UNIVERSITY OF TORONTO | Facilities & Services

Lighting and lighting control design standard (Non-addressable)

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Revision 01

Table of contents

26 50 00 Lighting

1. The lighting systems and lighting control can be categorized into three basic configurations:
    a. Line voltage switching and dimming.
    b. Hardwired local low voltage control, switching, and dimming, including local multi-zone controllers, and local multi-zone controllers with programmable pre-set selection.
    c. Full building network lighting control systems, with switching and dimming, including programmable scheduling, daylight harvesting, and multi-zone controls.
2. The dimming functionality shall be provided through:
    a. Local line voltage devices.
    b. 0 - 10 V dimming control.
    c. Digitally addressable LED drivers shall not be used.
3. Retrofit and fit-out of existing spaces shall match the existing base building system.
4. The Design Team shall follow the lighting design practices as described in:
    a. IES LP-6-20 Lighting Control Systems - Properties, Selection, and Specification,
    b. IES LP-16-22 Documenting control Intent Narratives and Sequence of Operation.
5. Where a base building lighting control system does not exist, compatible devices shall be used to permit future integration with Athena or Encelium networked lighting control system.

26 50 01 General requirements

1. The University of Toronto is actively pursuing reliable, effective, efficient, and more sustainable indoor systems for new, renovation, and retrofit applications. Lighting is an important functional requirement that must be suitable for the application, be consistently applied, and be energy efficient. This design standard is the basis to create specifications for the lighting system.
2. All lighting shall be LED type with electronic driver.
3. All incandescent, fluorescent, and HID lighting sources are not acceptable.
4. All fixtures shall be rated at 120 V.

5. All lighting shall be fed from lighting panels (LP).
6. This section shall be read in conjunction with section 26 50 03 Lighting and lighting control systems, 26 50 23 Lighting control devices, 26 50 43 Network lighting controls, and 26 51 19.01 LED drivers.
7. This design standard shall be read in conjunction with the Deliverable Standard.

26 50 02 Retrofit requirements

1. This section applies to all lighting renovations, retrofits, replacements, and maintenance for facilities on the St. George campus. All incandescent, fluorescent, and metal halide lighting systems shall be replaced with suitable LED systems. Consultant shall use readily available and standard fixture/lamps to maintain installation and maintenance consistency across the campus.
2. The primary basis for interior lighting design shall be LED technologies with occupancy and dimming controls.
3. For renovations, light levels shall be taken and recorded at the project site before the project begins to define the baseline level and compare with industry standards. U of T shall sign off on the approved light levels before the project proceeds.
4. A consultant shall be retained if lighting circuits are to be rewired to accommodate new control strategies (such as zone lighting, emergency lighting, new voltage, rewiring, new or relocated lighting panels, etc).
5. The lighting system shall incorporate occupancy/dimming/daylighting control strategies that are capable of being integrated into full building lighting control system in the future.
6. If existing fluorescent luminaire is to be retained, the existing ballast shall be removed, and a LED driver installed. The consultant shall verify that the existing wiring to the lamp sockets is compatible with the LED driver and re-wire as necessary.
7. Lamps/fixtures/sensors shall be listed and eligible for current incentive plans. The consultant shall verify if the project is eligible for incentives with the University of Toronto before signing off on the design and purchasing product. All incentive applications shall be filed and approved by the U of T.
8. Documentation required to complete any active incentive programs shall be provided with the design.

9. Suppliers/manufacturers for LED technologies shall be from any of: GE, OSRAM, Sylvania, Leviton, Cooper.

26 50 03 Lighting and lighting control systems

1. General
   a. This section provides guidance to establish a degree of lighting solution consistency and standardization across campus. LED lamps and fixtures shall be used.
   b. University of Toronto requires designed lighting control systems to be robust, reliable, maintainable, and easily operated. All life cycle cost assessments shall be considered for lighting systems, lamps, fixtures, and lighting control systems.

2. Design requirements
   a. Energy standard
      i. Designs shall meet lighting power density requirements, levels, and performance criteria established in the following standards:
         a. ANSI/ASHRAE/IESNA - 90.1
         b. ANSI/ASHRAE/USGBC/IES 189.1
         c. International Dark Sky Association – IDA/IES Model Lighting Ordinance
         d. Canadian Underwriters Laboratories
         e. Energy Star (www.oee.nrcan.gc.ca)
         f. Consortium for Energy Efficiency (www.cee1.org)
         g. Design Lights Consortium (www.designlights.org)
         h. Ontario Power Authority – saveONenergy Program Criteria (www.saveonenergy.ca)
      ii. Consultant shall prepare a life cycle cost assessment for lighting solutions that presents the costs to operate and replace components over a minimum 10-year cycle.
      iii. Certification: All lamps and fixtures shall be CSA, UL-Canada, or equivalent with recognized certificate marks in OESC.
      iv. LED technologies listed with Energy Star/DLC tested to IESNA LM-80-08.

   b. Illumination levels
      i. Unless otherwise indicated in this document, illumination levels shall conform to

recommended minimum values identified by the current edition of the Illuminating Engineering Society of North America (IESNA) Lighting Handbook.

ii. The consultant shall follow the guidelines of IESNA Recommended Practice RP-3, Lighting for Educational Facilities.

iii. If task illumination levels as defined in the IESNA Lighting Handbook are not sufficient (based on the site-specific application), ambient and task lighting levels shall be adjusted to a higher level with concurrence of University of Toronto. Ambient light level shall not be less than one-third the task light level. Task Lighting shall be connected to a switched receptacle controlled by the lighting control system.

iv. In small areas, such as restrooms or portions of egress areas, where a single luminaire is installed, a long-life product (greater than 50,000 hours) shall be used.

v. The consultant shall ensure that the selected LED and drivers can effectively implement strategies such as dimming, daylight harvesting, high end trim, level scheduling, or similar techniques.

c. Lighting efficiencies

i. The consultant shall ensure operating temperatures are suitable according to manufacturer's guidelines and warranties.

ii. All interior lighting solutions shall allow for strategies including high end trim from 50–100%, occupancy/vacancy, daylight harvesting, and personal dimming with compatible ballast/lamp combinations.

d. Light emitting diode (LED) lighting systems

i. LED shall be the base lighting design solution for all interior and exterior applications.

ii. Where applicable, wet location rated fixtures shall be used.

iii. Colour temperatures shall be 3,500 ºK for interior applications and 3,000–3,500 ºK for exterior applications.

iv. Colour rendering index, CRI, shall be greater than 85.

v. Fixtures/lamps shall be rated using LM-80-08 rating for > 35,000 hours on retrofit applications and > 50,000 hours for fixtures.

vi. All LED lamps shall include heat dissipation features to allow normal operation

and design life in fixtures being specified.

e. Sustainability requirements
   i. The consultant shall follow the lighting design requirements listed in University of Toronto's Tri-campus Energy Modeling and Utility Performance Design Standard.

3. Total life cycle cost of ownership
   a. The lighting system design shall consider solutions that offer the lowest total life cycle cost of ownership.
   b. The Consultant shall collaborate with all associated manufacturers to provide total cost of ownership information (life cycle cost analysis) for proposed lighting systems to the University. The Consultant shall prepare an energy density evaluation of the lighting systems.
   c. Luminaire height shall be kept to a minimum to allow lamp replacement from an 8-foot ladder.
   d. All fixtures will be compared using initial luminaire lumens taking into consideration fixture efficiency. If luminaire efficiency is not shown, 70% will be assumed.

4. Documentation
   a. Refer to the University of Toronto's Deliverable Standard for required deliverables.

5. Product requirements
   a. System description/performance
      i. Lamps and luminaires shall be selected for high efficiency, initial luminaire lumens including fixture efficiencies, application-based illumination, low energy, and best value life cycle cost.
      ii. Lighting systems shall be designed to achieve the required levels of illumination while minimizing energy consumption. Illumination levels shall be measured in maintained horizontal foot-candles on a working surface located 0.75 m above floor level, within a tolerance of plus or minus 20 percent in non-work areas, in accordance with the current edition of the IESNA Lighting Handbook for average maintained lumens.
      iii. Do not provide luminaires with fuses or receptacle outlets.

   b. Lighting control requirements

The table below contains the control strategies that shall be considered for both retrofit and new construction work.

Space	Occupancy/ vacancy sensor	Daylight Harvesting	Scene Based Dimming	Personal Control	Central Control
Auditorium	A	B	A	A	B
Residence Bedroom	A	B	N/A	A	N/A
Classroom	A	B	A	A	B
Conference Rooms	A	B	A	A	B
Corridors*	A	B	N/A	N/A	B
Dining halls	A	B	B	B	B
Gymnasiums	A	B	A	A	B
Kitchen	B	N/A	N/A	N/A	N/A
Laboratories	A	B	NA	N/A	N/A
Lecture halls	A	B	A	A	B
Libraries	A	B	B	N/A	N/A
Lobbies	A	B	B	N/A	B
Locker rooms	A	B	N/A	N/A	B
Lounges	A	B	B	B	N/A
Mechanical/Electrical	B	N/A	N/A	A	N/A
Music rooms	A	B	N/A	A	B
Open office	A	B	N/A	B	B
Private offices	A	B	N/A	A	B
Stairways*	A	B	N/A	N/A	N/A
Storage areas	A	N/A	N/A	N/A	N/A
Toilets*/ common/ general	A	B	N/A	N/A	N/A
Waiting areas	A	B	N/A	N/A	N/A
Workshops	A	N/A	N/A	A	N/A
Toilets- residence/private/	A	B	N/A	N/A	N/A

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KEY: *Where not in conflict with applicable codes. Consider partial shutdown strategies.

A - Required for this space B – Optional for this space N/A – Not applicable

c. Lighting control system requirements
   i. Occupancy/vacancy sensors
      a. Vacancy (manual on) sensors shall be considered where nuisance activations could be an issue. All offices shall include occupancy controls.
      b. Timeout options should have a range from 1 minute to 30 minutes.
      c. Integral photo sensor is not acceptable.
   ii. Daylight harvesting
      a. Shall be considered for control of lighting in areas adjacent to exterior facades and in areas containing skylights. Shall be compatible with dimming strategies. Refer to ANSI/ASHRAE/IESNA 90.1/189.1
      b. Daylight harvesting shall be considered during fixture layout to ensure fixture dimming within the distance specified in the Tri-Campus Energy Modeling and Utility Performance Design Standard.
      c. One exterior daylight sensor per facade is the required minimum. The consultant shall layout perimeter circuits to allow for daylighting control. Daylight control shall be capable of continuous dimming of multiple zones.
      d. All controls (daylight sensors, occupancy sensors, wall stations) shall be capable of connection directly to the LED driver for ease of installation. Upon loss of control signal, driver shall default to “full on” state.
      e. Automated shading shall be approved by University of Toronto.
   iii. Personal control
      a. Where daylight harvesting is possible, personal control shall include daylight/dimming strategies to directly control the lighting and dimming in the space.
      b. Office zoning shall allow for on/off/dimming and daylight harvesting (where appropriate daylight levels available) controlled individually.
   iv. Switching systems
      a. Shall be utilized for areas where dimming is not appropriate. Centralized panels and distributed switching modules shall be rated for 1,000,000 electrical operations.

b. Switching systems shall be capable of astronomic time clock and occupancy control.
c. Pin based time clock systems are not allowed.

v. Total building lighting control
   a. A network lighting control system shall be considered in all new construction and renovation projects.
   b. Lighting control system shall be an intelligent, distributed control system that automatically maximizes lighting energy efficiency that includes room controllers, occupancy sensors, switches, daylighting sensors, lighting control panels, interfaces and accessories to provide energy saving strategies.
   c. Shall continue to operate independently if communications with the BAS is lost.

d. Manufacturer support and commissioning
   i. When occupant sensors, time switches, programmable schedule controls, or photo sensors are installed, the following shall be confirmed:
      a. Placement, sensitivity, and time-out adjustments for occupant sensors yield acceptable performance.
      b. Photo sensor controls reduce electric light levels.
      c. Dimming levels are operating as programmed.
   ii. Lighting control system supplier shall provide technical support during normal business hours, maximum 24 hour turn around.
   iii. Refer to Building Commissioning Standard for the contractor's and commissioning agent's responsibilities.

e. Quality control
   i. After the lamps have been in service for approximately 100 hours, obtain foot-candle measurements during periods of darkness at enough locations to demonstrate that the design criteria have been met. Submit the results to the University of Toronto.
   ii. For noise, electrical or wireless sensitive applications, verify that ballasts noise/electrical/wireless specifications meet BOD requirements in Deliverable Standard.
   iii. Lamp, ballast and fixture manufacturers/suppliers shall be dedicated and experienced lighting solution providers with local lighting solutions market presence over five years.

26 50 23 (a.k.a. 26 09 23) – Lighting control devices

1. All controls shall be hardwired. Wireless controls will only be considered in areas with heritage finishes.
2. Line voltage devices shall be specification grade.
3. Lighting controls and luminaire drivers shall have 100% compatible control protocols.
   The consultant shall coordinate with driver and luminaire manufacturers, low voltage relay panel manufacturers and dimmer/occupancy control manufacturers to ensure that components are compatible with each other and that interconnections do not affect performance, life, or any warranties.
4. General requirements for sensors:
   a. Occupancy/vacancy sensors (manual on) shall be dual technology, passive infrared (PIR) and ultrasonic sensors.
   b. Daylight sensors for daylight harvesting to be provided where required for dimming or controlling lights in areas of windows and atriums/skylights.
   c. Devices shall be ceiling mounted independent of the light fixtures.
   d. 2.4 GHz, 5Ghz, and 6Ghz Doppler microwave technology is not acceptable.
   e. Microwave occupancy sensors are permitted only if devices can be shown to not interfere with existing, new, or future Wi-Fi signal channels.
5. For outdoor applications:
   a. Outdoor lighting shall be controlled by an astronomical time clock turning on 30 minutes prior to dusk and shutting off 30 minutes after dawn.
   b. Outdoor sensors, photocell, shall be in weatherproof and rain tight enclosure with adjustable light level from 5.4 lux to 2150 lux
6. Consultant shall confirm exact sequence of operation with the University.
7. Where occupancy/vacancy sensor is used in low movement spaces such as office and washroom spaces, the auto-off timing shall be adjusted and/or an auxiliary detection system shall be installed to reduce nuisance shut offs. Adjustable time delay shall be set to a minimum of 15 minutes.
8. Lighting control system touch screen interfaces accessible to the end user shall not be made accessible to the public. Provide transparent, polycarbonate, ventilated, and lockable enclosure for touch screen interfaces indoors.

9. Where luminaires are fed from normal and emergency power circuits, provide suitable relays and provisions to ensure that operation of luminaires on emergency power are maintained during loss of normal power. All relays used to control emergency fixtures shall be UL 924 listed.
10. An integrated fire alarm module shall be installed to establish a connection between the fire alarm system and the lighting control system. Upon fire alarm activation, the lighting control system shall initiate an emergency sequence, transitioning dimmed lighting to full brightness. Once the fire alarm event is resolved, lighting levels shall return to the previous state. Additional interfaces, modules, and connectors shall be provided to ensure a comprehensive system integration.
11. All system interfaces, module, connectors, and components shall be approved by the University of Toronto.
12. All devices shall be new and available in current offering for 10 years before being obsolete.

26 50 43 (a.k.a. 26 09 43) – Network lighting controls

1. Lighting control system shall adhere to the latest edition of the following standards:
    a. OBC SB-10 standards
    b. Toronto Green Standard
    c. University of Toronto – Electrical Design Standard
    d. University of Toronto – Building Automation Systems Design Standard
    e. University of Toronto – Facility Accessibility Design Standard, and
    f. University of Toronto – Tri-Campus Energy Modeling and Utility Performance Design Standard
    g. ANSI/IES LP 6-20 – LP Lighting Control Systems – Properties, Selection and Specification
    h. ANSI/IES LP 16-22 – LP Documenting Control Intent Narratives and Sequence of Operation
2. Lighting control system shall be CSA, ULC, ETL listed, or shall have an equivalent listing acceptable in Ontario.
3. Lighting control system software shall run on a local server. It shall be accessible via web client. See Figure 1 for high level lighting control diagram.
4. The lighting control system shall be stand-a-lone in the building/facility where installed and provide remote alarms to the local BAS and EMRS for alarm dispatch. The system shall be

remotely accessible via the F&S Network, by users with access to the F&S Network. Refer to the BAS Design Standard.

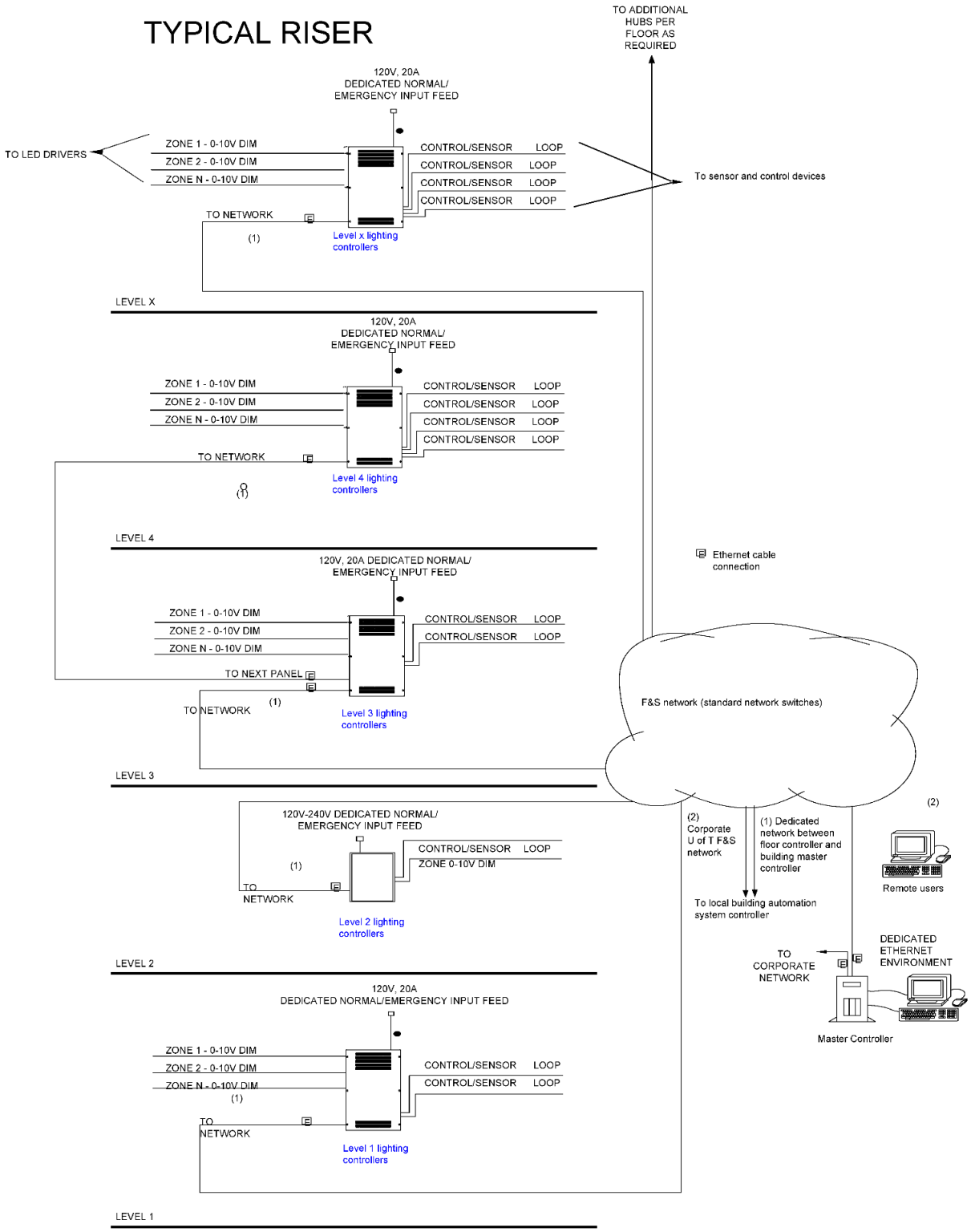
5. Lighting control system shall be able to monitor and report to the Building Automation System (BAS) the following parameters:

Type of Failure	Electrical Condition
Electrical Fault	Driver or control system fault including loss of power or comms.
Occupancy	Zone occupancy time stamped occupied / not occupied
Load	Power consumption by zone

6. Lighting control system shall report failures and status to the existing ERMS system through BACnet using intrinsic alarms. Refer to the U of T Building Automation Systems design standard for connection, integration, and communication requirements.
7. The lighting control system shall provide monitoring and reporting functionality for at least the following:
    a. Schedule, schedule changes, and schedule overrides,
    b. Occupancy/vacancy report for afterhours,
    c. Faults and Failures, including, communication, device faults, loop faults, driver faults and electrical faults,
    d. Load monitoring by zone and to the device level.
    e. Light level settings and deviations from the settings.
8. All sensors and control devices shall be on a dedicated signal circuit.
9. Provide integral 0 -10 v dimming drivers. Power/switch packs are permitted where dimming is not possible/feasible.
10. Illumination levels shall be field-programmable for emergency power conditions.
11. The lighting control system shall provide light level control to permit the field adjustment of the lighting system to balance the light levels in the space, including high-end trim settings. This will allow the light output to be adjusted during the burn-in period and adjust for depreciation as the lighting system ages.
12. All lighting control wiring shall be sized and wired as per manufacturer’s recommendations.
13. The system shall have the ability to be expanded to an additional 20% connection capacity and storage capacity.

14. The lighting controllers shall be installed in the local electrical room. Provide the appropriate wall-mounted panel as required. The ethernet cables shall be extended from the controller to the local F&S Network switch. Refer to the BAS Design Standard for the necessary cabling and patching requirements.
15. The lighting control workstation shall be installed in the property manager's office, or office as designated by U of T, to meet the project requirements.
16. Acceptable systems:
    a. Athena from Lutron
    b. Encelium series from Legrand

Figure 1 – Typical high level lighting control diagram



26 51 19 LED interior lighting

All new interior lighting installations shall be LED type. Refer to general

requirements in section 26 50 00 Lighting for specific details.

26 51 19.01 LED drivers

A. General Requirements:

1. Operate for at least 50,000 hours at maximum case temperature and 90 percent non-condensing relative humidity.
2. Provide thermal protection by automatically reducing power output to protect LED driver and LED light engine/fixture from damage.
3. Provide integral recording of operating hours and maximum operating temperature.
4. Power factor greater than 0.90 at maximum power.
5. Total harmonic distortion (THD) current less than 20% at maximum power.
6. Class A sound rating; Inaudible in a 27 dBA ambient.
7. No visible change in light output with a variation of plus or minus 10 percent change in line-voltage input.
8. LED drivers of the same family/series shall ensure consistent and synchronized dimming or lighting control across all the fixtures at all light levels.
9. LED Driver shall be constant voltage, 0-10 V dimming control, from 100 to 0.1% of measured output current, 1% relative light output.
10. The design shall allow for precise adjustment of LED driver output current increments of 10mA or smaller. The adjustment shall be programmable to enable the configuration of custom fixture length and lumen output while meeting a low-end dimming range of 100 to 1 percent.
11. The design shall meet NEMA 410 inrush requirements for mitigating inrush currents with solid state lighting sources. Inrush limiting circuit to decrease the breaker nuisance tripping (inrush <2A).
12. Employ integral fault protection up to 120 V.

13. Individually 0-10 V dimming control, 0.1 percent dimming with Soft-On and Fade-to-Black low-end performance:

a. Features smooth fade-to-on and fade-to-low end dimming performance for an incandescent-like dimming experience.
b. Driver outputs shall be short circuit protected and open circuit protected.

26 52 00 Safety lighting

26 52 13 Emergency and exit lighting

1. All new emergency lighting installations shall be LED type. Refer to general requirements in section 26 51 19 LED interior lighting for specific details.
2. All emergency and exit lighting shall be fed from a life safety lighting panel.
3. Where a centralized emergency source is available in the building, all emergency and exit lighting shall be fed from that source. Rechargeable battery operated and self-contained emergency lighting units are not permitted with the exception noted in section 26 52 13.13 Emergency lighting.

26 52 13.13 Emergency lighting

In addition to the requirements outlined in section 26 52 13 Emergency and exit lighting, substations and generator rooms/enclosures shall also have emergency wall-mounted, rechargeable, battery-operated, and self-contained emergency lighting units.

26 52 13.16 Exit signs

In addition to the requirements outlined in section 26 52 13 Emergency and exit lighting, exit signs shall be of Green Running Man style or match existing building type.

26 56 00 Exterior lighting

26 56 13 Lighting poles and standards

All new lighting poles and standings lighting installations shall be LED type. Refer to general requirements in section 26 50 00 Lighting for specific details.

26 56 19 LED exterior lighting

Refer to section 26 50 00 Lighting for specific details.

i. Exterior lighting levels shall be based on IESNA/IDA lighting zone 2 (LZ2) hardscape criteria, refer to IESNA TM-15.

ii. Flood light applications shall have beam angle over 35º.