Using GreenWorx controls to meet 2013 Title 24 requirements in High-Bay installations

The new California 2013 Title 24 law becomes effective July 1, 2014 and this new set of requirements presents both challenges and possibilities for designers of high bay lighting installations. Installations that meet the 2013 Title 24 requirements offer the possibility of major energy savings over previous lighting implementations but add additional complexity to many aspects of installation. Given the size of the documentation - the Title 24 Building Energy Efficiency Standards is 262 pages and the Nonresidential Compliance Manual is 1446 pages – just understanding what is needed for a high-bay installation is the first hurdle to overcome.

At Powerline Control Systems we have been working with California Energy Commission staff both to understand its complexities and also to make modifications to our GreenWorx product line so it fully complies with the new 2013 Title 24. Title 24 is a large set of requirements that goes way beyond just lighting. In this brief introduction we focus only on the 10 requirements that affect all high-bay lighting installations.

All Controls must work on all fixtures
Manual Controls cannot override occupancy, daylighting, or demand response
**Requirement 1: Fixtures must implement multiple light levels**

Each fixture in the installation must be capable achieving multiple light levels. For the 2010 Title 24 it was possible to “checkerboard” a group of fixtures with every other fixture off, to achieve a 50% light level. The new Title 24 requires that every fixture be capable of being set to multiple levels.

One of the great misconceptions about Title 24 is that a full dimming 0-10V fixture is always required. While LED based fixtures or fluorescent with a continuous dimming ballast can easily be used, there are alternatives.

To use conventional linear fluorescent T5 or T8 fixtures, every fixture must be able to be set to a minimum of 5 levels including on and off. A standard 6 bulb T5 or T8 fixture can meet Title 24 requirements by being switched to the 5 different required levels. This type of fixture is least expensive of all the alternatives that meet these new requirements.

To use Induction fixtures, the Title 24 requirements for light levels are more relaxed than for LED or fluorescent fixtures. Induction fixtures used in the lighting design must be capable of one additional level somewhere between 50% and 70% in addition to on and off. Most 0-10V Induction fixtures meet the Title 24 “multi-level requirements.”

<table>
<thead>
<tr>
<th>Luminaire Type</th>
<th>Minimum Required Control Steps (percent of full rated power)</th>
<th>Uniform level of illuminance shall be achieved by:</th>
</tr>
</thead>
<tbody>
<tr>
<td>LED luminaires and LED source systems</td>
<td>Continuous dimming 10-100 percent</td>
<td></td>
</tr>
<tr>
<td>Linear fluorescent and U-bent fluorescent &gt; 13 watts</td>
<td>Minimum one step in each range: 20-40% 50-70 % 80-85 % 100 %</td>
<td>Stepped dimming; or Continuous dimming; or switching alternate lamps in each luminaire, having a minimum of 4 lamps per luminaire, illuminating the same area and in the same manner</td>
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<td>HID &gt; 20 watts</td>
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<tr>
<td>Induction &gt; 25 watts</td>
<td>Minimum one step between 50 - 70 percent</td>
<td>Stepped dimming; or Continuous dimming; or Switching alternate lamps in each luminaire, having a minimum of 2 lamps per luminaire, illuminating the same area and in the same manner.</td>
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<tr>
<td>Other light sources</td>
<td></td>
<td></td>
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</tbody>
</table>

1. Full rated input power of ballast and lamp, corresponding to maximum ballast factor
2. Includes only pin based lamps: twin tube, multiple twin tube, and spiral lamps
Adding GreenWorx 0-10V FCM1RD control modules to LED or Induction fixtures equipped with a 0-10V driver allows the GWX control system to remotely configure and adjust the lighting levels to produce the functionality required by Title 24.

When working with non-dimming fluorescent fixtures, the GreenWorx multiple relay modules can be used. By configuring the module and wiring necessary to separate bulbs into control sets, the fixture can meet the Title 24 level requirements.

Requirement #1 satisfied.

Requirement 2: Create and Control Zones in areas not exceeding 20,000 square feet

Each installation must be divided into control zones so that fixtures within those zones can be controlled as a block. The 20,000 square feet rule is for industrial areas as there is a smaller 5000 square feet rule for non-industrial installations. The issue here is that each separate zone must be capable of being separately controlled, both manually and automatically. GWX enabled fixtures combined with the GWX Central Controller enables the customer to arrange the lighting in whatever zones is appropriate for the installation. The GWX system allows for up to 250 different zones with each individual fixture belonging to up to 16 different zones.
Any of the GWX controlled fixtures as described above easily meets the Title 24 “zone” requirement.

Requirement #2 satisfied.

**Requirement 3: Multiple Level Manual Control**

In addition to the requirement that each fixture be capable of achieving multiple light levels, any controller of that lighting – manual or automatic – must be capable of controlling the fixtures remotely in a manner such that it can set all the fixtures in an entire zone to all of the “specified levels”. This means that in a high-bay installation with GWX controlled fixtures, there must be manual controls that are able to set all the fixtures in each zone to each of the three required levels. This requirement is similar to the old A/B 50% requirement. All GWX wall controllers are capable of setting a zone of fixtures to four different levels, such as 100%, 75%, 50% and OFF. This functionality easily satisfies the “multiple level manual control” requirement.
Requirement #3 satisfied.

Requirement 4: Automatic Time Schedules turning Zones Off during Unoccupied Times

This one, at least, is simple: When the facility is closed or a specific zone is typically unoccupied, then all the lights must be automatically off. The actual Title 24 language is "shutting OFF all of the lighting when the space is typically unoccupied". There must be a mechanism that defines the facility open and closed hours. For example open at 6am and close at 10pm. Outside those hours the facility is closed and the lighting must be off.

The GWX GSC Central Controller contains a complete 20 year schedule/calendar that enables the customer to schedule the lighting zones to be off whenever the facility or individual zone is scheduled to be unoccupied or closed. The “Automatic Time Schedule” requirement is easily met.

Requirement #4 satisfied.
Requirement 5: Override with Timeout

If the facility’s fixtures are scheduled to be OFF then there must be some mechanism to turn them on when lighting is needed outside of normal hours. Whatever mechanism is used – a manual keypad or wall switch, for example – this requirement specifies that it must contain a mechanism that limits the time on. A simple manual switch is not sufficient as it must contain a “time out” mechanism. After some time period the fixtures must automatically be turned OFF. The specified maximum time ON is two hours, but there is an exception for industrial spaces that specifies the timeout period can be longer than two hours. This is an important point that we will see again and again: The implementation of all these requirements must work together in an intelligent manner.

For example, this timeout can’t just “turn the lights off after 2 hours”. Suppose that the lights were manually controlled at 5am with a two hour timeout. Also suppose that the schedule would normally turn them ON at 6am. At 7am – after the two hour timeout – the lights can’t just “go off” as that violates the normal time schedule.

The GWX GSC Central Controller contains a “timeout mask” feature that enables the customer to specify certain time periods when a manual ON command is transmitted with an attached “time-out” function. The commissioning agent configures the time-out period per the Title 24 requirements and the customer requirements. An additional feature of the GWX over-ride time out function is that the lights can be set to blink before going out, giving the user time to press the manual control button again to renew the time-out period. The “Override with Timeout” requirement is easily met.

Requirement #5 satisfied.

Requirement 6: Calendar-based Holiday Schedules

The scheduling system under Title 24 must account for “holiday” schedules of the facility and this schedule must account for not only regular Monday thru Friday days when the facility is closed – but also “holidays”. “Holidays” in this context are special days that the facility is closed. This could be the usually New Years Day, Presidents Day, etc, but also other facility specific closures – for example a complete closure for the 1st week of August. The implication of this requirement is that, besides the required daily ON/OFF time-clock type timing, there must also be built into the system a programmable yearlong calendar that specifies these holidays.

The GWX GSC Central Controller contains a complete 20 year schedule/calendar that enables the installation to schedule the lighting zones to be off whenever the facility or individual zone is scheduled to be unoccupied or closed. The GSC schedule facilities include a daily calendar where holidays or other “closed” days can be configured. There are four different schedules that can be configured differently to satisfy both the user requirements and the Title 24 requirements at the same time. The “Calendar-based Holiday Schedules” requirement is easily met.
Requirement #6 satisfied.

Requirement #7: Daylight Control of 75% of the total High-bay Area

This is more of a requirement of the building design than the fixtures and control components of the installation, but the fixtures must respond to the level of daylight available. In most high-bay installations the daylight comes from skylights. In all new construction high-bay facilities at least 75% of the area must be in Skylight zones. For more detail, the Title 24 documentation contains charts and pictures that show how this is calculated and how much of the floor area is covered by a skylight. The bottom line is that all facilities must have most of the floor space in Skylight zones.
The lighting control part of this requirement is that all the fixtures in the Skylight Zones must be controlled to reduce their light level as the available daylight changes.

Fixtures must respond to this natural light in this manner: Suppose that the facility in a certain area needs “x” lumens of light. At night all of “x” is provided by the lighting fixtures. A bit after dawn, daylight begins entering the facility though the skylights. The fixtures must adjust so that the light level of “x” lumens is still achieved from the level produced from the fixtures plus the contribution from the daylight. As the day progresses the fixtures need to produce less light as more is contributed by the sun. As the day ends this process is reversed and the fixtures contribute more as the sun contributes less.

The number of steps required is different for different types of fixtures. For induction high-bay fixtures there need be only two steps: 50% and OFF. For other type of fixtures three steps are required. The fixture levels need to be adjusted down in these steps as daylight increases and up again in steps when daylight decreases. Title 24 allows for closed-loop continuous adjustments, which is appropriate for continuous dimming fixtures in office spaces, or open-loop stepped dimming, which is much less expensive and much more appropriate for high-bay installations.

The GWX system allows all the daylighting zones to be stepped up and down with only one outside open-loop sensor. This method both meets all the Title 24 requirements but is also extremely inexpensive and easy to commission. This method requires only one GWX Voltage Sense Module and one Intermatic 2-stage commercial photo sensor.
GWX Voltage Sense Module and Intermatic 2-Stage Photo Sensor

Requirement #7 satisfied.

Requirement 8: Occupancy Sensors in Warehouse Isles

In addition to all the requirements outlined above, warehouse isle fixtures have one additional requirement - giving these fixtures the “most regulated fixture in the facility” award.

Warehouse isles must have an occupancy sensor that allows the fixtures to be at a level – title 24 requires a minimum of 50% reduction - when not occupied. Title 24 has many other requirements about the speed at which the fixtures must react, and some exceptions for different types of fixtures.
There are many ways to implement the occupancy requirement. It can be met by using one occupancy sensor on every fixture or by using one sensor at each end of the row. One important and difficult control part of this requirement is that occupancy must work simultaneously with the daylighting and demand response functions and not override those functions. At night the occupancy might change the light level back-and-forth between 100% and 50%. When Skylights are over an aisle the level cannot go above the desired daylight level – so both the maximum upper and lower levels might be affected throughout the day. Only an intelligent properly designed system can meet these requirements simultaneously.

Using the GWX controls there are three different ways to implement occupancy sensor control. None of these methods require any control wires back to the central controller. This makes the design and installation of occupancy sensor controls very economical.

Method #1 is to wire a line-voltage occupancy sensor directly to the Occupancy Sensor input pin on the FCM fixture modules. Using this method you may use one occupancy sensor for each fixture in an aisle. An advantage of this method is that the fixture response is immediate and the process does not use any power line’s limited communications bandwidth.
Method #2 is to wire one line-voltage “traveler” wire run down the aisle connected to every fixture and wire one occupancy sensor to each end of the isle. The two occupancy sensors will control the entire isle. You may also wire other occupancy sensors to the traveler in the middle of the isle if necessary. This method also has immediate fixture response and the process does not use any power line’s limited communications bandwidth.

Method #3 is to wire one or more occupancy sensors to a VSM Input Module. The VSM is then programmed to turn on/off a zone. This method also has a 2 second delay and uses some of the power line’s limited communications bandwidth. This method should not be used in an installation with a large number of aisles.

Requirement #8 satisfied by any of these methods.

Requirement 9: Demand Response

All fixtures in the facility must have the combined capability to respond to an automated power reduction request initiated by some outside trigger source, typically the power company. This total reduction must be at least 15%. How that request enters the facility isn’t well specified in Title 24. The Title 24 Compliance manual shows that it is acceptable to use a simple single contact closure input as the trigger for the demand response function to the lighting system. Regardless of the ability of the local
power company to generate that request or not, the installation must be constructed with the ability to respond.

This requirement is very simple to fulfill with the GWX control system. One ISM low voltage input module is wired to line and neutral. The input is left open to be connected to the “undefined” utility demand response signal. Any or all fixtures can be configured in a Demand Response Zone and set to only achieve the Demand Response Maximum. This function is built into all GWX FCM modules. The Demand Response Maximum can be set to any level that the fixture can reach.

Requirement #9 satisfied.

Requirement 10: No override of occupancy, daylighting, or demand response functions

While each of the facility fixtures can be manually controlled, that manual control can’t override – except in defined circumstances – the limitations placed on that fixture by other Title 24 requirements. For example, since Title 24 mandates some form of daylight in the installation – probably skylights – that daylight adjusts the light level of the warehouse fixtures, but manual control can’t be used to cause the lights to be at a greater level set by the daylighting functions.

The GWX Fixture Control Modules have internal logic that allows the occupancy, daylighting, and demand response functions to be configured to internal “maximums”. They do not change the desired light level set by manual controls or schedules. They produce only a temporary “maximum” that cannot be exceeded until the maximum is released.

Requirement #10 satisfied.
Title 24: In Conclusion

And that’s all there is for title 24 and High-Bay installations. It should be clear that to implement these ten requirements some form of intelligence is necessary in the control of each fixture. The old form of contactors or “wires and relays” just will not work.

There are two main approaches: A decentralized system has all inputs – daylighting, occupancy, schedule, etc – distributed to each fixture and the intelligence resides in the fixture to respond appropriately. This requires a very smart and likely a very expensive fixture. Even with a very smart fixture with occupancy, daylighting and schedule/calendar controls all built in; there still must be some form of communication with a central controller in the system for programming, zone control, and demand response control.

The other approach is a centralized type system that has a single central controller receiving most of the inputs, making the appropriate decisions, and then controlling the fixtures as necessary. This allows use of a “dumber” fixture but some form of communication between the central controller and the fixtures must exist. This is the approach that the GWX system implements.

In conclusion, it is best not to look upon Title 24 requirements as an impediment but rather has a challenge. Properly implemented the energy savings can be impressive. The first step in that challenge is understanding just how title 24 impacts lighting designs. If you are working with High-Bay installations we hope this brief introduction has helped.

For more information about Title 24 and High Bay lighting, and to see the Title 24 documentation highlighted to show the High-Bay requirements please visit the Powerline Control Systems web site at www.PCSLighting.com.

Marshall Lester is the President of Powerline Control Systems Inc a manufacturer of industrial light controls that can be used to implement a Title 24 compliant installation. Kimberly Harms is an independent software developer working with Powerline Control Systems on the GreenWorx project.