providing insights for today's hvac system designer

Engineers Newsletter

volume 46–1

ASHRAE Standard 189.1-2014

Since its inaugural publication in 2009, ANSI/ASHRAE/USGBC/IES Standard 189.1, "Standard for the Design of High-Performance Green Buildings," has provided guidance for designing, building, and operating high-performance green buildings. By reference, the standard integrates other ASHRAE code-intended standards, which often focus on just one aspect of the building.

This *Engineers Newsletter* (EN) provides an overview of the 2014 updates to the standard, focusing on the HVAC-related requirements such as the energy efficiency, indoor environmental quality, and atmosphere, materials and resources categories. For jurisdictions referring to the 2011 version of the standard, a previous EN "ASHRAE Standard 189.1-2011," can be a helpful resource.[1]

Purpose and Scope

The purpose and scope of ASHRAE Standard 189.1-2014 match those of the 2011 version. A direct quote from ASHRAE Standard 189.1 explains its purpose.[2]

"The purpose of this standard is to provide minimum requirements for the siting, design and construction, and plan for operation of high-performance green buildings to

(a) balance environmental responsibility, resource efficiency, occupant comfort and well-being, and community sensitivity; and

(b) support the goal of development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

The standard presents provisions in six major categories:

- Site sustainability
- Water use efficiency
- Energy efficiency
- Indoor environmental quality
- Impact on the atmosphere, materials, and resources
- Construction and plans for operation

Similar to Standard 90.1, most sections include mandatory provisions, prescriptive, and performance-based options (Table 1). The mandatory provisions must be met in all cases along with either the prescriptive options or corresponding performance options.

The scope of the standard includes: new buildings and their systems, new portions of buildings and their systems, and new systems and equipment in existing buildings.

Table 1. Compliance options for each section of ASHRAE Standard 189.1-2014

Categories	Mandatory provisions	Prescriptive or performance options
Site sustainability	comply with all	none
Water use efficiency	comply with all	comply with the prescriptive option, or one of the performance options
Energy efficiency	comply with all	comply with the prescriptive option, or one of the performance options
Indoor environmental quality	comply with all	each subsection can choose to comply with either the prescriptive option, or the performance option
Impact on atmosphere, materials and resources	comply with all	comply with the prescriptive option, or one of the performance options
Construction and plans for operation	comply with all	none

Site Sustainability

Section 5 of the standard addresses site selection, site assessment, invasive plants, stormwater management, heat island effect, light pollution, and transportation impacts. The selection and planning of a project site has a long term impact on the local environment. Few if any of the provisions in this section involve HVAC systems.

All of the site sustainability provisions are now mandatory. According to the United States' Environmental Protection Agency (EPA), heat island effect can increase cooling energy use, greenhouse gas emissions, and air pollution, and negatively impact human health and water quality. Site shading, landscaped surfaces, and high solar reflectance index (SRI) for paving, walls, and roofs can help alleviate heat island effect. Higher SRI values mean more sunlight and heat are reflected, which in turn lowers the building cooling load.

Water Use Efficiency

Extreme weather patterns change the availability of water necessary to replenish aquifers. Human activity can also negatively affect the available quantity and quality of potable water. Section 6 of the standard focuses on reducing and monitoring water usage and increasing water reuse for both the site (exterior) and the building (interior).

Mandatory provisions. For HVAC systems, once-through cooling with potable water is prohibited.

Large cooling towers and evaporative coolers must include submetering to track and control water usage and alarm capability to notify the operator of excess water usage. Cooling towers must be designed to limit drift to a maximum percentage of the recirculated water volume.

For air-conditioning units with a capacity greater than 5.4 tons (19 kW) and located in climates where the mean coincident wet-bulb temperature at ASHRAE 1% design cooling conditions equals or exceeds 72°F (22°C), a condensate collection system must be included. Generally, in the moist climate zones, this is 5A and warmer. In the dry climate zones, this is 2B and warmer. A handful of marine locations may also require condensate collection.

Other requirements. In addition to the mandatory provisions, HVAC systems must be designed to reduce water use by meeting the provisions of either the prescriptive-option or performance-option design path.

For example, cooling towers must limit the water discharge rate. The cycle of concentration represents the accumulation of dissolved minerals in the recirculating cooling tower water. Replacing water at a slower pace and keeping the water in the tower longer reduces water use, but increases the concentration of dissolved minerals. The standard specifies a minimum cycle of concentration based on water hardness to reduce water use.

Performance-based requirements, on the other hand, limit annual building water use to no more than the water use that would have been achieved by meeting all mandatory and prescriptive requirements. This approach requires the calculation and demonstration of reduced building water use.

Energy Efficiency

As a minimum, Standard 189.1-2014 requires compliance with nearly all Standard 90.1-2013 requirements by reference, then increases stringency in some cases and adds new requirements as well.

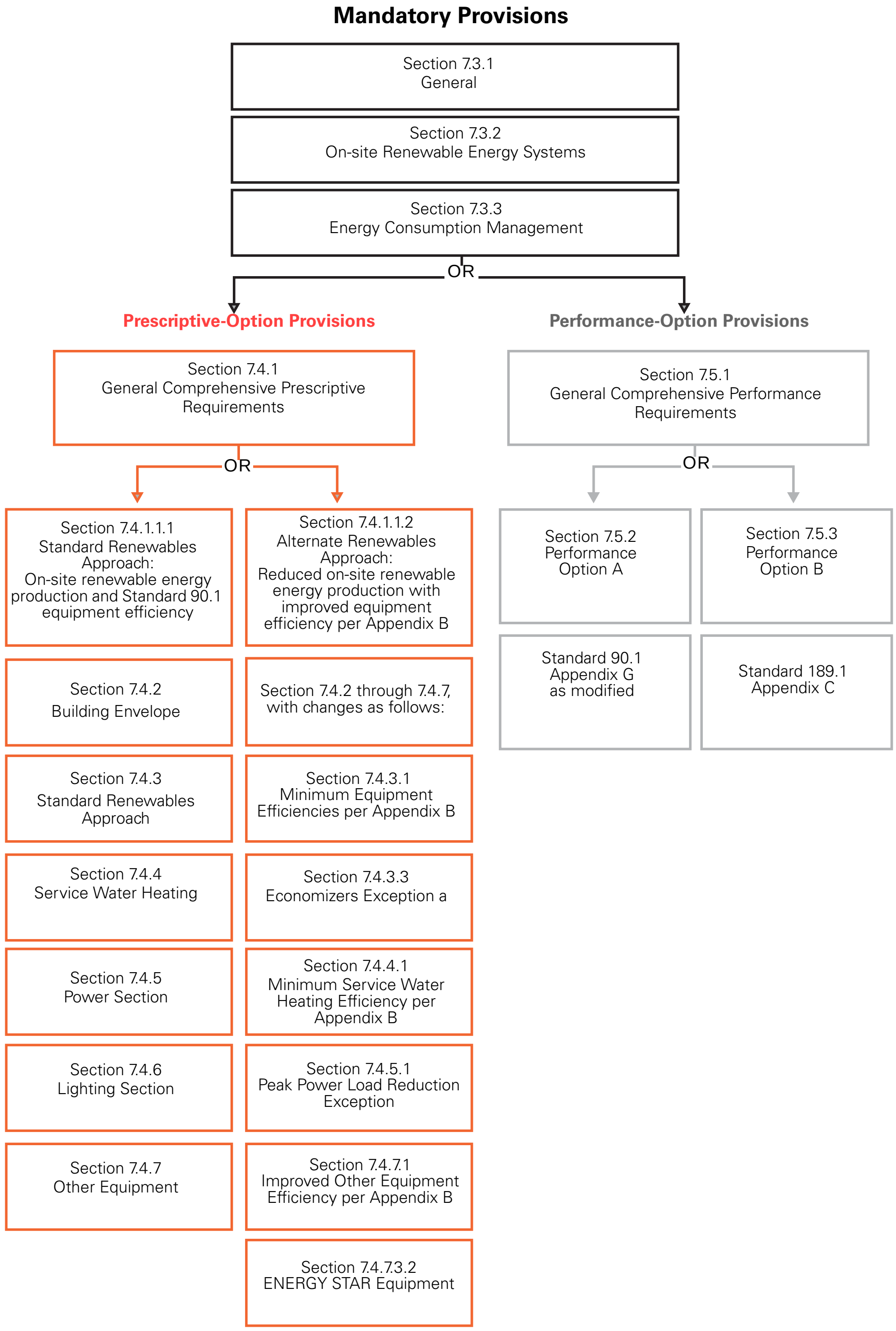
Mandatory provisions. To comply with Section 7, the energy efficiency section of Standard 189.1, building projects must meet all of the mandatory provisions found in Section 7.3, including all provisions in Standard 90.1, Sections 5.4, 6.4, 7.4, 8.4, 9.4, and 10.4.

Notable mandatory requirements are allocating space and pathways for the future installation of renewable-energy systems, such as photovoltaic (PV) systems, and monitoring energy use for specific energy sources.

Other requirements. In addition to the mandatory provisions, either the prescriptive-option provisions in Section 7.4 or the performance-option provisions in Section 7.5 must be met (see Figure 1).

Prescriptive option. Designers may choose to comply with the standard by meeting all mandatory requirements *and* all prescriptive-option design requirements, which cover building envelope, lighting power, HVAC systems, service water heating, and other equipment.

Figure 1. Compliance paths for Energy Efficiency section (modified from Standard 189.1-2014 *Users Manual*[3])



The prescriptive option itself includes two alternative compliance paths—Standard Renewables Approach and Alternate Renewables Approach. Many prescriptive option requirements are common for both approaches.

The main difference is that the Standard Renewables Approach uses standard equipment efficiencies from Table 6.8.1 of Standard 90.1 and more renewable energy, while the Alternate Renewables Approach uses higher equipment efficiencies from Appendix B of Standard 189.1 and less renewable energy. The greater investment in higher efficiency equipment is justified by a lesser investment in the renewable systems. Standard 189.1 does not dictate where the initial investment should be made—the project team needs to make that determination.

To demonstrate the required equipment energy efficiency improvement for the Alternate Renewables Approach, excerpts covering air-cooled air conditioners and water-cooled air conditioners are shown as examples in Tables 2 and 3. Table 4 (p. 5) lists both mandatory and prescriptive-option provisions for HVAC systems.

Performance option. As an alternative, designers may choose to comply with the standard by meeting all mandatory requirements *and* simulating building performance (performance-option requirements). Standard 90.1 Appendix G Performance Rating Method (PRM) provides the simulation basis to compare the proposed building performance to the baseline building performance. Standard 189.1 simulation provisions exceed the Standard 90.1 Appendix G baseline. Unlike the 2011 version, the 2014 version has been expanded to two options: Option A and Option B. Designers may choose to simulate building energy performance using either Standard 90.1 Appendix G alone (Option A) or using a version of Appendix G, modified by Standard 189.1 Appendix C (Option B). Both Option A and B use two performance measures - annual energy cost and annual carbon dioxide equivalent (CO2e) - to demonstrate compliance. CO2e emission factors are listed in Table 7.5.2B.

Performance Option A uses the PRM of Standard 90.1 Appendix G to calculate a baseline building performance. Based on building type, a percentage reduction is then applied using Table 7.5.2A to obtain the Standard 189.1 baseline building performance. The energy performance of the simulated proposed building must be equal to or less than baseline building performance.

Performance Option B is based on Standard 189.1 Appendix C which modifies Standard 90.1 Appendix G. Since Option A does not include simulation for renewables (at all), Appendix C explains how the renewables must be calculated to obtain Standard 189.1 baseline building performance.

Excerpts from Table C1.1 of Standard 189.1 Appendix C are shown in Table 5.

Table 2. Air-cooled air conditioners

class	size	heating type	sub-category	mandatory & standard renewables (90.1-2013)[a]	alternate renewables[b]
Air conditioners, air-cooled	< 65,000 Btu/h	all	split system	13.0 SEER	14.0 SEER 12.0 EER
		all	single package	14.0 SEER	14.0 SEER 11.6 EER
	≥ 65,000 and < 135,000 Btu/h	none/electric	split and single package	11.2 EER 12.9 IEER (1/1/2016)	11.7 EER 13.0 IEER)
		other	split and single package	11.0 EER 12.7 IEER (1/1/2016)	11.5 EER 12.8 IEER
	≥ 135,000 and < 240,000 Btu/h	none/electric	split and single package	11.0 EER 12.4 IEER (1/1/2016)	11.7 EER 12.5 IEER
		other	split and single package	10.8 EER 12.2 IEER (1/1/2016)	11.5 EER 12.3 IEER
	≥ 240,000 and < 760,000 Btu/h	none/electric	split and single package	10.0 EER 11.6 IEER (1/1/2016)	10.5 EER 11.3 IEER
		other	split and single package	9.8 EER 11.4 IEER (1/1/2016)	10.3 EER 11.1 IEER
	≥ 760,000 Btu/h	none/electric	split and single package	9.7 EER 11.2 IEER (1/1/2016)	9.9 EER 11.1 IEER
		other	split and single package	9.5 EER 11.0 IEER (1/1/2016)	9.7 EER 10.9 IEER

a. Column "mandatory & standard renewables" uses the Standard 90.1 equipment efficiency levels.
b. Column "alternate renewables" uses the Standard 189.1, Appendix B equipment efficiency levels.

Table 3. Water-cooled air conditioners

class	size	heating type	sub-category	mandatory & standard renewables (90.1-2013)[a]	alternate renewables[b]
Air conditioners, water cooled	< 65,000 Btu/h	all	split and single package	12.1 EER 12.3 IEER	14.0 EER 14.3 IEER
	≥ 65,000 and < 135,000 Btu/h	none/electric	split and single package	12.1 EER 13.9 IEER (1/1/16)	14.0 EER 15.3 IEER
		other	split and single package	11.9 EER 13.7 IEER (1/1/16)	13.8 EER 15.1 IEER
	≥ 135,000 and < 240,000 Btu/h	none/electric	split and single package	12.5 EER 13.9 IEER (1/1/16)	14.0 EER 14.8 IEER
		other	split and single package	12.3 EER 13.7 IEER (1/1/16)	13.8 EER 14.6 IEER
	≥ 240,000 and < 760,000 Btu/h	none/electric	split and single package	12.4 EER 13.6 IEER (1/1/16)	14.0 EER 14.8 IEER
		other	split and single package	12.2 EER 13.4 IEER (1/1/16)	13.8 EER 14.6 IEER
	≥ 760,000	none/electric	split and single package	12.2 EER 13.5 IEER (1/1/16)	14.0 EER 14.8 IEER
		other	split and single package	12.0 EER 13.3 IEER (1/1/16)	13.8 EER 14.6 IEER

a. Column "mandatory & standard renewables" uses the Standard 90.1 equipment efficiency levels.
b. Column "alternate renewables" uses the Standard 189.1, Appendix B equipment efficiency levels.

Table 4. Summary of HVAC-Related Mandatory and Prescriptive-Option Provisions of Standard 189.1, Section 7

Standard 189.1 Section		Summary of Provisions
Mandatory Provisions		
7.3.1	General	For HVAC systems, designers must comply with the mandatory requirements of Standard 90.1, section 6.4.
7.3.2	On-site Renewable Energy Systems	Allocate space for on-site renewables: ≥6 kBtu/ft^2 (≥20 kWh/m^2) of gross roof area for single-story buildings or ≥10 kBtu/ft^2 (≥32 kWh/m^2) of gross roof area for taller buildings.
7.3.3	Energy Consumption Management	Provide measurement devices with remote communication capability to collect energy consumption data for each energy supply source. The Building Automation Systems coordinating HVAC operation can be used to collect and report this energy consumption data. Minimum data storage of 36 months is needed.
Prescriptive Option		
7.4.1	General	Comply with Standard 90.1, except where the requirements listed in section 7.4 of Standard 189.1 supersede the requirements in Standard 90.1.
7.4.1.1.1	**Standard Renewables Approach:** baseline on-site renewable energy system	Building projects must contain on-site renewable energy systems that are ≥6 kBtu/ft^2 (≥20 kWh/m^2) of gross roof area for single-story buildings or ≥10 kBtu/ft^2 (≥32 kWh/m^2) of gross roof area for taller buildings. For locations that do not have enough solar radiation and committed to purchase renewable electricity products complying with Green-e Energy National Standard for Renewable Electricity, building projects do not need to install renewable energy systems.
7.4.1.1.2	**Alternate Renewables Approach:** reduced on-site renewable energy system	For systems using higher efficiency equipment (see Normative Appendix B, 7.4.4.1, 7.4.7.1 and 7.4.7.3.2), the minimum renewable energy production requirement is reduced to 4 kBtu/ ft^2 (≥13 kWh/m^2) of gross roof area for single-story buildings or 7 kBtu/ ft^2 (≥22 kWh/m^2) of gross roof area for taller buildings.
7.4.2	Building Envelope	Comply with all of Section 5 of Standard 90.1, except as noted in sub-sections. To highlight for climate zones 4 through 8, the maximum (opaque) U-factor, C-factor and F-factor, and (for east and west vertical fenestration) SHGC must be reduced by 10%. Each U-factor of vertical fenestration must be reduced by 10%.
7.4.3	Heating, Ventilating and Air Conditioning	Comply with all of Section 6 of Standard 90.1 with the additions and modifications in the sub-sections below.
7.4.3.1	Minimum Equipment Efficiencies for the Alternate Renewables Approach	Use higher efficiency equipment that comply with: (a) Normative Appendix B; and (b) Applicable ENERGY STAR requirements in Section 7.4.7.3.2.
7.4.3.2	Ventilation Controls for Densely Occupied Spaces (addresses Standard 90.1, Section 6.4.3.9)	Provide DCV for any densely occupied spaces (25 or more people per 1000 ft^2 or per 100 m^2) served systems with one or more of the following – an airside economizer, automatic modulating control of the OA dampers, or a design OA >1,000 cfm (500 L/s). DCV system must be designed to comply with Section 6.2.7 of Standard 62.1.
7.4.3.3	Economizers (addresses Standard 90.1, Section 6.5.1)[4]	(a) Provide economizer cooling in all climate zones (except 1A and 1B) for any system with cooling capacity of 33,000 Btu/h (2.75 tons) or greater (with exceptions). (b) Rooftop/DX units (smaller than 4.5 tons or 16 kW) shall have two stages of capacity control, with the first stage controlling the economizer and second stage controlling mechanical cooling. (c) Systems that control to a fixed leaving air temperature must be capable of resetting the supply air temperature up at least 5°F (3°C) during economizer operation.
7.4.3.4	Zone Controls (addresses Standard 90.1, Section 6.5.2.1)	Limit simultaneous heating and cooling in more cases than required by Standard 90.1. There are no more exceptions for zones without DDC.
7.4.3.5	Fan System Power and Efficiency (addresses Standard 90.1, Section 6.5.3.1)	a.) Limit fan power to values 10% lower than those required by Standard 90.1, Table 6.5.3.1-1. b.) Fan efficiency at the design point of operation must be within 10% of maximum total fan efficiency.
7.4.3.6	Exhaust Air Energy Recovery (addresses Standard 90.1, Table 6.5.6.1)	Where required, exhaust-air energy recovery systems must have at least 60% effectiveness. Standard 90.1 requires at least 50% energy recovery effectiveness.
7.4.3.7	Kitchen Exhaust Systems (addresses Standard 90.1, Section 6.5.7.1, 6.5.7.2, and 6.5.7.5)	The kitchen hood exhaust rate is limited by the type of kitchen hood. Standard 189.1 covers more application by reducing the rate to >2,000 cfm.
7.4.3.8	Duct Insulation (addresses Standard 90.1 Tables 6.8.2-1 and 6.8.2-2)	Use duct insulation with higher minimum R-values than required by Standard 90.1.
7.4.3.9	Automatic Control of HVAC and Lights in Hotel/Motel Guest Rooms	In hotels/motels with more than 50 guest rooms, provide automatic controls in each guest room to raise the cooling setpoint by at least 5°F (3°C), lower the heating setpoint by at least 5°F (3°C), and turn off ventilation as well as exhaust fans within 30 minutes of occupant departure from the room. An automatic preoccupancy purge cycle must provide proper outdoor air ventilation as specified.
7.4.4	Service Water Heating	Comply with all of Section 7 of Standard 90.1, except as noted in sub-sections.
7.4.5	Power	Comply with all of Section 8 of Standard 90.1, except as noted in sub-sections.
7.4.6	Lighting	For interior lighting, project should comply with either Section 9.5 or Section 9.6 of Standard 90.1, except as modified in this section.
7.4.7	Other Equipment	Comply with Section 10 of Standard 90.1 with modifications and additions in the sub-sections.
7.4.8	Energy Cost Budget	The ECB option in Section 11 of Standard 90.1 must not be used.

One distinct advantage for Option A is the use of Standard 90.1 Appendix G. If one of the performance compliance paths for the local code is the 90.1 Appendix G simulation result, the use of Option A with few or no modifications can potentially satisfy both 90.1 and 189.1 requirements which might reduce the amount of energy modeling work.

In addition to the code compliance, projects going through green building rating systems such as LEED 2009 or LEED v4 (which refer to Standard 90.1-2007 and 90.1-2010, respectively) need to run a separate building energy simulation because of the version differences. Since there are many details associated with energy modeling using Option A and B, designers can find very useful, detailed information in the Standard 90.1[5] and Standard 189.1 User's Manuals for appropriate guidance and examples.

Table 5. Excerpt from Table C1.1 of 189.1-2014 Appendix C: Modifications and additions to Table G3.1 of Standard 90.1 Appendix G

Option B baseline design: Based on Standard 189.1 Appendix C
• Use 90.1 Appendix G building envelope with modifications and additions in 189.1 except orientation (7.4.2.8).
• Use the **lowest** annual energy cost of the four building energy simulations (actual orientation, rotated 90, 180, 270 degrees) as the baseline energy performance.
• Use minimum equipment efficiencies for the standard renewables approach (HVAC, Service hot-water systems, receptacle and other loads) based on Standard 90.1.
• Comply with reduced lighting power density in Section 7.4.6.
• Include onsite renewable energy system to reduce both performance measures.

Indoor Environmental Quality

The quality of the indoor environment has a significant impact on the health, comfort, and productivity of its occupants. Indoor Environmental Quality (IEQ) addresses more than just indoor air quality (IAQ). Thermal comfort, acoustics, daylighting, lighting quality, and materials used for furnishings and finishes can all contribute toward building IEQ.

Mandatory provisions. To comply with Section 8, all building types within the scope of this standard, except health care facilities, must meet all requirements in Sections 4 through 7 of Standard 62.1-2013[6], as well as any superseding requirements in the following list, such as:

- The minimum outdoor air intake flow must be determined using the Ventilation Rate Procedure (Standard 62.1, Section 6.2).
- The outdoor airflow rate must be monitored.
- Minimum Efficiency Reporting Value (MERV) 8 filters must be used upstream of wetted surfaces (such as cooling coils) and in buildings located in EPA-designated non-attainment areas for particulate matter smaller than 10 micrometers (PM10) or smaller. This supersedes section 6.2.1.1 of Standard 62.1.
- MERV 13 filters must be used in buildings located in EPA-designated non-attainment areas for particulate matter 2.5 micrometers (PM2.5) or smaller. This supersedes section 6.2.1.2 of Standard 62.1.
- Ozone air cleaners with at least forty percent ozone removal efficiency must be used in buildings located in EPA-designated non-attainment areas for ozone. This supersedes section 6.2.1.3 of Standard 62.1.

Health care facilities must meet the requirements of ANSI/ASHRAE/ASHE Standard 170-2008-Ventilation of Health Care Facilities.

In addition to IAQ, mandatory requirements also cover environmental tobacco smoke, building entry systems, guest room preoccupancy outdoor air purge cycle, and preoccupancy ventilation control. Mandatory requirements such as thermal comfort, acoustic controls, and moisture controls are summarized in Table 6 (p.7).

Other requirements. The selection of prescriptive option and performance option is slightly different from the Energy Efficiency section. Each option includes requirements in each of three main subsections:

- daylighting (daylighting in large space, sidelighting for office spaces and classrooms, and shading for office spaces),
- materials (emission and VOC requirements), and
- lighting for presentations (illuminance).

Design teams can select the prescriptive option or performance option from each subsection independently. For example, one can choose the prescriptive option for daylighting and materials, while selecting the performance option for lighting for presentations.

Table 6. Summary of HVAC-Related Mandatory Provisions, Prescriptive Option, and Performance Option of Standard 189.1, Section 8

Standard 189.1 Section		Summary of Provisions
Mandatory		
8.3.1	Indoor Air Quality	The building must comply with Standard 62.1, section 4 through 7. Health care facilities must comply with Standard 170.
8.3.1.1	Minimum Ventilation Rates	Ventilation Rate Procedure of Standard 62.1 must be used. For health care facilities, designers must use the required minimum outdoor airflow rates in Standard 170.
8.3.1.2	Outdoor Air Delivery Monitoring	Outdoor air intake must be monitored for testing & balancing, and recommissioning. Permanently installed monitoring device must maintain an accuracy of ±10% of the minimum outdoor airflow through the entire airflow range.
8.3.1.3	Filtration and Air Cleaner Requirements	For upstream of wetted surfaces and particulate matter smaller than 10 micrometers (PM10), particulate matter filters or air cleaners must have Minimum Efficiency Reporting Value (MEV) of 8 or above according to ASHRAE 52.2. For PM smaller than 2.5 micrometers (PM2.5), MERV 13 or above filter must be used. Air cleaning devices for ozone (removal efficiency no less than 40%) must be provided for buildings located in the ozone "non-attainment" designated area according to the EPA.
8.3.2	Thermal Environmental Conditions for Human Occupancy	The building must comply with Standard 55-2010, section 6.1, "Design" and 6.2, "Documentation."
8.3.3	Acoustical Control	Acoustic control must be considered for both exterior and interior sound. Perimeter walls and roof-ceiling assemblies must achieve a composite outdoor-indoor transmission class (OITC) rating of 40 or greater or a composite sound transmission class (STC) rating of 50 or greater, and fenestration that is part of the building envelope must have an OITC or STC rating of 30 or greater for buildings within certain distance to the high outside noise areas. Inside the building, interior walls and floor-ceiling assemblies must also achieve a minimum composite STC rating depending on the space types.
8.3.6	Moisture Control	For the spaces that are conducive to condensate formation, such as exterior building envelope and humid spaces, a dynamic heat and moisture analysis following Standard 160-2009, Criteria for Moisture-Control Design Analysis in Buildings (or steady-state water vapor transmission analysis), must be performed.
Prescriptive		
8.4.1	Daylighting	Daylighting in large space directly under a roof and having high ceilings, a minimum daylight area must cover at least 50% of the floor area. More requirements are defined in the standard.
8.4.2	Materials	Report emissions or volatile organic compound (VOC) contents for adhesives, sealants, paints and coatings, floor covering materials, composite wood, etc.
8.4.3	Lighting for Presentations	Luminaires located within 3 ft (0.9m) horizontally of a permanently installed presentation surface must be controlled separately.
Performance		
8.5.1	Daylighting simulation	Usable daylight illuminance in large spaces must be demonstrated by physical or computer models.
8.5.2	Materials	All materials listed must be modeled for individual VOC concentration and the sum of each individual VOC concentration must be in compliance with the limits in the standard.
8.5.3	Lighting for Presentations	Lighting systems must be controllable by the occupant(s) to meet the illuminance and uniformity requirement specified for each permanently installed presentation system.

Impact on Atmosphere, Materials, and Resources

Building construction impacts natural resources, the atmosphere, and the availability of building materials. Reduce, reuse and recycle principles are typical ways of addressing material longevity and limitation issues.

Single product attributes, such as recycled content, have existed for years and continue to build awareness and impact consumer product selection.

Multiple-attribute product declaration or certification, including industry-wide environmental product declarations, third-party multi-attribute standard certifications and product lifecycle assessment, have gained traction in recent years and are incorporated in Standard 189.1.

Mandatory provisions. In addition to construction waste management, managing materials, and recycling/disposal, Section 9 includes requirements related to refrigerant selection. To reduce the impact of the building project on atmospheric ozone, HVAC equipment must not use CFC based refrigerants, and fire suppression systems must not use ozone-depleting substances.

Other requirements. The design team can comply with either prescriptive or performance option requirements.

Prescriptive option. To meet prescriptive requirements and promote the use of reduced-impact materials, designs must meet specific materials requirements related to recycled content, source proximity to building site, bio-based content, and multiple-attribute declaration, such as the Type III Environmental Product Declaration (EPD). For example, design teams can meet one of two elected options by installing at least 10 EPD certified products. Within various EPD certifications, product-specific multiple attribute declaration is weighted higher than the industry-wide declaration. Each product with industry-wide declaration is counted as one product for compliance. Each product under product-specific Type III EPD, third-party multi-attribute certification, or third-party Life-Cycle Assessment (LCA) review is counted as two products toward compliance.

Performance option. Performance-option provisions, on the other hand, require a life-cycle assessment (LCA) to analyze at least two alternative designs, using at minimum, the materials considered for the prescriptive option (above). The LCA must demonstrate that one approach results in at least five-percent improvement over other alternative approach(es) in at least two of several resource impact categories.

Type III EPD certification has gradually increased in recent years due to the product transparency push in the green building industry. Trane announced its first EPD product line back in 2011 with the CenTraVac™ centrifugal chiller product line as the first product-specific Type III EPD certification for water-cooled chillers. Subsequently, the EPD certification was renewed in 2015.

Construction and Plans for Operation

Section 10 of the Standard addresses construction requirements and operation plans to ensure the high-performance green building (HPGB) operates as intended throughout the entire building life cycle. Because of its critical importance, all provisions in this section are mandatory. The building owner and facility management staff are encouraged to be involved with the project in the early stages, preferably at the initial integrated design phase.

Construction requirements related to HVAC systems include acceptance testing, project commissioning, indoor air quality (IAQ) management during construction, and moisture control. HVAC systems, building envelope systems, lighting systems, renewable energy systems, and measurement devices must be commissioned and included in the final systems manual and commissioning report.

Building operation plans must include measurement and verification of HVAC systems and IAQ. Regular data collection, tracking, and review activities verify building energy performance, as well as IAQ performance. The required maintenance plan, including periodic inspection and maintenance of key systems, helps to minimize unexpected downtime and costly repairs.

Summary

ASHRAE Standard 189.1 defines high performance building requirements using enforceable, code-friendly language to ease the process of adoption by local jurisdictions. Once adopted into the local building codes, either directly or indirectly through model codes, this standard will help design and sustain high-performance green buildings of the future.

Although **site sustainability** features seem distant from HVAC designs, site shading and solar reflectance index impact energy consumption of the building. Designers must pay extra attention when evaluating these opportunities to maximize the total benefit.

In the **water** section, cooling coil condensate collection must be incorporated for air conditioning units above 5.4 tons (19 kW) in the climate locations specified. Designers must also follow the requirements in reducing cooling tower water use.

In the **energy** section, the mandatory provisions refer to Standard 90.1 equipment efficiencies. Both prescriptive-option and performance-option provisions include renewable energy systems. For prescriptive-option provisions, the Standard Renewables Approach uses Standard 90.1 equipment efficiencies with requirements for more renewable energy, while the Alternate Renewables Approach uses Standard 189.1 equipment efficiencies without requiring as much renewable energy. For performance-option provisions, performance option A uses Standard 90.1 Appendix G (as modified by Section 7.5.2) while performance option B uses Standard 189.1 Appendix C.

Most HVAC-related requirements for the **indoor environmental quality** are mandatory provisions where designers must comply with specific sections in both Standard 62.1 and Standard 55. Minimum ventilation rates, outdoor air delivery monitoring, filtration and air cleaning, thermal comfort, acoustical control and moisture control are all part of the mandatory requirements.

In addition to the mandatory requirement of no CFCs, multiple-attribute product declaration is gaining acceptance in the **Materials and Resources** section. EPD certified products can be found from various Program Operators' websites (e.g. UL Sustainable Product Guide) including a handful of HVAC-related products.

Finally, the whole **construction** and plans for **operation** section is mandatory. This section is to ensure the high-performance green building has been constructed, commissioned, operated, maintained, and sustained throughout its lifetime.

By Chris Hsieh, systems engineer, Trane. You can find this and previous issues of the Engineers Newsletter at www.trane.com/engineersnewsletter. To comment, e-mail us at ENL@trane.com.

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[3] ANSI/ASHRAE. 2015. Standard 189.1-2014 User's Manual - ANSI/ASHRAE/USGBC/IES Standard 189.1-2014, Standard for the Design of High-Performance Green Buildings Except Low-Rise Residential Buildings. Atlanta, GA: ASHRAE.

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High-Performance Air Systems examines the properties of high-performance air systems and provides guidance on their design. Topics include right-sizing and proper component selection, duct design guidelines, system control strategies, selection for part-load efficiency and much more. (September)

Demand Response in Commercial Buildings discusses the relevant improvements that load shifting and demand response can provide, with examples of the types of utility and funding programs that are available. (October)

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