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Lighting Control Systems

ASHRAE 90.1 2010 Part 2: The 14 Relevant Updates Effecting Networked Lighting Controls

EXECUTIVE SUMMARY:

ASHRAE 90.1 is a standard that provides minimum requirements for energy efficient designs for buildings. The original standard ASHRAE 90 was published in 1975 and had multiple editions to it in years after. In 1999 the Board of Directors for ASHRAE voted and placed the standard on continuous maintenance, which allowed it to be updated multiple times in a year. This is because of the rapid change in technology and energy prices. Now the standard is ASHRAE 90.1 and started in 2001. It has been updated in 2004, 2007, and 2010 since. The updates come from making technologies more efficient and developing new technologies.

The lighting controls industry has always been influenced by the requirements for code compliance from ASHREA. In the early days, compliance was simplified to mean buildings greater than 5,000 sq. ft. were to include some type of lighting control capability.

ASHRAE's latest version of 90.1 for 2010 is the new generation of requirements aimed at delivering higher levels of energy efficiency to commercial and industrial building types. Published in November, the 2010 version can achieve more than 30 percent energy savings compared to the 2004 standard, according to an announcement made by ASHRAE at its 2011 Winter Conference. The determination was the results of an analysis by Pacific Northwest National Laboratories in support of the DOE Building Energy Codes Program.

Part II of this new standard draws heavily on new demands for lighting controls and the role they will play in facilities. The Lighting Controls Association (LCA) has compiled a comprehensive summary of the new requirements. To summarize the salient points, please see the below bullet points.

ASHRAE/IES 90.1-2010 REQUIRES:

- automatic shutoff of indoor and outdoor lighting when not in use
- automatic lighting shutoff now required in buildings <5,000 sq.ft. unless specifically exempted
- automatic lighting shutoff requirements of code now required for lamp plus ballast retrofits impacting 10+% of the connected lighting load
- occupancy sensors required for a broader range of applications
- manual-ON or auto-ON to 50% operation required for automatic controls
- multilevel lighting in spaces using manual space controls
- automatic multilevel lighting in certain stairwell, parking garage and other spaces
- automatic daylight harvesting control
- power credits providing additional lighting power allowances as an incentive for using advanced control strategies
- functional testing of controls; and documentation requirements including a control narrative and maintenance schedule.

Automatic Shutoff

ASHRAE/IES 90.1-2010 requires that all lighting systems be turned OFF when not in use, with some exceptions.

Indoor: As with previous versions of the standard, for indoor lighting systems, this could be satisfied through use of a schedule-based control device, occupancy sensor or signal from another control or alarm system indicating the area is unoccupied. Previous versions of the standard limited its automatic shutoff requirements to buildings larger than 5,000 sq.ft.

The 2010 standard requires these controls in all buildings, with exemptions limited to lighting required for 24-hour operation, where patient care is provided, and where they might endanger safety or security.

> "This change is a direct result of the realization that with the reduction in cost for controls in general and the options available for compliance—e.g., occupancy sensors—the rationale for application only to larger facilities was no longer compelling,"

says Eric Richman, LC, senior research engineer for the Pacific Northwest National Laboratory and chair of the ASHRAE 90.1 Lighting Subcommittee. "Of course, this will increase initial control costs in some smaller facilities, but they should also see energy benefits over the life of the facility."

Occupancy Sensors

In previous versions of ASHRAE/IES 90.1, occupancy sensors began to be required in certain applications. The 2010 version expands this list: Occupancy sensors (or timer switches, per approval by the authority having jurisdiction) that turn the lights OFF within 30 minutes of the space becoming unoccupied are required in:

- classrooms and lecture halls
- conference, meeting and training rooms
- employee lunch and break rooms
- storage and supply rooms between 50 and 1,000 sq.ft. in size
- rooms used for document copying and printing
- office spaces up to 250 sq.ft.
- restrooms
- dressing, locker and fitting rooms

"Since the first requirement for this technology in the 2004 standard, the intent has always been to explore the addition of more space types to the list where it can be found to be an effective energysaving option," says Richman. "These new additions to the list are based on the latest research and case studies for different space types. Occupancy sensing control is considered one of the most effective methods for reducing lighting energy usage, and supporting its installation in as many spaces as possible—where it is a practical application—will have a large and immediate impact on lighting energy savings."

Exceptions include shop and laboratory classrooms, spaces with multi-scene (e.g., dimming) control systems, lighting required for 24-hour operation and spaces where automatic shutoff would endanger safety or security of people or property.

Occupancy sensing is also required in guestroom bathrooms in hotels, motels, boarding houses and similar buildings. The sensor must turn OFF the lighting, with the except for night lighting not exceeding 5W, within 60 minutes of the occupant leaving the space. (In addition, bathroom lighting is now exempt from the requirement that all lighting in the guestroom must be controlled by a master control at the entry door.)

Outdoor: The previous version of 90.1 requires outdoor lighting to be controlled by a photosensor (daylight) or astronomical time

switch (scheduling) for dusk-to-dawn lighting and either a time switch or combination photosensor/time switch. It also required that building grounds lighting fixtures >100W either use lamps with an efficacy of 60+ lumens/W or be controlled by a motion sensor, with a long list of exceptions. The new standard simplifies these requirements. First, all outdoor lighting must be controlled by a photosensor. Second, building façade or landscape lighting must also be controlled by an astronomical time switch that turns the lights OFF between midnight or business closing (whichever comes first) and 6AM or business opening (whichever comes first) (or at times designated by the authority having jurisdiction).

Retrofits as trigger: ASHRAE/IES 90.1-2010 now explicitly covers "maintenance-like" lamp plus ballast (lamp/ballast) retrofits in both indoor and outdoor applications, which have traditionally been ignored for the most part by code officials. Specifically, if a building owner replaces lamp/ballast systems representing 10% or more of the connected lighting load in an indoor space or outdoor area, the owner must comply with the standard's lighting power density limits expressed in watts per square foot and also its automatic shutoff requirements.

Note that in this situation the standard requires automatic shutoff but not space controls. If a panelboard upgrade is undertaken to provide automatic lighting shutoff in an existing building, the designer should take care to ensure that some form of override is provided to users so they are not left in the dark, even though this is not explicitly required in the standard.

Multilevel Lighting

Previous versions of ASHRAE/IES 90.1 do not require multilevel lighting; the current version embraces it broadly for indoor and outdoor automatic shutoff and space controls, with special requirements for specific applications.

> "While the benefits are generally always smaller than automatic controls, the application of bilevel-type manual control has become common practice in a lot of commercial construction, and this requirement encourages the use of occupancy sensors that can be more cost-effective than the wiring needed for bilevel control."

Manual-ON or auto-ON to 50%: Previous versions of the standard allowed automatic control devices to activate the lighting system as well as turn it OFF. In 90.1-2010, no longer: Automatic shutoff controls must be manual-ON or automatically turn the lighting ON to not more than 50% power. Exceptions include public corridors and stairwells, restrooms, primary building entrance areas and lobbies, and areas where manual-ON would endanger safety or security. Manual-ON and auto-ON to 50% occupancy sensors, for example, have been demonstrated to save energy compared to auto-ON to full occupancy sensors, while eliminating nuisance false-ON triggering. Allowing auto-ON to 50% also increases flexibility in choice of light levels for users.

Space controls: The lights in each enclosed space in the building must be independently controlled by a conveniently located manual control device or automatic occupancy sensor with manual-ON or auto-ON to 50% operation. Certain enclosed spaces, identified in the previous section of this whitepaper, require occupancy sensors (or timer switches if approved), while designers have a choice of manual control or occupancy sensors in all other spaces. Regardless if using manual controls or occupancy sensors, the lighting must be configured for multiple levels enabling users to select at a minimum OFF, a step between 30% and 70% (inclusive) of full lighting power, and 100% of

full lighting power. Exceptions include corridor, electrical/mechanical room, public lobby, restroom, stairway and storage room lighting.

"This change was made primarily to provide users with light level options that have been shown in some studies to have energy-saving benefits," says Richman.

Stairwell lighting: Stairwell lighting must be controlled so that lighting power can be reduced by at least 50% within 30 minutes of the stairwell space becoming unoccupied.

> "While stairwell and egress lighting are critically important for occupant use, the realization is that these areas are often rarely occupied and these are great opportunities for energy savings,"

Richman explains. "It is understood that some jurisdictions may have local requirements that may conflict with this requirement but as with all energy code documents, any legislated life, health or safety requirements typically take precedent."

Parking garages: Parking garages must comply with the standard's automatic shutoff requirements but also be controlled so that lighting power can be reduced by at least 30% when there is no activity detected for no longer than 30 minutes, with some exceptions. To satisfy this requirement, the lighting must be grouped in zones no larger than 3,600 sq.ft. "The 2010 version of the standard includes specific parking garage control requirements," Richman says. "These include reducing lighting power for luminaires by 30% when the area is unoccupied, providing separate control for daylight transition zones—entrance/exit—and daylight-responsive control of luminaires within 20 ft. of effective daylight openings. This is a new area for the 90.1 standard but one where there is typically a lot of lighting use when spaces are unoccupied and therefore ripe for effective controls."

Daylight harvesting: Daylight harvesting is an important area of the standard and is covered in detail in the next section.

Outdoor lighting: ASHRAE/IES 90.1-2010 requires a reduction of lighting power during times of night when the lighting is required to be ON but is unlikely to be used, or will be used only intermittently. If the lighting is not building façade or landscape lighting, it must be controlled by a device that reduces lighting power by at least 30% for at least one of these conditions:

- from midnight or within 1 hour of the end of business operations (whichever is later) until 6 AM or business opening (whichever is earlier); or
- during any period when no activity has been detected for a time of no longer than 15 minutes.

The standard specifically states this requirement also applies to advertising signage; exceptions include the same as those that apply to automatic shutoff (see previous section of this whitepaper). This requirement would entail using either a time switch or occupancy sensing.

Daylight Harvesting

Previous versions of ASHRAE/IES 90.1 do not address daylight harvesting control, an advanced control strategy that has matured due to strong demand in projects requiring high levels of sustainable design, such as LEED projects. The new standard now includes the most aggressive and complex daylight harvesting control requirements in current codes.

The code first distinguishes between primary sidelighted areas directly adjacent to daylight apertures and secondary areas in proximity but not directly adjacent to daylight apertures. These areas are strictly defined by the standard using helpful diagrams and are intended to define zones in which consistent,

unblocked, high levels of daylight availability is typically expected. If the primary sidelighted area (defined in the standard and based on space geometry and window effective aperture characteristics) in an enclosed space is 250 sq.ft. or larger, the general lighting in that area must be separately controlled using either a stepped switching or continuous dimming controller, with some exceptions. More aggressive daylight harvesting in primary and secondary sidelighted areas is rewarded with power adjustment credits described later in this whitepaper.

In toplighted spaces, if the total daylight area under skylights plus the total daylight area under rooftop monitors is larger than 900 sq.ft., the general lighting must be separately controlled using either a stepped switching or continuous dimming controller, with some exceptions. As with sidelighted spaces, more aggressive daylight harvesting control (i.e., automatic continuous dimming) is rewarded with power adjustment credits.

Additionally, perimeter lighting in parking garages is required to be automatically reduced in response to daylight, with some exceptions.

> "Daylighting control has been an elusive item for energy codes and standards because of its natural complexity, which makes it very difficult to write a code requirement that is practical and enforceable,"

notes Richman. "The requirements in 2010 include control of electric lighting when sufficient sidelighting from windows or top lighting from skylights or roof monitors is present. A second part of the requirements makes the installation of skylights mandatory but only when there is sufficient open area available to make good use of daylighting. The trick with these requirements is the determination of an effective daylight capability."

While ASHRAE/IES 90.1-2010 endeavors to simplify the process, its approach to daylight harvesting control will increase the complexity involved in compliance. Of particular concern is the fact that daylight harvesting control, particularly zoning, is now treated differently in ASHRAE/IES 90.1-2010, ASHRAE 189.1, IECC 2009 and California's Title 24-2008.

"This will not be the easiest energy code requirement to apply but the diagrams do a good job of clarifying the requirements," says Richman. "This is the most aggressive and involved daylighting requirement in current codes and is expected to help increase the use of daylighting control as standard commercial construction."

Power Adjustment Credits

When using the Space by Space Method of compliance with the standard's prescriptive lighting power allowance requirements, ASHRAE/IES 90.1-2010 offers lighting power adjustment credits based on use of advanced lighting control strategies in certain offices, meeting spaces, education spaces, retail sales areas and public spaces. Qualifying technologies range from manual dimming control to automatic continuous daylight harvesting dimming, with power adjustment factors, which are applied to the controlled lighting load, of 5-30%.

"When a lighting control system is installed that is more advanced—higher energy-saving capability—than the controls required in the standard, an incentive in the form of additional lighting power is allowed," says Richman.

> "Because the 2010 version of the standard is aggressive in terms of controls, users will find that the controls needed to go beyond the requirements and enable getting the additional allowance will be advanced and more complicated but will also provide additional energy savings."

For example, in an open office, if workstation-specific fixtures are installed with occu-

pancy sensor-based dim-to-OFF control of the downlight component and occupant manual continuous dimming control of the downlight component, the designer can claim 30% of the wattage of these fixtures as an additional interior lighting power allowance anywhere inside the building.

Functional Testing

ASHRAE/IES 90.1-2010 requires functional testing of lighting controls and systems, a service typically provided by the installing electrical contractor in a new construction project, sometimes supervised by the designer or a commissioning agent. The standard requires that the construction documents identify who will conduct and certify the testing.

Specifically, all specified lighting controls and associated software must be calibrated, adjusted, programmed and assured to operate in accordance with construction documents and manufacturer installation instructions. Specific requirements are identified for occupancy sensors, programmable schedule controls and photosensors. For example, at a minimum, the party conducting the testing must confirm that the placement, sensitivity and time-out settings for any installed occupancy sensors provide acceptable performance —e.g., the lights must turn OFF only after the space is vacated, and must turn ON only when the space is occupied. Time switches and programmable schedule controls must be programmed to turn the lights OFF. And photocontrol systems must reduce light levels produced by the electric lighting based on the amount of usable daylight in the space as specified.

Richman explains. "The requirements ensure that the systems are running correctly when the facility is turned over to building owners and that provisions are in place to make sure that they are periodically reviewed for correct operation. Too often, well designed systems are eventually overridden or fall out of function, which defeats their ability to affect energy savings."

Documentation Includes Control Narrative

ASHRAE/IES 90.1-2010 requires that certain documents be turned over to the owner within 90 days of system acceptance, including, for example, as-built drawings of the lighting and control system, operating and maintenance manuals for all lighting equipment, recommended relamping program, schedule for inspecting and recalibrating lighting controls, and a complete narrative of how each lighting control system is supposed to operate, including its recommended settings. "This documentation requirement is intended to ensure that the new owner and/or operator of the lighting systems has the information needed to understand their operation, plan for future maintenance, and address any configuration concerns," says Richman. "The requirements are fairly straightforward encompassing the need to provide drawings, operation and maintenance manuals on equipment, and narratives on the operation of each control system. Most of these are standard items that these requirements now ensure will be completed and provided."

A Stronger Code Standard

The ASHRAE/IES 90.1-2010 standard is far more comprehensive, stringent and complicated than its predecessors. Expect early adoption in states and other jurisdictions that are most progressive towards energy conservation, such as the Northeast and Pacific Northwest. To obtain a copy of the standard, visit the ASHRAE bookstore at www.ashrae.org or the IES bookstore at www.ies.org.

SOURCES:

Lighting Controls Association: "ASHRAE RELEASES 90.1-2010 PART 2" May 16, 2011.

Department of Energy: "DOE recognizes 90.1-2010 As New Standard" November 2, 2011

Wikipedia: ASHRAE 90.1 History" January 10, 2012

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