5 requires that multiple-zone systems (such as VAV systems) be equipped with controls to automatically reset the SAT setpoint in response to either building loads or the outdoor air temperature.

In previous versions of the standard, buildings in climate zones 0A, 1A, 2A, and 3A were exempt from this requirement; the 2019 version narrowed the exceptions as follows:

- In climate zone 0A, 1A, or 3A, only systems with a design outdoor airflow < 3000 cfm are exempt.
- In climate zone 2A, only systems with a design outdoor airflow < 10,000 cfm are exempt.
- In climate zone 0A, 1A, 2A, or 3A, systems with ≥ 80% outdoor air that are equipped with an exhaust-air energy recovery device complying with Section 6.5.6.1 (Exhaust Air Energy Recovery are exempt)

For systems that require additional dehumidification while resetting the SAT setpoint, an informative note added to the standard suggests using a dual-path configuration, as shown in Figure 4, with a separate cooling coil in the outdoor-air path (refer to SYS-APM008*-EN for more information), a dedicated outdoor-air system, a return-air bypass configuration, or an energy-recovery device in series with the cooling coil.

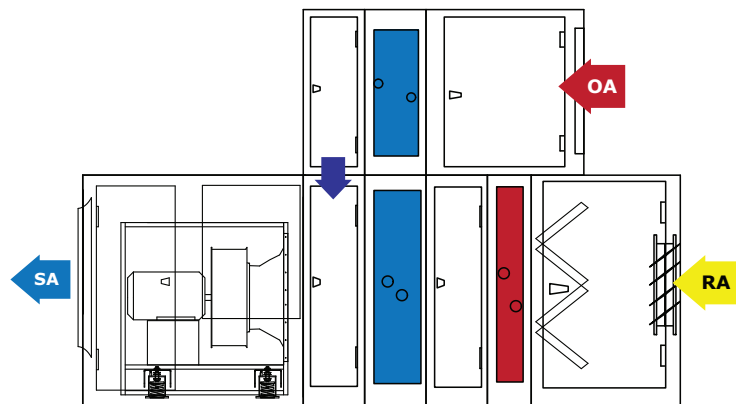
Figure 3. Operating ranges for high and low FEI fans



Note: dotted curve above represents the maximum speed in which FEI ≥ 1.0 at best efficiency point

Source: Air Movement and Control Association International, Inc. (<https://www.amca.org/advocate/energy-efficiency/about-fan-energy-index/>)

Figure 4. Dual-path VAV air-handling unit



NEW Occupied-Standby Controls.

Section 6.5.3.8 sets new requirements for when a zone is in “occupied-standby” mode. Occupied-standby mode means that the zone is scheduled to be occupied, but an occupancy sensor indicates that no occupants are currently present.

This new requirement applies only to zones serving rooms that are all required to have automatic partial or full OFF lighting controls, per Section 9.4.1.1, and where ASHRAE Standard 62.1 permits ventilation air to be reduced to zero (indicated by the label “OS” in Table 6-1 of standard 62.1).

The zone shall meet the following within five minutes of all rooms in that zone entering occupied-standby mode:

- Active heating set point must be lowered by at least 1°F.
- Active cooling set point must be raised by at least 1°F.
- All airflow supplied to the zone must be shut off whenever the space temperature is in the deadband between the active heating and cooling set points. This allows outdoor airflow to be reduced to zero.

The only exception to occupied-standby controls is a multiple-zone system without automatic zone flow control dampers.

This control strategy does not replace demand-controlled ventilation, and both control strategies may be applied to a zone when appropriate.

Exhaust Air Energy Recovery.

Section 6.5.6.1 sets new requirements for outdoor air energy recovery ventilation (ERV) systems in non-transient dwelling units.

Non-transient dwelling units have occupancy for more than 30 days and include buildings such as apartments and condominiums. Previously ERV threshold air-flow requirements excluded these buildings.

Enthalpy recovery ratio must be at least 50% at cooling design condition and at least 60% at heating design condition.

Exemptions include:

- Non-transient dwelling units that are in Climate Zone 3C
- Non-transient dwelling units that have less than 500 ft² in Climate zone 0, 1, 2, 4C or 5C
- Enthalpy recovery ratio requirements at heating design conditions in warmer climate zones 0, 1 and 2
- Enthalpy recovery ratio requirements at cooling design conditions in cooler climate zones 4, 5, 6, 7 and 8.

Waterside Considerations.

Heat Recovery for Space Conditioning.

In section 6.5.6.3, in addition to Service Water Heating, heat recovery requirements were added to certain hospital facilities. Acute inpatient hospitals are required to have a condenser heat recovery system if they:

- use hot water heating
- have chilled-water capacity exceeding 3,600,000 Btu/h
- have simultaneous heating and cooling above 60°F outdoor air temperature.

The heat recovery system must have a cooling capacity at least 7 percent of total design chilled-water capacity of the acute inpatient hospital at peak design conditions.

Buildings with 60 percent or more on-site renewable energy or site-recovered energy are exempted from this requirement. Buildings in climate zones 5C, 6B, 7 and 8 are also exempt.

New minimum efficiency requirements for Heat-Pump and Heat Recovery Chiller Package.

An example of ASHRAE Table 6.8.1-16, shown in Figure 5, includes efficiency requirements for both air-cooled and water-cooled chillers. To use the table simply find the equipment type and size in the first two columns and then find the cooling and heating efficiency requirements in the remaining columns for the appropriate application and design conditions. The heat recovery chiller COP in columns 10 to 13 use combined cooling and heating capacity divided by the power to calculate the required COP.

To date, four official interpretations have been issued relative to this table. Official interpretations become part of the standard’s requirements. The interpretations define which columns are applicable to different types of applications.

- Chillers that are dedicated to heating applications, such as boiler replacement, must only comply with the heating requirements.

[illegible]

- Chillers that will serve both cooling and heating requirements must comply with both heating and cooling requirements in the table.
- Water cooled chillers need only comply with one of the heating conditions (leaving water temperature: 105°F, 120°F, 140°F, or 140°F).
- Air cooled chillers must comply with both heating requirements (entering air temperature: 47°F and 17°F).

Minimum equipment efficiency tables. Several efficiency tables were updated and some were reordered. The following list summarizes the equipment tables with the most impact on the 90.1 progress indicator.

Updated part load efficiencies on air-cooled unitary equipment to comply with new DOE requirement taking affect 1/1/2023. Increases are on the order of fifteen percent and include new metrics called SEER2, EER2, and HSPF2. With the new metrics come new test procedures that must be followed. DOE has defined these in 10 CFR 430 Appendix M1 and AHRI also published AHRI 210/240-2023 covering the changes. The referenced test procedures clarify what standard should be used for each equipment type.

Updated several small packaged unit efficiencies to align with DOE requirements taking affect from 2014 - 2023.

Updated efficiencies on furnaces to comply with new DOE requirement taking affect 1/1/2023 and added requirements for stand-by power consumption. Efficiency increases are about one percent.

Added dry cooler minimum efficiency referencing CTI ATC-105 as the test standard. Also increased axial fan minimum efficiency for closed circuit cooling towers by about 16%. In addition, reduced efficiency requirements by 1.9% for both axial and centrifugal fan evaporative condensers to reflect the performance difference between refrigerant R507A which is being phased out and R448A which is being phased in due to its substantially lower GWP

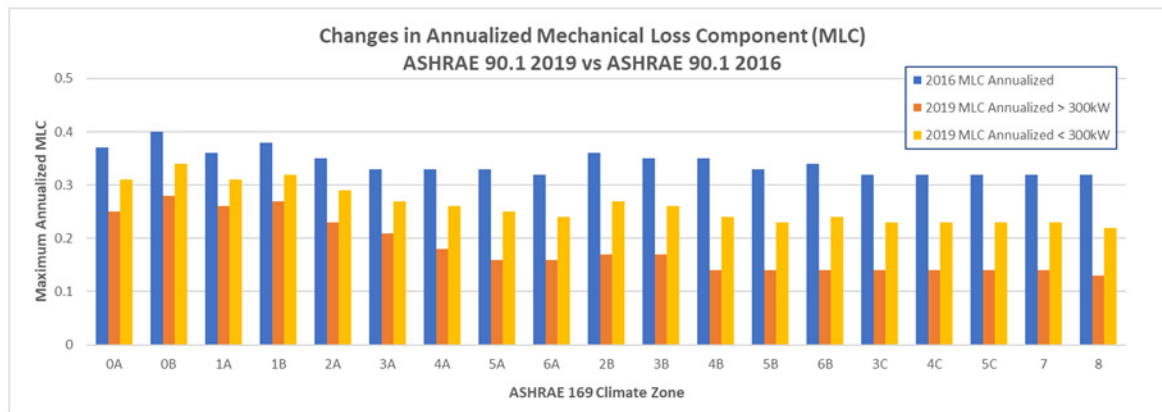
Combined tables for Commercial Refrigeration and Commercial Refrigerator and Freezers, updated to DOE 2017 minimum efficiencies and renumbered.

New heating efficiency requirements for air-cooled and water-cooled machines used for space heating and aligned with AHRI 550/590 rating conditions. Refer to “New minimum efficiency requirements for Heat-Pump and Heat Recovery Chiller Package.” in this newsletter.

Requirements for computer rooms with IT electrical loads 10kW or smaller are still covered by 90.1 but now within the body of sections 6.4 and 6.5 that is, the PUE alternative compliance path was removed. Table 6.8.1-10 was added specifying minimum Net Sensible COP for Floor-Mounted Air Conditioners and Condensing Units Serving Computer Rooms.

Recognizing data center energy consumption is more than HVAC and IT loads, 90.4 has annualized requirements for both mechanical and electrical system losses.

Figure 6. Mechanical loss component 90.1-2016 versus -2019



Source: ASHRAE 90.4-2016 and ASHRAE 90.4-2019

The Mechanical Loss Component (MLC) includes cooling energy, pump energy and fan energy from both air-handlers and heat rejection equipment divided by electrical energy load of the information technology equipment (ITE). Values from the 2016 and 2019 version are shown in Figure 4. Clearly, the requirements vary by climate zone and 2019 requirements are considerably more stringent. For ITE design power greater than 300kW maximum annualized MLC ranges from 0.13 in zone 8 to 0.25 in zone 0A. Data centers with 300kW or lower the maximum annualized MLCs range from 0.22 in colder zones such as zone 8, to 0.31 in warmer zones such as zone 0A.

Similarly, the Electrical Loss Component (ELC) includes annualized electrical losses from the incoming electrical service, uninterrupted power supply and ITE distribution divided by the ITE electrical energy load. Values for ELC range from 0.189 – 0.265 depending on load point and IT design load. Although not relevant to HVAC, it is interesting to note that the incoming electrical service segment represents more than half of the ELC.

Air-cooled chilled water plants are typically used for large data centers and rooftop units and split systems are typically used for small data centers.

Pump Energy. As of January 2020 pumps must comply with DOE rules governing pump energy. The DOE rule 10 CFR 429 & 43, and subsequently ASHRAE 90.1-2019 require that the Pump Energy Index (PEI) not exceed 1.0.

PEI is ratio of the pump energy rating (PER) divided by the PER for a minimally compliant standard pump in the same class at standard conditions.

PEI_{CL} is for constant load pumping applications and PEI_{VL} is for variable load pumping applications and each are weighted values reflecting their respective load curves and flow modulation about the Best Efficiency Point. Make sure your pump specifications include these requirements.

Renewable Energy. Renewable energy definitions and requirements were added to the standard within prescriptive requirements in section 6.5 and trade offs in appendix G and section 11. Per 90.1 on-site renewable energy is defined as:

“energy generated from renewable sources produced at the building site.”

In section 6.5, the use of on-site renewable energy allows for exceptions to certain prescriptive requirements for boiler efficiency, heat recovery for space conditioning and indoor pool dehumidifier energy recovery.

Renewable energy trade offs have been included that allow credit for renewable energy generated on site even if the building owner does not own the system provided that:

- The owner has signed a lease agreement for a minimum of 15 years
- The owner has signed an agreement to purchase the renewable energy for a minimum of 15 years

Summary

ANSI/ASHRAE/IES 90.1-2019 saves 5 percent of energy cost as compared to 90.1-2016 and 54 percent compared to the original ASHRAE 90-1975. These significant savings were developed using a rigorous and open process that includes multiple public reviews and whose goal is to reach consensus with directly and materially affected parties.

Given the savings and consensus, this standard will become the basis for building codes in North America as well as other parts of the world.

The information in this newsletter allows you to guide project teams in application of the standard either to meet new codes or to simply reduce the energy intensity of the world.

By Rick Heiden, Trane. To subscribe or view previous issues of the Engineers Newsletter visit trane.com and select the Training & Support from the drop down menu. Send comments to ENL@trane.com.

Resources

- [1] ANSI/ASHRAE/IESNA Standard 90.1-2019, *Energy Standard for Buildings Except Low-Rise Residential Buildings*. Atlanta, GA: ASHRAE. 2019
- [2] Pacific Northwest National Laboratory (2020). "Energy Savings Analysis of ANSI/ASHRAE/IES Standard 90.1-2019 Final Progress Indicator". PNNL-SA-150731. ASHRAE SSPC 90.1 Winter meeting, Orlando, FL, February 2, 2020
- [3] ANSI/ASHRAE/IES, Standard 202-2018, *Commissioning Process for Buildings and Systems*. Atlanta, GA: ASHRAE. 2018.
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- [6] ANSI/AMCA, Standard 208-18, *Calculation of the Fan Energy Index*. Arlington Heights, IL: AMCA. 2018.
- [7] ANSI/ASHRAE/IESNA, Standard 90.4-2019, *Energy Standard for Data Centers*. Atlanta, GA: ASHRAE. 2019.
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- [11] Code of Federal Regulations. 10 C.F.R. 430 Appendix M — *Uniform Test Method for Measuring the Energy Consumption of Refrigerators, Refrigerator-Freezers, and Miscellaneous Refrigeration Product*. DOE. 2020.
- [12] Cooling Tower International. CTI ATC 105: *Acceptance Test Code for Closed Circuit Cooling Towers*. Houston, TX: CTI. 2011.
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Coming Soon...

VRF Engineers Newsletter LIVE program!

Applying VRF for a Complete Building Solution (December) This ENL builds upon the 2014 VRF program "Applying Variable Refrigerant Flow" with detailed discussions on several considerations. Topics will include: when to use heat recovery instead of heat pump configurations, how to scale VRF systems to include other building systems, ventilation delivery, humidity management and more.

Contact your local Trane office for dates and details.



For additional information on **Variable Refrigerant Flow (VRF)** technology, visit Trane.com/VRF to view and download the latest VRF System Catalog.

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