BASIS OF DESIGN

This section applies to the design and installation of lighting systems.

Design Criteria

Lighting systems are expected to use less energy than the energy code allows. Do not rely on prescriptive measures to meet the energy code.

The lighting design shall maximize the use of recessed and direct/indirect 2-foot by 4-foot luminaires using two rows of F32T8/741 low-mercury lamps. T8 lamps shall be 20,000+ hour rated life for at least 90 percent of all lighting. Ballasts for lamps shall be normal and high-output. Do not use low-output T8 ballasts.

Do not use lamps over 48 inches; incandescent, mercury vapor, T12, U-Bend, or circline lamps; or lamps less than 13 watts (except for auditorium pathway and step lighting). Avoid the use of 1-lamp and 4-lamp T8 ballasts.

1. Fluorescent lamps greater than 12 watts must be 80+ color rendering index (CRI), separable from ballast, and rapid-start.

2. Typical lamps should be 4,100 K.

3. In food service areas, any lamp may be 3,000 K, and compact fluorescent lamps may be 2,700 K.

4. Use amalgam lamps where compact fluorescent is used in cold or widely variable temperature locations.

Select interior lighting to achieve initial system efficiencies greater than 64 lumens per watt. Efficiency can be calculated as follows:

1. Determine the initial lumen output (initial lamp lumens times ballast factor times luminaire efficiency) for the luminaires.

2. Determine the input watts for each luminaire type.

3. Calculate the system efficiencies for the different spaces lighted by the various lamp/luminaire types in lumen output per watt.

Design for prescribed light levels that use realistic maintenance factors based on products actually used.

1. For example, F32T8/835 lamps produce an initial 2,950 lumens and have a lumen depreciation of 5 percent, while the more commonly used F32/T735 lamps produce an initial 2,850 lumens and have a lumen depreciation factor of 12 percent. There is an 8 percent difference in maintained lumens between the two lamp types.
2. T8 luminaires will probably not be cleaned until lamps are replaced at 24,000 to 30,000 hours.

When making light-level calculations, use a ballast factor of .87 for normal-output T8 ballasts, 1.18 for high-output ballasts, and 1.0 for compact fluorescent ballasts.

For radio frequency-sensitive areas such as laboratory and medical center procedure areas, use ballast meeting Federal Communications Commission (FCC) Code of Federal Regulations (CFR) 47 Part 18 class B requirements and/or provide luminaires with sufficient radio frequency interference (RFI) shielding, including shielded lenses and high-integrity ground bonding.

Coordinate selection of surface finishes with the Engineer so as to control brightness ratios, glare, and contrast, while using surface finishes with maximum reflection factors and minimum deterioration.

Coordinate with the Engineer so the lighting system can be maintained. Access to the luminaires must be considered in design.

Access to all lighting equipment must not put personnel at risk and shall not require that personnel bring equipment such as ladders or lifts unless approved by Construction Management plan review.

Average Maintained Foot-Candles at Work Surfaces

<table>
<thead>
<tr>
<th>Foot-Candles</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>70</td>
<td>Laboratories, drafting rooms</td>
</tr>
<tr>
<td>50</td>
<td>Paperwork-intensive offices, shops, kitchens, library study areas, etc.</td>
</tr>
<tr>
<td>42</td>
<td>Classrooms, lecture rooms, classroom auditoriums, computer-oriented offices, and general-purpose computer work stations/labs. Consider two-level switching (50/17 ft-c) for mixed computers and paperwork</td>
</tr>
<tr>
<td>30</td>
<td>Non-classroom auditoriums, conference rooms</td>
</tr>
<tr>
<td>20</td>
<td>Restrooms, mechanical and electrical rooms, locker rooms, etc.</td>
</tr>
<tr>
<td>10</td>
<td>Special computer labs: Consider two-level switching (30/10 ft-c) for mixed uses or dimmable ballast.</td>
</tr>
</tbody>
</table>
Minimum Maintained Foot-Candles

15  Corridors, passageways, and stairways adjacent to spaces with more than 50 foot-candles

10  Corridors, passageways, stairways, storerooms, etc.

2.5  Covered parking garages

1  Open parking

1  Roadway (use Illuminating Engineers Society [IES] recommendation to suit security level)

0.5  Walkways (use IES recommendation to suit security level)

Specific Application Requirements

Roadway and Pathway Lighting: Streets, parking lots, sidewalks, and pathways will generally be illuminated with pole-mounted, Metal Halide luminaires.

1. Protect all street and walkway luminaires with waterproof in-line fuse holders located in each pole base.

2. The fuse shall be on the line side of the ballast.

3. Fuse holders shall be Buss Tron HEB, ESNA, or equal.

4. All outside lighting will be controlled by a photocell and lighting contactor with hand–off–auto switch.

5. Each lighting circuit will be on its own single pole breaker.

6. All mounting bolts shall be installed with anti-siege.

Classroom Lighting: Educational and classroom spaces at the University require use of audiovisual teaching aids. Special lighting design may include the following:

1. Switching to permit operation of the general lighting system by the instructor, speaker, and/or projectionist. Low-voltage relay control is recommended.

2. Dimmable low-level lighting from 2 to 8 ft-c for note-taking while viewing projected images. Provide switching for 60 percent of all luminaires, including all perimeter luminaires. Provide dimming for the remaining note-taking luminaires. Dimming shall be accomplished with F32T8/835 lamps and ballasts designed to dim to a 10 percent ballast factor.

3. Independent switching for chalk/markr board and podium lighting as needed.

4. General lighting should be in or close to the ceiling. Pendant luminaires tend to interfere with the viewing of projection screens and pendant-mounted video monitors.
5. Mount luminaires so lamps are parallel to the front wall.

6. Note-taking luminaires should provide sharp cutoff optics to minimize illumination of walls and projection screen.

**Classroom Auditoriums:** Spaces designated as “classroom auditoriums” in the building program will use University-provided equipment. The designer shall ensure that Contract Documents include appropriate wireways, wiring, and power necessary for this University-provided equipment.

**Sports and Non-Classroom Auditoriums:**

1. Fluorescent lighting may be used for most applications.

2. Metal halide and other high-efficiency lamps may be used for sports and coliseum facilities.

3. Use alternate phasing of high-intensity discharge (HID) lamps to reduce flicker effect and to ensure that sufficient instant-start light sources are utilized to avoid total darkness immediately following a momentary power outage.

4. Compact fluorescent lamps are preferable to low-wattage HID lamps.

**Library Lighting:** Maintain a minimum of 50 foot-candles at all study and work surfaces and 15 foot-candles on the vertical surface of a book on the bottom shelf of each stack. Lighting design must be closely related to fixed furniture placement. Study carrels and stacks divide the area into cubicles and aisles. Normal on-center stack spacing is 4 feet, 6 inches.

**Corridor, Entrance Lobby, and Public Area Lighting:** Break the circuiting into different categories.

1. “Y” circuits: Luminaires located in (non-daylighted) interior areas requiring operation whenever the building is in use.

2. “Z” circuits: Luminaires located in (daylighted) open stairways or exterior areas requiring operation during hours of darkness.

3. “Y” and “Z” circuits shall operate by mechanically-held relays or contactors wired for multiple control as follows:
   a. Local manual control on each floor (key type or to be located in janitor closets, permitting operation only by authorized personnel)
   b. Master manual, keyed control on main floor
   c. Master remote control from central supervisor control system.

**Wet Laboratory Lighting:** Provide egress lighting on emergency power near door inside wet laboratories.
Controls

Multiple switching and split circuiting is preferred to single switching of higher light levels.

Control all interior lighting with local switching. Do not use standard circuit breakers as light switches.

Lighting control panels and relays for difficult access spaces such as vivariums, biohazard areas, operating rooms, patient rooms, and procedure rooms shall be readily accessible, preferably in a hallway outside the space.

When automatic controls are to be used, occupancy sensors are generally preferred to master lighting control systems to avoid maintaining time schedules.

1. All lighting controls shall switch loads when output voltage is approximately 0.
2. Occupancy sensors shall operate in series, with an ON/OFF switch having the look and feel of a typical light switch and mounted in a typical light switch location.
3. Occupancy sensors shall fail ON.
4. Occupancy sensors shall have time delay adjustments of 10 to 30 minutes before turning lights OFF. Choose delay settings to minimize ON time while limiting the number of starts to less than 12 per day. Provide a statement of occupancy sensor adjustments in the construction documents. When in doubt, use 10 minutes for meeting spaces such as classrooms and 30 minutes for other applications.
5. Use infrared sensors when appropriate, ultrasonic detectors when necessary for partitioned spaces, and dual-technology sensors for meeting spaces, such as classrooms, where large motions are required to turn lights ON and seated reading or writing will keep lights ON.
6. Large common office spaces might use zoned dual-technology control or time-of-day control with a 2-hour override feature.
7. Occupancy sensors may be used to reduce pathway and warehouse light levels but "stumble lighting" should be maintained ON. This may be coordinated with emergency lighting requirements.

Daylight zones should typically have independent dual switching.

1. One switch controls all lamps nearest windows and some of the lamps in each luminaire further away from the windows. (Consider turning OFF additional lamps nearest the north wall of rooms with east- or west-facing windows by this same switch.)
2. A second switch controls all remaining lamps in the daylight zone.

No automatic controllers or time clocks will be used on outside lighting. The University DDC control system has a virtual photocell and will be used.
Lighting control panels and contactors shall be located away from occupied spaces and shall be accessible. All lighting control panels and contactors will have a hand off auto switch. Electrical spaces and corridor ceiling spaces are acceptable. Latching type relays will be used.

Systems utilizing a carrier frequency for control shall not be used.

Locate photocells in protected, accessible areas.

Design Evaluation

The following information is required to evaluate the design:

- **Schematic Design Phase**
  - Zones with foot-candle levels are needed for the lighted spaces; provide information on fixture types to be used, energy code requirements, and the different control designs being considered.

- **Design Development Phase**
  - A description of the fixture layout and the switching schemes to be used in the different lighted spaces.
  - Light-level calculations with the factors used in calculating the levels, to evaluate the efficacy of the design.

- **Construction Documents Phase**
  - Description of all of the fixtures to be used (provide with the schedules circuited with the lighting homeruns). Provide control diagrams for the different areas of the lighting design.

Submittals

Luminaires, lamps, and ballasts shall be submitted with all lighting control equipment to be used in the design.

Products, Materials, and Equipment

Average luminaire efficiency shall be greater than 75 percent for the entire interior lighting system. Use white reflecting surfaces with a total reflectance greater than 88 percent and anodized aluminum reflecting surfaces with a total reflectance greater than 93 percent.
Flat lenses shall be mounted in frames designed for replacement with lenses up to .38 inch thick.

1. Clear plastic lenses shall be 0.125 inch minimum thickness, virgin acrylic.
2. Use pattern 12 lenses where a diffuse light source is desired.
3. Pattern 15 lenses are preferred to minimize imaging on video monitors.
4. Areas intended for exclusive computer use may require Holophane #8248 or high-efficiency parabolic louvers.
5. Sealed luminaires with Corning pattern 79 glass lenses are preferred in sterile areas.

Fluorescent lamp sockets shall be selected for high-frequency ballast use. Typically provide knife-edge lamp sockets. Provide Vossloh rotary lock sockets or similar easy-to-use positive locking sockets for lamps that can fall out of the luminaire if the socket connection fails (such as strip and industrial luminaires).

Provide 20 percent spare of each type of lamp installed on the project.

Building entrance, landscape, and courtyard lighting shall have automatic control. Use enclosed amalgamated compact fluorescent up to 42 watt and 70 watt or higher metal halide. Luminaires shall be heavy-duty cast, non-ferrous metal construction designed to withstand anticipated weather conditions.

A list of approved luminaires is available from University of Cincinnati Construction Management (CM).

**Fluorescent T8 Lamp Ballasts**

This specification uses the term “programmed-start” to describe ballasts incorporating a starting sequence in which lamps are not started until the \( R_n/R_c \geq 4.25 \) and \( \leq 6.25 \).

Transient protection shall meet Institute of Electrical and Electronics Engineers (IEEE) 587, Category A requirements.

Socket voltage to luminaire ground or another socket shall not exceed the socket voltage rating under any operating condition.

Power current flow to lamps shall alternate at greater than 42 kHz.

Current crest factor shall be \( >1.35 \) and \( \leq 1.5 \) for rapid-start and programmed-start ballasts, and \( <1.7 \) for instant-start ballasts.

Ballasts shall be Underwriters Laboratories (UL) listed, Class P.

Ballasts shall have a sound rating of A or better.

Ballasts designated Normal Output shall be programmed-start and have a ballast factor of .85 to .93.
Ballasts designated High Output shall be rapid-start and have a ballast factor of 1.18 to 1.28.

Ballasts designated Dimming shall be programmed-start and have a ballast factor range of .05 to \( \geq .90 \).

Ballasts designated Low Temperature shall be used where lamps sometimes start in temperatures below 50 degrees F. Low-temperature ballasts shall start F32T8 lamps at 0 degrees F, shall be normal or high output, shall have less than 20 percent total harmonic distortion (THD), and may be instant-start.

Compact fluorescent lamps shall have rapid-start ballasts.

*Fluorescent T4/T5 Lamp Ballasts*

Ballasts shall be electronic rapid-start with a ballast factor of .95 to 1.05, a power factor greater than .95, and less than 10 percent total harmonic distortion.

Ballasts shall have protection circuitry which turns off the lamp at the end of lamp life, or, if an inappropriate lamp is installed, before damage occurs to lamps, socket, or ballast.

*Illuminated Exit Signs*

Illuminated EXIT signs shall use light-emitting diodes (LEDs) as the source of illumination.

1. The housing and faceplate shall be white in color (other colors must be approved).
2. Input power shall be less than 5 watts per face and operate on dual voltage 120/277 VAC.
3. EXIT signs shall comply with UL 924 and U.S. Environmental Protection Agency (EPA) EnergyStar Specifications at the end of 5 years of continual use.

Letters shall be red and not less than 6 inches high, and strokes shall not be less than 0.75 inch wide. Luminance contrast shall be greater than 0.8.

1. At the end of 5 years of continual use (when measured at 0 degrees and 45-degree viewing angles), average luminance shall be greater than 15 candelas/meter, minimum luminance shall be greater than 8.6 candelas/meter, and maximum-to-minimum luminance ratio shall be less than 20:1.
2. Letter illumination shall appear even when viewed in a typical installation.
3. The manufacturer shall replace all defective parts for 5 years from the date of purchase.

*Installation, Fabrication, and Construction*

Design louvers and lenses to open easily, hang open from the luminaire, and be removed from the luminaire, all without the use of tools.
Support pendant-mounted fluorescent fixtures with one hanger 6 to 18 inches from each end of the luminaire, with a minimum of two hangers, plus an additional one hanger per 8 feet of luminaire.

All dimmable fixtures will have a minimum of 100 hours burn-in time before dimming.

All installation must meet current National Electrical Code (NEC) requirements.

All fixtures must be located where they can be serviced from a step ladder or standard lift.

All outside light fixtures shall have anti-siege on all mounting hardware.