Big Box Lighting Guidelines
Best Practices for Efficiency

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Commissioned by

UI and CL&P

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Introduction

Big box retail and wholesale stores are one of the fastest growing segments of the construction market. Big box stores are characterized by open structures with the ceiling 16' or higher above the floor. Ceiling heights of 20 to 30 feet are common.

Advances in state-of-the-art lighting technology can significantly reduce energy use and costs while providing light levels and quality recommended by the Illuminating Engineering Society of North America. In order to ensure compliance with applicable energy codes, achieve typical lighting energy levels substantially less than the energy code allowance, and contribute to regional energy and demand management, the following guidelines for lighting are strongly recommended. Note that these guidelines generally provide substantial benefits from utility incentive programs and through LEED and other certification programs and may offer significant tax deductions and other benefits.

Facilities Affected

These Guidelines are intended to be used by contractors, architects, engineers, and others responsible for designing, specifying and/or building new lighting systems, including new buildings, tenant fit-out, remodeling, and/or energy-upgrade initiatives.

In general, these Guidelines should be applied to the following:

- Big box retail stores (high ceiling area only)
- Big box wholesale stores
- Sales warehouses open to shopping
- Exhibition halls

In addition, some types of industrial spaces may benefit from using these Guidelines.

Facilities Less Affected

These Guidelines are not necessarily intended to address any of the following space types.

- Storage warehouses
- High end specialty stores in high bay spaces
- Spaces with considerable display and focal lighting

However, the principles of cost effective, energy efficient design expressed by these Guidelines should be employed in these or other space types whenever possible.

Implicit Considerations

These Guidelines were developed in consideration of applicable codes and standards in the U.S., including the following:

- Standards of the Illuminating Engineering Society of North America, including IESNA/ANSI RP-2, American National Standard for Office Lighting. IESNA Standards apply in the USA, Canada and Mexico
- Standards of Underwriters Laboratories.
- Energy efficiency standards of the States of Connecticut, Massachusetts, and IESNA/ASHRAE/ANSI 90.1-2001.

General Design Requirements

All designs must comply with applicable codes and ordinances. Note that in general, the following requirements will result in lighting designs that demand less power (watts per square foot floor area) than mandated by the energy code. The energy cost savings realized by this practice will often pay back the incremental cost for the more efficient system within 3 years. Additionally, in many cases the first cost of lighting may be less than traditional designs because these Guidelines optimize the amount and type of lighting equipment than can be used.

Lighting Systems

General Requirements

A complete, hardwired lighting system must be installed that has an average power density of less than 1.2 watts per square foot. Storage rooms and other back of house spaces including mailrooms, lunchrooms, restrooms, copy rooms, locker rooms, and similar spaces shall not exceed a connected lighting power density of 0.6 watts per square foot.

Additional lighting, such as lighting within merchandising and shelving systems, may be installed in big box sales space. Because many projects are designed and constructed before the sales systems are selected, accounting for task lighting is difficult. When provided, it should not exceed 0.25 w/sf, or alternately, the combination of general lighting and task lighting should not exceed 1.4 w/sf..

Compliance Documentation

Designs shall be certified using COM-CHECK 3.1 release 1 or higher. For the Code to be used, select ASHRAE/IESNA 90.1-2004. If these guidelines are followed closely, the resulting designs should achieve approximately 25-35% better than 90.1-2004 and 40-50% better than 90.1-2001. NOTE: Achieving performance significantly better than these target values is very difficult and not recommended without design involving considerable expertise.

Principal Lighting Systems

For most spaces, designers should employ either of the two pattern lighting layouts illustrated below. Spacing measurements are taken from the plan view center of the luminaire. Luminaires should be mounted at least 1/3 of the indicated mounting distance away from any ceiling-high partition. In general, do NOT use incandescent lighting, halogen lighting, or track lighting systems or monopoints of any kind or voltage of operation.

Other Lighting Systems

In every building, there are a number of other lighting situations. Consult other Guidelines for suggestions for efficient solutions.

Special Allowance for Decorative and Accent Lighting

Energy codes permit decorative and accent lighting and usually provide an additional power allowance for them. Properly applied, these allowances can permit significant additional lighting power and still comply with the energy code and other targets such as a LEED criterion. For the purposes of this program, significant use of such additional power is not consistent with exceptional energy efficiency, but it is acceptable to use the allowance for specialty displays and highlighting. If adding lighting for highlighting or for aesthetic effects or décor, this program

has chosen to limit the use of this added energy to 0.25 watts per square foot for the entire building or the amount permitted by the code, whichever is less.

Lamps and Ballasts

General

The secret to achieving outstanding energy efficiency in big box spaces is to use electronic ballasts on high wattage HID lamps as well as fluorescent. Harmonic distortion should be less than 20%,

HID Systems

There are two types of suitable 250-400 watt HID lamps: quartz pulse-start metal halide lamps (QMH), and ceramic metal halide pulse-start lamps (CMH). As a basic design guide, high color rendering index QMH lamps tend to favor high color temperatures (5000K+) while CMH lamps with high CRI favor low and neutral color temperature (3000 to 4000K). When operated on a suitable electronic ballast, the superior lamp lumen management qualities of the ballast result in lower initial power levels as well as lower initial light levels as compared to standard pulse start magnetically ballasted HID. Note that the ballast must be matched to the lamp; CMH and QMH lamps operate at different frequencies.

Fluorescent Systems

Because instant start ballasts are the most efficient and least costly, they should be used in all longer duty cycle applications where the lights are turned on and off infrequently. For sales areas, although dimming may be considered, switching off lights is usually a once-a-day occurrence.

In Big Box, the principal consideration for ballasts is temperature. Ordinary fluorescent electronic ballasts are generally not designed for the operating temperature in the Big Box lighting system. In addition to using the most efficient ballast, be sure to address the ballast's operating temperature and rating

T-8 versus T-5

Four-foot T-8 fluorescent lighting systems must employ "high efficiency" lamps and "high efficiency" electronic ballasts. The low cost of T-8 systems is very appealing and if the lighting systems are mounted lower in the space than most high bay lighting, T-8 might be an excellent choice because the ambient air temperature of the lamp will be appropriate. However, with increased mounting height there is a typical increase in ambient air temperature, and for this reason, most high bay fluorescent fixtures use T5-HO lamps. Special high temperature electronic ballasts in both instant start and program start are available.

Induction Systems

There is a growing interest in the use of induction lamps in high bay applications. Historically, high costs of lamp and ballast systems have been an impediment, but recent advances have suggested that induction systems might compete.

Multiple Compact Fluorescent Systems

Compact fluorescent lamps lack the efficacy of T-5 and T-8 systems, and can't reach the performance required by this program.

Pattern 1: the HID Solution

Metal halide lamps have been used for decades to illuminate high bay spaces. Having good energy efficiency and acceptable color, for many years HID lamps presented the only economically viable alternative for big spaces. But in order to compete with fluorescent lighting systems, significant improvements were called for and recently have been made available.

To meet this guideline, design the high bay metal halide lighting system as follows:

- High efficiency luminaire, preferably with qualities that reject dirt accumulation. An open, ventilated fixture with an internally protected (P rated) lamp and exclusionary socket is strongly recommended.
- Proper candlepower shape for the space. For glare control commensurate with retail, the spacing criterion should be less than 1.4; with 18-20' mounting height, optimum performance is achieved when the spacing criterion is around 1.2. Luminaire efficiency at least 75% with CU = 0.80 at RCR = 2.0 and reflectances 80/50/20.
- High CRI QMH lamp with high frequency electronic ballast, or high CRI CMH lamp with low frequency electronic ballast
- Choice of lamp between 250 and 400 watts (with appropriate ballast) matching the lamp+ballast input power to a lighting power density of less than 1.2 watts per square foot. For example, using a 320 watt lamp, a typical electronic ballast has 345 watts input power. Each luminaire should cover an area of at least (345/1.2) = 288 square feet, or an average spacing of about 16 by 18 feet.

Note that some electronic HID ballasts can operate lamps between 250 and 400 by making a simple adjustment. They may also have ballast options that include dimming, quartz auxiliary control, etc.

Pattern 2: the High Bay T5HO Fluorescent Solution

Unlike foregoing fluorescent lamp products, the T5HO lamp was designed for peak performance in ambient air at 35 degrees C. Mounted high in a big box space, these lamps actually take advantage of thermal stratification to perform properly. Fluorescent lamps have superior lumen maintenance, starting and restarting qualities as compared to HID, and efficacy (mean lumens per watt) as good or better than most metal halide lamps. When these features are combined with a high performance reflector, fluorescent high bay luminaires are a viable alternative to HID luminaires. Side benefits include simple multi level switching and redundancy to ease maintenance demands.

To meet this guideline, design the high bay fluorescent lighting system as follows:

- High efficiency luminaire, preferably with qualities that reject dirt accumulation. Luminaires designed to manage lamp and ballast case temperatures should be selected.
- Proper candlepower shape for the space. For glare control commensurate with retail, the spacing criterion should be less than 1.4.
- T5HO non-amalgam lamps

- Luminaire efficiency of at least 75% with a minimum CU of 0.80 at RCR = 2.0 with reflectances 80/50/20.
- Electronic instant start ballast(s) use slightly less power (about 1.5 watts per lamp) than programmed start ballasts. With the infrequent switching of lights in stores, instant start ballasts are probably a slightly better choice.

Daylighting Integration

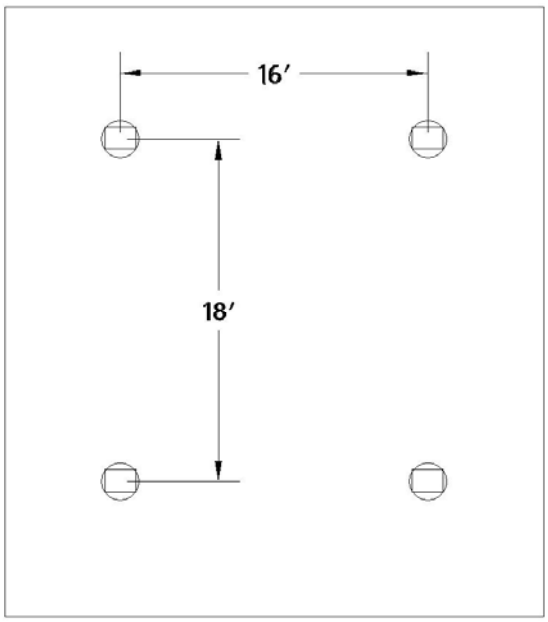
Fluorescent lamps provide superior dimming behavior to HID. In stores with significant daylighting, fluorescent high bay systems may be preferred because the dimming range is larger and when dimmed, fluorescent systems have higher efficacy than HID.

Interior Finishes

As a general rule, interior ceilings, structures and upper walls should be painted a light color, but the impact on high bay lighting is not as great as in other space types.

TABLE A –Lighting Systems

Applications	*Lighting Systems*	*Lamp Watts (Fixture input watts)*	*Spacing Area (approx grid)*	*Note*
PATTERN 1 Sales Area using HID.	CMH or QMH metal halide lamp with electronic ballast.	250 (275) 320 (345) 350 (380) 400 (430)	230 (16’ x 14’-6”) 288 (16’ x 18’) 317 (17’-6” x 18’) 358 (18’ x 20’)	Mounting height at least 20’ AFF; only recommended for high bay spaces. Set lamp height to narrow for a spacing criterion of <1.3
PATTERN 2 Sales Area using High Bay Fluorescent T5HO.	T5HO with high bay reflector system and ballast designed for at least 60 degree C ambient temperature and 80 degree C case temperature in a properly designed luminaire with spacing criterion of <1.3	(4) T5HO with BF=1.0 IS ballast (226 watts) (6) T5HO with BF=1.05 IS ballast (344 watts)	188 (14’ x 13’6”) 288 (16’ x 18’)	Mounting height at least 16’ AFF; only recommended for high bay spaces. Mounting height at least 18’ AFF; only recommended for high bay spaces.
Store Area using Induction.	Induction fluorescent lamp in high bay luminaire. NOTE: this is evolving technology that has a minimum of experience and installed base. Check proposed product literature and testing data carefully.	Depends on lamp and ballast system	Not to exceed 1.2 w/sf	Mounting height as recommended by manufacturer
Shelf and display lighting	Hardwired fluorescent luminaires nom.2’, 3’ or 4’ in length and employing an electronic ballast	No greater than 8.5 watts per foot of luminaire	When mounted in fixed cabinets and displays.	Luminaires may be mounted end-to-end if needed to accommodate cabinet length. Use low ballast factor ballast.
Specific accent lighting for primary displays	Ceramic metal halide track, , accent lights or monopoint lights having an integral transformer	Lamps to 70 watts	Very limited use	For accent lighting only – should not be used for general lighting
Exit Signs	LED	No greater than 3.5 watts/sign		

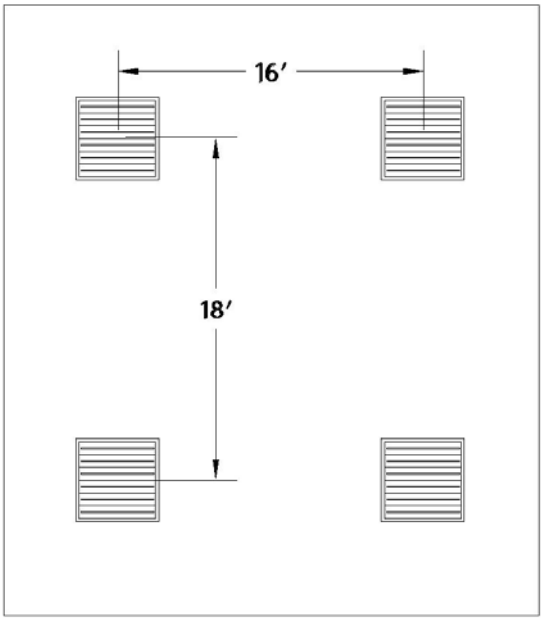


PATTERN 1
GENERAL LIGHTING
BIG BOX RETAIL
LARGE OPEN AREAS

320 WATT METAL HALIDE
LUMINAIRE WITH
ELECTRONIC BALLAST
1.2 SPACING CRITERION

80 FC INITIAL/60 FC MAINTAINED
IN AN EMPTY ROOM
AT 1.20 WATTS PER SQUARE FOOT

OTHER LAMP WATTAGES POSSIBLE
CONSULT TABLE FOR SPACING



PATTERN 2
GENERAL LIGHTING
BIG BOX RETAIL
LARGE OPEN AREAS

LUMINAIRE WITH (6) F54T5HO
LAMPS AND INSTANT START
1.05 BF ELECTRONIC BALLAST
1.2 SPACING CRITERION

80 FC INITIAL/60 FC MAINTAINED
IN AN EMPTY ROOM
AT 1.20 WATTS PER SQUARE FOOT

OTHER NUMBERS OF LAMPS PER LUMINIARE
CONSULT TABLE FOR SPACING

Control Recommendations

By code, each interior space enclosed by ceiling high partitions must have separate local switching and some form of automated-off control (occupancy sensing, time based scheduling, or other). In addition, wherever possible, provide separate switching for lights in daylighted zones. Energy codes also require separate switching of display lighting systems.

In order to comply with code requirements and ensure maximum energy savings, an automated relay control panel is required. In addition to time of day control, be certain to provide 2-level switching for stocking, and separate circuits for display lighting. If dimming is available, also consider adaptation compensation (dimming lights at night) to save energy.