**SECTION 26 51 00**

**INTERIOR LIGHTING**

**BASED ON DFD MASTER ELECTRICAL SPEC DATED 09/03/24**

This section has been written to cover most (but not all) situations that you will encounter. Depending on the requirements of your specific project, you may have to add material, delete items, or modify what is currently written. The Division of Facilities Development expects changes and comments from you.

It is the intent of all new DFD projects that the interior and exterior lighting be LED type. Fluorescent luminaires may be used with the DFD’s consent to match existing installations.

**PART 1 - GENERAL**

**SCOPE**

The work under this section includes interior luminaires and accessories, exit signs, and building-mounted exterior lighting. Included are the following topics:

PART 1 - GENERAL

 Scope

 Related Work

 Reference Standards

 Submittals

 Operation and Maintenance Data

 Extra Materials

 Definitions

PART 2 - PRODUCTS

 Interior Luminaires and Accessories

 Prohibited Lamp Types

 LED Luminaires

 LED Drivers

PART 3 - EXECUTION

 Installation

 Adjusting and Cleaning

 Interface with Other Products

 Zero-to-10V Dimming Control Wiring Installation

 Field Quality Control

 Luminaire Connections

 Construction Verification Items

 Agency Training

RELATED WORK

Applicable provisions of Division 1 govern work under this Section.

Section 01 91 01 or 01 91 02 – Commissioning Process

Section 26 08 00 – Commissioning of Electrical

Section 26 27 26 – Wiring Devices

Consult with DFD Engineer and Agency if there will be any lighting powered via Power over Ethernet (PoE) cabling. Section 27 10 00 – Structured Cabling may need to be edited specifically for the lighting PoE cabling. UW-Madison has special color requirements for PoE cabling used for lighting: Plenum – Black; Non-Plenum – Green. See UW Madison’s Division 27 Technical Guidelines: <https://cpd.fpm.wisc.edu/technical-guidelines/>.

[Section 27 10 00 – Structured Cabling]

REFERENCE STANDARDS

IEEE 1789 – Recommended Practices for Modulating Current in High-Brightness LEDs for Mitigating Health Risks to Viewers.

RoHS – Restriction of Hazardous Substances. Council of the European Union (EC) Directive 2002/95/EC on the restriction of the use of certain hazardous substances in electrical and electronic equipment.

LM-79-08 (or latest) – IES Approved Method for the Electrical and Photometric Measurements of Solid-State Lighting Products.

LM-80-08 (or latest) – IES Approved Method for Measuring Lumen Maintenance of LED Light Sources.

TM-21-11 (or latest) – IES Technical Memorandum on Projecting Long Term Lumen Maintenance of LED Light Sources.

NEMA SSL 1-2010 (or latest) – Electronic Drivers for LED Devices, Arrays, or Systems.

**SUBMITTALS**

Include outline drawings, lamp and ballast data, support points, weights, accessory information and performance data for each luminaire type.

For each luminaire type, submit luminaire information including catalog cuts with highlighted catalog numbers and required accessories:

* Luminaire:
	+ Manufacturer and catalog number,
	+ Type (identification) as indicated on the plans and schedule,
	+ Delivered lumens,
	+ Input watts,
	+ Efficacy,
	+ Color rendering index.
* Driver:
	+ Manufacturer and catalog number,
	+ Type (Non-Dimming, Step-dimming, Continuous dimming, etc.),
	+ Power Factor, Crest Factor, THD, etc.

# **OPERATION AND MAINTENANCE DATA**

All operations and maintenance data shall comply with the submission and content requirements specified under section GENERAL REQUIREMENTS.

***Coordinate Extra Materials with the facility staff. If they want spare luminaires and drivers, add a general note on the Luminaire Schedule on the drawings that states “Provide Extra Materials (spares) per specification sections 26 51 00 Interior Lighting and 26 56 29 Site Lighting.” Edit the quantity of spares below as coordinated with the facility staff.***

**EXTRA MATERIALS**

# Provide one (1) of each type of luminaire.

# Provide one (1) LED driver of each type.

**DEFINITIONS**

Driver: The power supply used to power LED luminaires, modules, or arrays.

L70, L70, or L70%: The reported life of an LED component or system to reach 70% lumen maintenance, or 70% of the LED’s original light output.

LED’s: Broadly defined as complete luminaire with light emitting diode (LED) packages, modules, light bars or arrays, complete with driver.

LED luminaire failure: Negligible light output from more than 10 percent of the LEDs, or less than 70 percent of the listed lumen output constitutes luminaire failure.

**PART 2 - PRODUCTS**

***Provide Luminaire Schedule on the drawings with three catalog numbers of each type of luminaire as shown on the DFD website.***

**INTERIOR LUMINAIRES AND ACCESSORIES**

See the Luminaire Schedule on the drawings for types of luminaires and catalog numbers. Catalog numbers are shown on the drawings for quality and performance requirements only. Luminaires manufactured by others are equally acceptable provided they meet or exceed the performance of the indicated luminaires and meet the intent of the design.

Luminaire shall be listed by a NRTL (Nationally Recognized Testing Laboratory: e.g. UL, ETL, etc.).

Provide luminaires with quick-connect disconnecting means similar to Thomas & Betts Sta-Kon.

**PROHIBITED LAMP TYPES**

Fluorescent, metal halide, high-pressure sodium, low-pressure sodium, mercury vapor, halogen, and incandescent lamp types are prohibited.

General Use Incandescent Lamps and Incandescent Reflector Lamps are also prohibited. Use LED retrofit lamps or LED luminaires in lieu of fluorescent, incandescent, or halogen lamps. LED fluorescent replacement lamps shall be line-voltage compatible or compatible with the existing ballast type as coordinate with facility staff and DFD.

LED retrofit lamps shall be:

* Rated for the voltage of the incandescent lamp/luminaire they are replacing.
* Dimmable where required as indicated on the plans.
* Rated for the luminaire in which they are being installed. Verify whether the luminaire is enclosed and whether the LED retrofit lamp is rated for enclosed luminaires and the temperatures that will be encountered.
* LED lamps/luminaires shall provide delivered footcandles equal to or greater than the footcandles provided by an equivalent incandescent lamp/luminaire.
* LED retrofit lamps shall have an average rated life of 25,000 hours, minimum.
* Lamp color temperature shall be nearly equal to the incandescent lamp it is replacing.

All lamps shall be new.

**LED LUMINAIRES**

* LED Luminaires shall meet all DesignLights Consortium® (DesignLights.org) Product Qualification Criteria. This does not require that the luminaire be listed on the DesignLights Consortium’s® Qualified Products List, but they must meet the Product Qualification Criteria. The technical requirements that the luminaire shall meet for each Application Category are:
	+ Minimum Light Output.
	+ Zonal Lumen Requirements.
	+ Minimum Luminaire Efficacy.
	+ Minimum CRI.
	+ L70 Lumen Maintenance.
	+ Minimum Luminaire Warranty of 5 years (not pro-rated) to include LED driver and all LED components.

*Additional requirements:*

* Color Temperature of 3000K-4100K for interior luminaires as listed in the Luminaire Schedule on the plans. The color temperature of exterior LED luminaires should not exceed 4100K (nominal).
* Color Consistency: LED manufacturer shall use a maximum 3-step MacAdam Ellipse binning process to achieve consistent luminaire-to-luminaire color for interior luminaires. Exterior luminaires shall use a maximum 5-step MacAdam Ellipse binning process.
* Glare Control: Exterior luminaires shall meet DesignLights Consortium’s® criteria for Zonal Lumen Distribution requirements or Backlight-Uplight-Glare (BUG) standards for exterior luminaires.
* Luminaire shall be mercury-free, lead-free, and RoHS compliant.
* Luminaire shall comply with FCC 47 CFR part 15 non-consumer RFI/EMI standards.
* Light output of the LED system shall be measured using the absolute photometry method following IES LM-79 and IES LM-80 requirements and guidelines.
* Luminaire shall maintain 70% lumen output (L70) for a minimum of 50,000 hours.
* Lumen output shall not depreciate more than 20% after 10,000 hours of use.
* Luminaire and driver shall be furnished from a single manufacturer to ensure compatibility.

***Where color rendering is extremely important, specify a CRI of 95 and an R9 value of 80+.***

* Luminaire Color Rendering Index (CRI) shall be a minimum of 80 for interior luminaires, and a minimum of 70 for exterior luminaires.
* LED luminaire shall be thermally designed as to not exceed the maximum junction temperature of the LED for the ambient temperature of the location the luminaire is to be installed. Rated case temperature shall be suitable for operation in the ambient temperatures typically found for the intended installation. Exterior luminaires to operate in ambient temperatures of -40°F to 104°F (-40°C to 40°C).
* Luminaire shall operate normally for input voltage fluctuations of plus or minus 10 percent.
* Luminaire shall have a maximum Total Harmonic Distortion (THD) of <20% at full input power and across specified voltage range.
* All connections to luminaires shall be reverse polarity protected and provide high voltage protection in the event connections are reversed or shorted during the installation process.
* All luminaires shall be provided with knockouts for conduit connections.
* The LED luminaire shall carry a limited 5-year warranty minimum for LED light engine(s)/board array, and driver(s).
* Provide all of the following data on submittals:
	+ Delivered lumens
	+ Input watts
	+ Efficacy
	+ Color rendering index.

*LED Luminaires used for Emergency Egress Lighting:*

* The failure of one LED shall not affect the operation of the remaining LEDs.

*Emergency LED Luminaire Compatibility with Inverters:*

* Emergency Inverters shall be sine-wave type, or have written confirmation from the luminaire manufacturer that the luminaire will function with a square-wave inverter.

**LED DRIVERS**

General:

* Provide driver type (non-dimmed, step-dimmed, continuous-dimming, etc.) as indicated on the luminaire schedule on the drawings.
* Minimum Warranty of 5 years (not pro-rated) to include LED driver and all LED components.
* Driver shall have a rated life of 50,000 hours, minimum.
* Driver and LEDs shall be furnished from a single manufacturer to ensure compatibility.
* Driver shall modulate current at high frequencies.
* Driver shall have a minimum power factor (pf) of 0.9 and a maximum crest factor (cf) of 1.5 at full input power and across specified voltage range.
* Driver shall operate normally for input voltage fluctuations of plus or minus 10 percent.
* Driver shall have a maximum Total Harmonic Distortion (THD) of <20% at full input power and across specified voltage range.
* Wiring connections to LED drivers shall utilize polarized quick-disconnects for field maintenance.
* Fuse Protections: All luminaires shall have built-in fuse protection. All power supply outputs shall be either fuse protected or be Polymeric Positive Temperature Coefficient (PTC)-protected as per Class 2 UL listing.
* Provide all of the following data on submittals:
	+ Input watts
	+ Power Factor (pf)
	+ Crest Factor (cf) at full input power
	+ Total Harmonic Distortion (THD).

Dimming Drivers:

* LED driver shall be compatible with dimming controls where dimming is indicated on the plans. Dimmable drivers shall use Dimming Constant Current (DCC), Constant Voltage, or a hybrid of Constant Current Reduction (CCR) with Pulse Width Modulation (PWM) operation. All dimmable drivers shall operate at high frequencies.
* Step-Dimming Drivers: Easily switched from 0% to 50% to 100% output power. Both switch-leg inputs shall control 50% of the luminaire’s light output equally.
* Continuous Dimming Drivers:
	+ Drivers shall conform to IEEE 1789 standards. Alternatively, manufacturers must provide product literature which demonstrates conformance with this standard.
	+ Luminaires shall dim to (10%, 1%, or 0.1%) as specified in the Luminaire Schedule on the plans without visible flicker.
	+ Luminaires shall dim without the “popcorn effect”. “Popcorn effect” is defined as the luminaire being on a pre-set dimmed level (less than 100%), and going to 100% prior to returning to the pre-set level when power is returned to the luminaire. Continuous Dimming Drivers shall use 0-10V control.

**PART 3 - EXECUTION**

**INSTALLATION**

Verify ceiling types with Architectural plans or with existing ceilings. Verify specified luminaires are compatible with specified ceiling type(s) prior to ordering luminaires.

Install in accordance with manufacturer’s instructions.

***The consultant shall provide suspension method (pendant or chain) in Luminaire Schedule.***

Install suspended luminaires using aircraft cable, or pendants supported from swivel hangers. Heavy duty chain supports may be used where indicated on the luminaire schedule. Provide aircraft cable, pendants, or chain lengths required to suspend luminaire at indicated height. All aircraft cables or pendant supported luminaires shall have an independent support to structure at all cable or pendant support locations. When chain is used, tie-wrap the luminaire wiring method to the chain.

Support luminaires larger than 2 x 4 foot (600 x 1200 mm) size independent of ceiling framing.

Provide independent support for all luminaires over 50 lbs.

Locate ceiling luminaires as indicated on reflected ceiling plan.

Install surface mounted luminaires and exit signs plumb and adjust to align with building lines and with each other. Secure to prohibit movement.

***Consultant to review the support required for the luminaire and define by detail on the drawings.***

The Contractor shall install luminaire supports as required. Luminaire installations with luminaires supported only by insecure boxes will be rejected. It shall be the Contractor's responsibility to support all luminaires adequately, providing extra steel work for the support of luminaires if required. Any components necessary for mounting luminaires shall be provided by the Contractor. No plastic, composition or wood type anchors shall be used.

Install recessed luminaires to permit removal from below.

Install recessed luminaires using accessories and firestopping materials to meet regulatory requirements for fire rating.

Install code required hardware to secure recessed grid‑supported luminaires in place.

Install wall mounted luminaires and exit signs at height as scheduled. Use pendants supported from swivel hangers in exposed ceiling/structure locations where necessary to mount exit signs at the specified height.

Install accessories furnished with each luminaire.

Make wiring connections to branch circuit using building wire with insulation suitable for temperature conditions within luminaire.

Bond luminaires and metal accessories to branch circuit equipment grounding conductor.

Install specified lamps in each luminaire and exit sign.

HID High-Bay or Low-Bay Luminaires: Use power hook hangers rated 500 pounds (225 kg) minimum and provide safety chain between ballast and structure. Also provide safety chain between reflector and ballast.

Dimmed luminaire circuits shall have separate neutrals.

Dimmed LED luminaires shall have a positive OFF, which requires turning off the circuit to the luminaire so that the luminaires don’t “glow” at the lowest dimmed setting. This shall be accomplished using a switch, relay, or some other means acceptable to DFD.

All new luminaires shall be operational at the Substantial Completion of the project.

**ADJUSTING AND CLEANING**

Align luminaires and clean lenses and diffusers at completion of Work. Clean paint splatters, dirt, and debris from installed luminaires.

Aim and adjust luminaires as indicated on Drawings or as directed by the A/E.

Touch up luminaire finish at completion of work.

**INTERFACE WITH OTHER PRODUCTS**

Interface with air handling accessories furnished and installed under Division 23.

Provide controls as indicated on the plans. Refer to section 26 27 26 - Wiring Devices. Controls shall be compatible with the luminaires/drivers being installed.

**ZERO-TO-10V DIMMING CONTROL WIRING INSTALLATION**

Zero-to-10V dimming control conductors are classified by the NEC as Class 2 conductors and shall be kept separate from line-voltage conductors per NEC 725.136(A). Matching the insulation rating of Conductors of Different Systems does not apply to Class 2 conductors per NEC 300.3(C)(1), Informational Note No.1.

Wall box dimmers shall typically be installed with two conduits: One conduit for line-voltage power, and one conduit or conduit stub for the 0-10V control wiring.

At each luminaire, separate openings (either manufactured knock-outs or punched openings) shall be used for the line-voltage power and the 0-10V wiring. The EC shall use a cable connector at the opening for the 0-10V wiring. Zero-to-10V conductors entering and within a luminaire enclosure shall maintain a minimum separation of 6 mm (0.25 in.) per NEC 725.136(D).

Zero-to-10V Dimming Control Wiring Connections:

Zero-to-10V dimming control conductors are classified by the NEC as Class 2 conductors and shall be kept separate from line-voltage conductors per NEC 725.136(A). Use code-compliant connectors to splice double-jacketed control/signal conductor pairs in MC-PCS cable, which provide the necessary separation between power and control conductors inside of the electrical box or enclosure as required per the NEC article 725.136(B) or 725.136(D). Use connectors such as IDEAL In-Sure® MC-PCS, RACO Shield-IT™, or equal products to meet this NEC code requirement.

Exposed 0-10V cables shall be installed in separate conduits from line-voltage conductors.

The 0-10V cables may be routed in free air where concealed above accessible ceilings. Cables routed in free air shall observe the following installation requirements:

The 0-10V cables may be tie-wrapped to the outside of the luminaire power raceway where allowed by NEC 300.11(B)(2). Tie-wraps shall be UL listed for UV resistance. Care should be taken in the use of cable ties to secure and anchor the cabling. Ties shall not be over tightened as to compress the cable jacket. No sharp burrs shall remain where excess length of the cable tie has been cut.

Cabling shall be neatly run at right angles and be kept clear of other trades work.

Cabling shall be secured within twelve (12) inches of direction change or termination.

Cabling shall be supported at a maximum of 5-foot intervals utilizing “J-Hook” or “Bridle Ring” supports anchored to ceiling concrete, piping supports or structural steel beams. If cable sag at mid-span exceeds 12-inches, another support shall be provided. Cable supports shall be installed to maintain cable bend to larger than the minimum bend radius.

Cabling shall not be attached to or supported by existing cabling, plumbing or steam piping, ductwork, suspended ceiling supports or electrical or communications conduit. Do not place cable directly on the ceiling grid or attach cable in any manner to the ceiling grid wires.

All cables shall be free of tension at both ends. Nylon strain relief connectors shall be provided at each device and junction box where cables enter. In cases where the cable must bear some stress, Kellum type grips may be used to spread the strain over a longer length of cable.

Cable manufacturer’s minimum bend radius shall be observed in all instances.

Use suitable cable fittings and connectors.

**FIELD QUALITY CONTROL**

Operate each luminaire after installation and connection. Inspect for proper connection and operation.

**LUMINAIRE CONNECTIONS**

METAL-CLAD (MC) CABLE WHIPS

Metal-Clad (MC) type cable that combines power and Class 2 circuits into a single cable may be used for luminaire whips where 0-10V dimming control wiring is required. Whips may not exceed six (6) feet in length. Examples of such products are Encore Wire® MC-LEDTM or Southwire® MC-PCS DuoTM. Manufacturer's names and catalog numbers are used for quality and performance only. MC Cables manufactured by others shall be equally acceptable provided they meet or exceed in performance and quality as specified.

Recessed, including Master-Satellite connections:

* Use a luminaire fixture whip from a J-box for recessed lay-in luminaires. Luminaire fixture whips shall be aluminum or steel AC Cable (Armored Cable) or Flexible Metal Conduit (FMC). Metal Clad (MC) cable that combines power and Class 2 circuits (for 0-10V dimming control) into a single cable may be used as a whip for luminaires that are dimmed.
* Cable/Conduit whips shall be 3/8" (10 mm) minimum diameter, six feet (1.8 m) maximum length.
* Flexible whips or pre-wired systems between master and satellite luminaires may be supported by the ceiling grid wires.
* The flexible connectors shall be steel, galvanized, clamp type with locknut, snap-in type with locknut, or snap-in connector type, including those used on the master-satellite units.

Chain or Cable Hung (unfinished spaces):

* Use manufacturer’s SO cord or a luminaire fixture whip from a J-box. Luminaire fixture whips shall be aluminum or steel AC Cable (Armored Cable) or Flexible Metal Conduit (FMC). Metal Clad (MC) cable that combines power and Class 2 circuits (for 0-10V dimming control) into a single cable may be used as a whip for luminaires that are dimmed.
* Conduit whips shall be 3/8" (10 mm) minimum diameter. Conduit whip or SO cord shall be cut to length (six feet (1.8 m) maximum) and shall allow movement of the chain/cable/luminaire, but shall not be long enough to “loop” and shall present a neat and workmanlike appearance.
* Luminaire field wired flexible cord installations shall be connected per NEC 410.62.
* The flexible connectors shall be steel, galvanized, clamp type with locknut, snap-in type with locknut, or snap-in connector type, including those used on the master-satellite units.
* Conduit whip slack shall be tie-wrapped to the chain supports. Tie-wraps shall be UL listed for UV resistance.

Cable Hung (finished spaces):

* Use manufacturer’s SO cord from luminaire to a J-box.
* SO cord shall be cut to length (six feet (1.8 m) maximum) and shall allow movement of the cable/luminaire, but shall not be long enough to “loop” and shall present a neat and workmanlike appearance.
* SO cord slack may be tie-wrapped to the cable supports. Tie-wraps shall be UL listed for UV resistance.
* Luminaire field wired flexible cord installations shall be connected per NEC 410.62.

Surface Mounted (unfinished spaces):

* Provide direct conduit and box connection.

Surface Mounted (finished spaces):

* Provide direct conduit and box connection. Use surface metal raceway where indicated on drawings. Conceal box and conduit where appropriate. Flexible metal conduit shall not be used where the conduit is exposed.

**CONSTRUCTION VERIFICATION**

Contractor is responsible for utilizing the construction verification checklists supplied under specification Section 26 08 00 in accordance with the procedures defined for construction verification in Section 01 91 01 or 01 91 02.

# **AGENCY TRAINING**

All training provided for agency shall comply with the format, general content requirements and submission guidelines specified under Section 01 91 01 or 01 91 02.

END OF SECTION