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ASHRAE/IESNA 90.1–1999 update

90.1 Ways to Save Energy

from the editor…
Five years have elapsed since we last devoted an Engineers Newsletter *to one of the most far-reaching standards in the building industry: Standard 90.1,* Energy Standard for Buildings Except Low-Rise Residential Buildings. *The then-proposed revision was approved in 1999, and the first printed copies were made available at ASHRAE's winter 2000 meeting in Dallas. It was an immediate sellout—and with good reason. Each day brings new concerns about finite natural resources, waste, soaring energy costs, and global warming.*

Standard 90.1 is a national consensus standard that was developed jointly by the American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE) and the Illuminating Engineering Society of North America (IESNA). It sets minimum requirements to promote the principles of effective, energy-conserving design for buildings and building systems.

Why revisit this topic now? For two reasons. The minimum equipment efficiencies required under ASHRAE/IESNA 90.1–1999 become effective after October 29, 2001. Also, after a year of comparative analyses with the 1989 edition, the U.S. Department of Energy is about to release a determination that could require states to adopt codes at least as stringent as those in the 1999 standard.

Actually, ASHRAE/IESNA Standard 90.1–1999 offers many more than 90 ways to save energy. This article shares some of them, with particular attention to the standard's effect on the design of HVAC systems. First, however, let's briefly review the **purpose and scope** of the standard, **how the 1999 edition differs** from its predecessor, and **what compliance entails**.

Energy-Efficient Buildings

As its title and purpose suggest, the objective of Standard 90.1 is to "provide minimum requirements for the energy-efficient design" of commercial buildings. It does not apply to low-rise residential buildings, which are covered under Standard 90.2.

> *"Standard 90.1–1999 includes alterations of, and additions to, buildings and the systems they entail."*

Moreover, Standard 90.1 focuses on *comfort conditioning* rather than industrial, manufacturing, or commercial *processes*. Note, too, that the stated purpose of the standard is to provide *minimum* requirements; a designer or owner can always exceed these basic conditions for compliance.

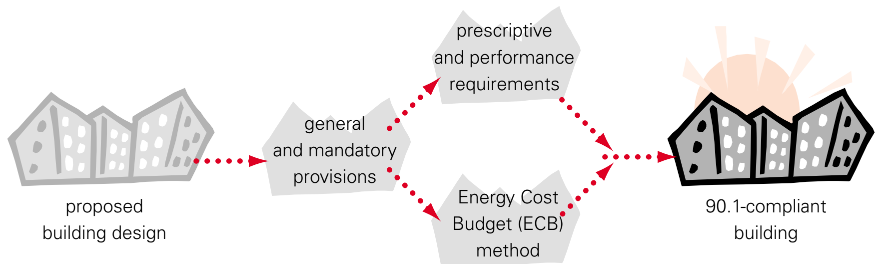
What's new in Standard 90.1–1999? Reorganized for ease of use, the new standard clarifies requirements and provides a simplified compliance path for small commercial buildings. More importantly, the 1999 edition expands the standard's scope to include new *and existing* buildings and building systems. For alterations and additions, the *90.1 User's Manual* notes that, "In general, the Standard only applies to building systems and equipment…that are being replaced."

Other improvements to the standard include information for a broader range of climate locations and separate editions for inch–pound (IP) units and the International System of Units (SI). Also, a life-cycle-cost analysis was used to define the criteria in the 1999 edition and thereby balance energy efficiency with economic reality.

What does compliance entail? Standard 90.1–1999 addresses building components and systems that affect energy usage. The technical sections of the standard, Sections 5 through 10, specifically address components of the building envelope, HVAC systems and equipment, service water heating, power, lighting, and motors. Each technical section contains general requirements and mandatory provisions; some sections also include prescriptive and performance requirements.

For example, Section 5, "Building Envelope," addresses walls, roofs,

Figure 1. Compliance Paths for ASHRAE/IESNA 90.1–1999



floors, and fenestration. U-factors, solar-heat-gain coefficients, and allowable areas define both prescriptive and performance criteria based on climate, space conditioning category (residential, nonresidential, and semiheated), and construction class. The 1999 standard organizes all prescriptive requirements in a single table.

In Section 9, "Lighting," the 1999 standard consolidates all lighting power requirements on a single page. Design professionals will notice lower power inputs for most building categories, plus the addition of mandatory lighting controls. Fewer "exempt" areas are permitted in and around the building, too.

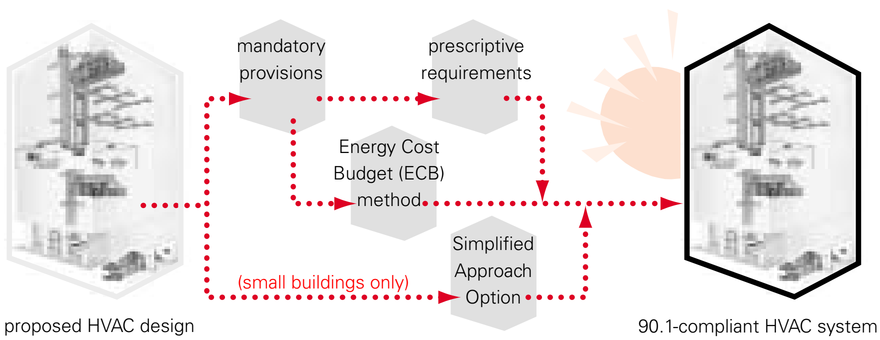
To comply with Standard 90.1–1999, the prospective design must first satisfy the general requirements and mandatory provisions of each technical section. But that's not all. The design must either *(a)* fulfill the prescriptive and performance requirements described in each technical section or *(b)* satisfy the energy cost budget (ECB) method; see Figure 1.

The ECB method permits tradeoffs between building systems (lighting and fenestration, for example) if the annual energy cost estimated for the proposed design does *not* exceed the annual energy cost of a base design that fulfills the prescriptive requirements. Using the ECB approach requires simulation software that can analyze energy consumption in buildings and model the energy features in the proposed design. Standard 90.1 sets minimum requirements for the simulation software; suitable programs include BLAST, DOE-2, and TRACE.

Energy-Conscious Comfort

What is now the HVAC section of Standard 90.1, Section 6, represents a substantial reorganization of several sections in the 1989 edition. It presents HVAC-related requirements in order of complexity, beginning with the simplest and most common design obligations. Because the HVAC section is 21 pages (and this newsletter is not), this article limits itself to summarizing the key requirements. –EN editor

Figure 2. Compliance Paths for HVAC Design under ASHRAE/IESNA 90.1–1999



Section 6 of ASHRAE/IESNA 90.1–1999 describes mandatory and prescriptive requirements for commercial heating, ventilating, and air-conditioning systems. It also defines three methods for compliance:

- A **Prescriptive Path**, which comprises mandatory provisions and prescriptive requirements
- An **Energy Cost Budget Method**, which combines mandatory provisions and a computerized methodology that permits tradeoffs between various building systems and components
- A **Simplified Approach Option**, which consists of a subset of all mandatory provisions and prescriptive requirements

For small buildings, the "simplified approach" consolidates the provisions on roughly two pages so that design professionals can quickly locate all applicable requirements. As Figure 2 implies, stringency is equivalent to the Prescriptive Path; the difference lies in ease of use and the degree of flexibility allowed. Eligibility for this approach requires that the building occupy less than 25,000 ft^2 of gross floor area and not more than two stories. Another prerequisite (there are others) is that each air-cooled or evaporatively cooled HVAC system serves only one zone.

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Mandatory HVAC Provisions.

Mandatory requirements for HVAC systems include mechanical equipment efficiencies, controls, construction, insulation, and completion. These requirements are an integral part of every compliance path.

Mechanical equipment efficiency. The 1999 standard revises the minimum efficiency requirements for many types of HVAC equipment and *adds* efficiency requirements for heat-rejection equipment, ground-source heat pumps, and absorption chillers. Standard 90.1–1999 also provides tables for centrifugal chillers selected at nonstandard conditions (leaving chilled water temperatures, entering condenser water temperatures, or condenser water flow rates).

Table 1. Comparison of Equipment Efficiencies (90.1–1989 versus 90.1–1999)

Equipment Type	Minimum Efficiency[a] Per 90.1–1989	Minimum Efficiency[a] After 29-Oct-2001	Test Procedure
Rooftop air conditioner, 15 tons	8.5 EER[b]	9.7 EER[b]	ARI 340/360[c]
Water-source heat pump, 4 tons (cooling mode)	9.3 EER (85°F EWT)	12.0 EER (86°F EWT)	ARI 320[d] (ARI/ISO-13256-1 after 29-Oct-2001)
Water-cooled screw chiller, 125 tons	3.80 COP 3.90 IPLV	4.45 COP 4.50 IPLV	ARI 590[e]
Water-cooled centrifugal chiller, 300 tons	5.20 COP 5.30 IPLV	6.10 COP 6.10 IPLV[e]	ARI 550[e]

[a] Coefficient of performance (COP), energy efficiency ratio (EER), entering water temperature (EWT), integrated part-load value (IPLV)

[b] Deduct 0.2 from the required EER if the rooftop air conditioner includes a heating section other than electric resistance heat.

[c] ARI 340/360, *Commercial and Industrial Unitary Air-Conditioning and Heat Pump Equipment*

[d] ARI 320, *Water-Source Heat Pumps*

[e] Near the end of the ASHRAE/IESNA 90.1–1999 approval process, the Air-Conditioning and Refrigeration Institute (ARI) combined and replaced ARI 550–1992 and ARI 590–1992 with ARI 550/590–1998, *Water Chilling Packages Using the Vapor Compression Cycle.* As a result, the committee responsible for the continuous maintenance of Standard 90.1 released Addendum 90.1j, which revised the efficiencies for subject chillers to reflect the new part-load rating method in ARI 550/590–1998. Although the addendum raises the IPLV requirements for electrical chillers (from 6.10 to 6.40 for the 300-ton water-cooled centrifugal chiller in this example), full-load requirements remain unchanged. Adoption of the addendum appears imminent because the public review period held last summer (2000) did not elicit comments.

For equipment covered under the previous edition, the 1999 standard allows the present (1989) efficiencies until October 29, 2001. After that time, new requirements take effect. Table 1 compares "before" and "after" minimum efficiency ratings for several types of equipment. The following requirement becomes critical if two or more rating conditions are cited:

> Where multiple rating conditions or performance requirements are provided, the equipment shall satisfy all stated requirements, unless otherwise exempted by footnotes in the table. [Section 6.2.1]

In the case of the centrifugal chiller in Table 1, both the full-load COP and IPLV must be 6.10 or better, that is, 0.576 kW/ton or less. [kW/ton = 3.516 /COP]

Controls. The 1999 standard also contains extensive HVAC control requirements regarding deadbands, restrictions for set-point overlap, and off-hour controls. Stipulations for off-hour controls include all of the following…

- Shutoff damper controls that automatically close when the systems or spaces served are not in use (These dampers must also have a maximum allowable leakage rate.)
- Zone isolation capabilities that permit areas of the building to continue operating while others are shut down
- Automatic shutdown
- Setback controls
- Optimum start controls after the system airflow exceeds 10,000 cfm

Construction, insulation, and completion. Mandatory HVAC requirements also address construction (duct sealing, leakage tests) and insulation of ducts and piping. Climate and placement dictate insulation requirements for ducts; for piping, the requirements depend on pipe location and the operating temperature range of the fluid.

Drawings, manuals, and a narrative of system operation must be supplied to the building owner… which makes a lot of sense. Even if an engineer designs a great system, it's unlikely that energy savings will accrue if the operator doesn't know how the system *should* work.

The standard also addresses balancing for air systems larger than 1 hp and for hydronic systems larger than 10 hp. It also requires control elements to be calibrated, adjusted, and in proper working condition for buildings that exceed 50,000 ft^2.

Prescriptive HVAC Requirements.

Under the Prescriptive Path, a prospective HVAC design must satisfy specific prescriptive requirements in addition to the mandatory provisions reviewed above.

Economizers. Climate and equipment size dictate the prescriptive requirements for airside and waterside economizers. Table 2 offers examples of economizer requirements for several locations.

The economizer must also be *integrated,* that is, capable of operating in conjunction with mechanical cooling. In addition, the pressure drop of the waterside economizer must be less than 15 feet of water or a secondary loop must be created to avoid its pressure drop altogether when the economizer is not in use.

An economizer can be omitted from unitary equipment if its performance is efficient enough. For example, the requirement for a 20-ton rooftop air conditioner in Tucson, which has 6,921 Cooling Design Days–base 50 (CDD50), is 9.7 EER. If the EER of the selected rooftop air conditioner is 11.1 or better, an economizer is unnecessary.

Simultaneous heating and cooling. Although the 1999 standard *limits* this practice, it does *not* ban simultaneous heating and cooling. Exceptions provide sufficient flexibility to maintain either temperature or humidity control. For example, unlimited reheat is permitted if at least 75 percent of the reheat energy originates from a site-recovered or on-site solar energy source. Such provisions should increase the popularity of heat-recovery designs that salvage heat from the condenser in an applied chilled-water system or a desuperheater in a direct-expansion system.

Air system design and control. Fan power limitations, now expressed in terms of *nameplate* power, must be met when the total fan power for the system exceeds 5 hp. The 1999 standard increases the power allowance to compensate for pressure increases imposed by specific filtration or heat-recovery devices and when the supply-air temperature is less than 55°F.

Fans of 30 hp and larger must use less than 30 percent of design power at 50 percent of design air volume *and* at one-third of the total design static pressure. This requirement will almost certainly prompt increased use of variable-speed drives or vaneaxial fans in systems of this size.

Another notable addition to this set of prescriptive requirements is the following:

> **6.3.3.2.3 Set Point Reset**. For systems with direct digital control of individual zoned boxes reporting to the central control panel, static pressure set point shall be reset based on the *zone* requiring the most pressure; i.e. the set point is reset lower until one *zone* damper is nearly wide open.

Also known as fan-pressure optimization, the basic premise of set point reset is that the static-pressure set point can be reduced *dynamically,* which lets energy savings accrue rapidly. (For more information, see "VAV System Optimization: Critical Zone Reset," *Engineers Newsletter* 20–2, 1991.)

Hydronic system design and control. Like the fan on the air side of the system, the 1999 standard requires that the pump in a variable-flow system draws substantially less power at part load. Unless there are three or fewer control valves in the system, each pump with a head greater than 100 feet and a motor larger than 50 hp must include a means for reducing electrical demand to 30 percent of design power at 50 percent of design water flow. This requirement will undoubtedly prompt greater use of variable-speed drives.

Supply-temperature reset is required, too—but not for variable-flow systems nor where it "…cannot be implemented without causing improper operation of heating, cooling, humidifying or dehumidifying systems."

Heat-rejection equipment. For heat-rejection equipment such as cooling towers, the fan must be able to reduce its speed to two-thirds or less if its motor is 7.5 hp or larger. Beyond this power limit, a cooling tower with less than two cells must be equipped to reduce fan speed on all cells—perhaps with pony motors, two-speed motors, or variable-speed drives. If the cooling tower has three cells, at least two of them must be equipped with speed control.

Energy recovery. Systems larger than 5,000 cfm that bring in lots of outdoor air (at least 70 percent of

Table 2. Example Economizer Requirements from ASHRAE/IESNA 90.1–1999 [a]

Locale	1% Cooling-Design WB	Time at 55°F < OAT_{db} < 69°F from 8 a.m.–4 p.m.	System Size that Requires an Economizer
Chicago, Ill.	73°F	613 hr	135,000 Btu/h
Denver, Colo.	59°F	739 hr	65,000 Btu/h
Miami, Fla.	77°F	259 hr	No economizer required
Minneapolis, Minn.	71°F	566 hr	No economizer required
New York, N.Y.	73°F	790 hr	135,000 Btu/h
San Francisco, Calif.	62°F	1,796 hr	65,000 Btu/h
Tucson, Ariz.	65°F	716 hr	65,000 Btu/h

[a] Wet-bulb (WB) temperature, outdoor-air dry-bulb temperature (OAT_{db})

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design airflow) must include energy recovery; the means of recovery must be at least 50-percent effective. This proviso will probably lead to the increased use of energy recovery in air handlers dedicated to ventilation, particularly in retrofit applications in which ventilation airflow is brought into compliance with ANSI/ASHRAE 62.1.

Exceptions to this airside requirement include (but are not limited to) series-style energy recovery and systems in which the largest exhaust air stream is less than 75 percent of design outdoor airflow.

Heat recovery for service water heating is required in facilities that operate 24 hours a day, where the heat rejection capacity exceeds 6 million Btu/h, and where the service-water heating load exceeds 1 million Btu/h.

The 1999 standard also requires radiant heating for unenclosed spaces and exhaust-hood control to reduce energy consumption at part-load conditions.

How Will 90.1–1999 Affect You?

Apart from the specific influences on HVAC designs just described, ASHRAE/IESNA 90.1 will almost certainly prompt increased vigilance from professionals in the building and building systems communities. The reasons are twofold: **energy codes** and **continuous maintenance** of the standard.

A *Quantifiable* Increase in Energy Efficiency

The U.S. DOE posted the results of its quantitative analysis on its Web site, www.eren.doe.gov. Titled *Commercial Buildings Determinations—Explanation of the Analysis and Spreadsheet,* the report observes that “Overall, considering those differences that can be reasonably quantified, the 1999 edition [of ASHRAE/IESNA Standard 90.1] will increase the energy efficiency of commercial buildings.”

Both the report and SSPC 90.1, the ASHRAE committee responsible for maintaining the standard, acknowledge that increased efficiency is not necessarily true for all building types nor for all components and systems. In some instances, the 1989 standard was either unjustifiably stringent (metal roofs, for example) from a cost standpoint or did not adequately reflect real-world conditions (warehouse lighting).

Estimated Energy Savings with ASHRAE/IESNA 90.1–1999

Building Type	Floor Area Weighting	Percentage Change in Whole-Building Energy Use Intensity (EUI)				
		Electricity	Gas	Site EUI	Source EUI	$UI (USD)
Assembly	0.068	9.5	–5.3	4.4	7.2	7.5
Education	0.218	11.4	–6.3	5.2	8.6	9.0
Food	0.027	–1.2	1.7	–0.4	–0.8	–0.9
Lodging	0.079	0.2	–6.5	–1.7	–0.6	–0.5
Office	0.190	10.6	–12.7	8.2	9.7	9.8
Retail	0.246	15.7	–30.7	12.7	14.7	14.9
Warehouse	0.173	–71.6	–11.3	–45.1	–58.7	–59.7
National	1.000	7.3	–8.6	3.9	5.9	6.2

Energy Codes. The Energy Policy Act or **EPAct** (P.L. 102-486) requires states to certify that their energy codes meet or exceed the requirements of ASHRAE Standard 90.1–1989. EPAct also requires that the U.S. Department of Energy (DOE) evaluate subsequent revisions of Standard 90.1 to determine whether they improve energy efficiency in commercial buildings. The DOE analyzed the 1999 edition last year and recently drafted its determination; when this *EN* was printed, the draft was undergoing an internal review. Upon its release, the DOE’s determination *could* require states to adopt codes at least as stringent as the 1999 standard.

ASHRAE/IESNA 90.1–1999 has already been approved for inclusion in the International Code Council’s model code, which currently references the 1989 edition. (The ICC represents the International Conference of Building Officials, ICBO; Building Officials and Code Administrators, BOCA; and the Southern Building Code Congress International, SBCCI.) In a related press release, ASHRAE President James E. Wolf noted that the ICC’s adoption of the 1999 standard “recognizes the incorporation of new technologies, increased energy savings, and easier use.”

The significance of Standard 90.1–1999’s inclusion in the ICC energy code is far-reaching…and perhaps immediate, depending on your location. As of January 1, 2001, Massachusetts had actually incorporated the 1999 standard (with minor modifications) into its state energy code. Many other states—

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including California, Kentucky, South Carolina, and Wisconsin—are currently considering its implementation.

Put simply, state and local code-writing bodies are quickly accepting ASHRAE/IESNA 90.1–1999 as the standard of care in their jurisdictions. (When this *EN* went to press, the February 2001 *ASHRAE Journal* announced the standard's adoption by the American National Standards Institute, ANSI…a fact that should further accelerate widespread acceptance.)

Continuous Maintenance. As a continuous-maintenance standard, ASHRAE/IESNA 90.1 remains a dynamic document. Rather than periodic updates (every five years, for example), committee members can request changes to the standard at any time. Public proposals submitted by February 20 are considered at the ASHRAE annual meeting (usually held in June). If the committee sees merit in a proposed change, it issues an addendum for public review and comment. When consensus is reached, the addendum is incorporated in the standard.

Twenty-nine addenda were released for public review and comment last summer. Only 12 of these elicited comments (to which the committee is responding) and one addenda was withdrawn. Adoption of the other 16 addenda is likely to occur soon. From this activity, it's clear that Standard 90.1 will be revised more often. For this reason, we encourage building owners, contractors, and engineers to monitor the standard's activity closely.

Closing Thoughts

ASHRAE/IESNA 90.1–1999 sets a new standard for energy consumption in commercial buildings. Its impact is real; it is already being included in state and model building codes. Make sure that you're aware of the standard, its implications, and how it affects the designs you use to satisfy your clients. Implement the standard's minimum requirements as the basis for future designs…then apply your engineering and business acumen to determine the extent to which it is prudent to exceed those minimum standards. ■

By Mick Schwedler, PE, applications engineer, and Brenda Bradley, information designer, The Trane Company. (Mick served more than five years as a member of ASHRAE SSPC 90.1.)

You can find this and other issues of the Engineers Newsletter in the commercial section of www.trane.com. To comment, send a note to The Trane Company, Engineers Newsletter Editor, 3600 Pammel Creek Road, La Crosse, WI 54601, or e-mail us from the Trane Web site.

How to Learn More about ASHRAE/IESNA 90.1–1999

Read the new *90.1 User's Manual* (ISBN 1-883413-79-6) published by ASHRAE and cosponsored by IESNA. The user's manual effectively combines explanations of requirements with illustrations and examples of systems that demonstrate compliance and non-compliance with the standard. A CD-ROM accompanies the manual. It contains EnvStd 4.0 software to aid the calculation of building envelope tradeoffs, as well as a complete set of electronic compliance forms and worksheets.

Both the standard and the *90.1 User's Manual* are available from ASHRAE at **www.ashrae.org/bookstore**. Member/nonmember pricing is $75/$98 USD for the standard and $59/$75 USD for the user's manual. (Be sure to check the ASHRAE Web site for errata information.)

Watch a videotape of the U.S. Department of Energy telecast, *Standard 90.1–1999: The Next Generation of Commercial Building Energy Standards*. Originally broadcast last September, the two-hour program reviews the general requirements of the standard and specifically addresses the envelope, HVAC, and lighting sections.

To order the videotape and/or view the presentations and a transcript of the ensuing question-and-answer session, visit:
www.eren.doe.gov/buildings/codes_standards/buildings/satellite_post.html

Attend training. ASHRAE hopes to follow up the short courses offered last year with a two-day course on all sections of the standard as part of its ASHRAE Professional Development Series. The request for proposal issued in November calls for completion in September 2001 and delivery during the 2002 ASHRAE winter meeting. For more information about the course or about Standard 90.1, contact ASHRAE at **www.ashrae.org**, or call them at 800-527-4723 (U.S. and Canada) or 404-636-8400. ■

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