# [this section is new in its entirety]

# GENERAL

## SUMMARY

### Section Includes:

#### Occupancy sensors, switches, and control stations.

#### Daylighting sensors and photocells.

#### Power packs and distributed controls infrastructure.

#### System management & lighting control panels.

#### Sequence of Operations.

#### System Wiring.

### Related Documents & Sections:

#### Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 specification sections, apply to work of this Section.

#### Division 26 “Basic Electrical Requirements” sections apply to work in this Section.

#### Division 26 “Electrical General Provisions” sections apply to work in this Section.

#### Division 26 “Wiring Devices” sections apply to work in this Section.

#### Division 26 “Interior Lighting” sections apply to work in this Section.

#### Division 26 “Exterior Lighting” sections apply to work in this Section.

### Coordination Requirements:

#### Physically coordinate:

##### Placement of wall switch occupancy sensors with installed door swings.

##### Placement of occupancy sensors with millwork, furniture, equipment, or other potential obstructions to motion detection coverage installed under other sections or by others.

##### Placement of ceiling mounted occupancy sensors with lighting fixtures, HVAC supply and return, fire alarm components, projectors, speakers, and other potential obstructions.

##### Placement of photo sensors for daylighting controls with windows, skylights, and luminaires to achieve optimum operation.

#### In system planning and design coordinate:

##### Compatibility of control voltages and control interface with other systems such as HVAC controls, daylighting sensors, window shades, etc.

##### A specific and detailed sequence of operations for each space that has automatic lighting controls. The sequence of operations shall include a label, index, or other means of clearly and unambiguously indicating the intended sequence of operations for each space. See Sequence of Operations section of this specification.

##### Audio visual system interfaces on the project and coordinate the connections, functions, settings, and thresholds of the lighting controls with the space audio visual system. This work will require direct coordination with the UNL Audio Visual team.

#### Sequences of operations included in the bid and construction documents shall be reviewed with the users and approved by UNL Project Manager prior to ordering of materials or commencement of the work.

#### Notify Architect/Engineer of any conflicts or deviations from the contract documents to obtain direction prior to proceeding with work.

## DESCRIPTION OF WORK

### Design Expectations:

#### The preferred lighting control design is ‘performance based’ utilizing a sequence of operations table or similar chart that explains the list of space types and the lighting controls required in each space type. This is in lieu of a ‘prescription based’ design where all the particular lighting control devices, wiring, and central controls are explicitly shown on the plans. It is University preference to leave the exact layout, spacing, and wiring details of the installed lighting control devices & system to the lighting control vendor and electrical contractor. At designer’s discretion or as requested by the University, complete system design, device layout, and wiring diagrams shall be provided in the contract documents.

#### The construction documents shall include general & generic wiring specifications and connection diagrams for the system that is the basis of design specific for each space. Typical diagrams for similar spaces shall be acceptable for spaces with similar devices and sequence of operations. General lighting control details are expected to denote the basic elements of the lighting control system, not to pinpoint precise device layouts, wiring, rough-in locations, etc.

#### The construction documents shall include a specific sequence of operation indicated for each space with lighting controls. The plans shall include a label, index or other means of clearly and unambiguously indicating the intended sequence of operations for each space. See attached Lighting Controls Application Matrix for additional guidance.

#### Dept. of Energy (DoE) COMCheck: Designer shall provide COMcheck verification showing compliance with applicable lighting energy and control codes. Provide evidence of lighting system and controls compliance as part of the design review process prior to bidding.

#### Design system for HVAC and Audio-Visual system interfaces as noted in this specification.

### Construction Expectations:

#### The contractor is responsible for the location of all sensors, switches, user interfaces, relays and load controllers not necessarily shown on the construction documents. All physical devices shall be shown on the contractor submittal documents. Where there are multiple sensors, switches, or user interfaces in a room or space, the plans shall include labels, indexes, or other means to designate the light fixtures that are controlled by each device. Where a specified sensor has a directionally specific sensing pattern, the intended orientation shall be indicated on the plans. The labeling, indexing or other means of indication shall clearly and unambiguously indicate the design intent.

#### The lighting control system shall consist of occupancy sensors, daylight sensors, switches, user interfaces, load and level controllers, output relays, interconnecting wiring, and associated accessories required for a fully functional and complete digital lighting control system. The lighting control system shall be programmable via software interface without the use of dip switches or any other manual means of configuration. Hand-held remote setup and control devices used for initial programming, commissioning, and later adjustments to the system are acceptable but shall not be considered a substitute to permanent controls and software programs used to do those tasks.

#### Lighting controls shall be provided in each space as necessary to fulfill Project’s programming requirements and to meet Code requirements. See Lighting Controls Application Matrix.

#### Automatic lighting shutoff shall not be installed in electrical rooms, mechanical rooms, or elevator machine rooms. Automatic lighting shutoff shall not be installed in other such spaces where automatic shutoff would endanger the safety or security of the room or building occupants. A list of all spaces being exempted from automatic lighting shutoff based on safety and security concerns shall be submitted and reviewed with the University Project Manager during project design.

#### Each controlled space shall have lighting system relay contact outputs required for connection to the Building Automation System (BAS). Lighting system connections shall signal to the BAS when the room is occupied and not occupied.

#### System shall include RS-232 interface for connection to area audio visual system and controls.

#### Systems that utilize programming to set or adjust device operation or function shall include programming software and programming interface devices as required. Systems that require proprietary programming devices shall include one of each required device as part of the project. Software upgrades shall be included as ongoing manufacturer’s support of the lighting control system.

### **NOTE TO SPECIFIER: REVISE LIST OF WIRING DEVICES ACCORDING TO SPECIFIC PROJECT REQUIREMENTS.**

## QUALITY ASSURANCE

### Manufacturers: Firms engaged in manufacture of wiring devices of types, sizes, and ratings required, whose products have been in satisfactory use in similar service for not less than three (3) years.

### Installer: Qualified with at least two (2) years of successful installation experience on projects with electrical installation work like that required for this project.

### Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to the AHJ, components shall be listed by a nationally recognized testing laboratory (i.e. UL, ETL, etc…)

### System shall be listed as qualified under Design Lights Consortium Networked Lighting Control System Specification, version 2.0 or newer.

### System controls are certified by manufacturer to have been designed, manufactured, and tested for interoperability with project specific luminaires.

### Comply with NFPA 70, NFPA 101, and UL 924. All components and the manufacturing facility must be RoHS compliant.

### Electrostatic Discharge Tolerance: Design and test equipment to withstand electrostatic discharges without impairment when tested according to IEC 61000-4-2.

## COMPLIANCE, CODES & REFERENCES

### UL Compliance: Provide electrical wiring devices and controls which have been UL listed and labeled. System components shall comply with UL 916, and UL 924 standards as applicable.

### NEMA Compliance: Comply with NEMA standards for general and specific purpose wiring devices.

### NECA Compliance: Comply with NECA's "Standard of Installation”, NECA 1, and NECA 130.

### NFPA Compliance: Comply with NFPC 70, National Electrical Code.

### Energy Code: Comply w/ ASHRAE 90.1 (2016) or IECC (2018), but not both.

* 1. SUBMITTALS

### Product Data & Specification Sheets: Include ratings, configurations, standard wiring diagrams, dimensions, colors, service condition requirements, and installed features. Provide date for each lighting control panel and device. Include data on features, accessories, and the following:

#### Lighting control panels and devices.

#### Dimensions of control panels and devices.

#### Lighting control system one-line diagram.

#### Lighting control button configurations, suggested button labels, engravings, etc…

### Occupancy Sensor Layout Drawings: Scaled floor plans with lighting control manufacturer’s layout of occupancy sensors. Sensor layout and quantity shall completely cover each area indicated, show coverage patterns for each sensor. Include sensor model numbers, and orientation of each occupancy sensor, quantity and location of all power packs and all other associated system components. Also include interconnection diagrams showing field installed wiring.

### Information Technology (IT) and Audio Visual (AV) connection information pertaining to interconnection with facility IT and AV networking equipment and third-party systems.

### Field Quality Control Reports.

### Complete Bill of Materials necessary to include the networked lighting control system.

### Manufacturer’s Installation Instructions: Include application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.

### Operation and Maintenance Data: Include detailed information on device programming and setup.

### Contractor Start-Up/Commissioning Worksheet. File must be completed prior to factory start-up. Provide an example worksheet for commissioning as part of the submittal process prior to work.

### Project Record Documents: Record actual installed locations and settings for lighting control devices. Include service and support contact information for phone support, remote support, onsite support.

## DELIVERY, STORAGE, AND PROTECTION

### Store products in a clean, dry space in original manufacturer’s packaging in accordance with manufacturer’s written instructions until ready for installation.

### Only install indoor equipment when the following site conditions exist:

#### Ambient Temperature: 0 to 105 degrees F

#### Relative Humidity: less than 90%, non-condensing

## EXTRA MATERIALS

### At substantial completion of the project, furnish the following extra materials that match specified and installed products to the Owner for future use after completion of project warranty periods. Extra materials shall be delivered and stored at a location or locations directed by the Owner. Products shall be packaged with protective covering for storage and shall be suitably labeled by product type.

#### Provide five (5) spare occupancy sensors, daylighting sensors, power packs, per every 100 installed on the project. Provide a minimum of at least two (2) spares for each device type. This includes devices such as: sensors, ceiling & wall plates, power packs, photocells, and relays.

## WARRANTY

### Manufacturer’s Warranty: Manufacturer and Installer agree to repair or replace devices that fail in materials or workmanship within five (5) years from date substantial completion.

### The manufacturer shall make available to the Owner new parts, upgrades, replacements, software & firmware updates, etc. available for the installed system for a minimum of five (5) years following installation. Manufacturer shall cover all material costs associated with such upgrades.

# PRODUCTS

**NOTE TO SPECIFIER: REVISE LIST OF MANUFACTURERS AS REQUIRED FOR THE PROJECT.**

## SUMMARY

### Unless specifically indicated to be excluded, provide all required conduit, wiring, connectors, hardware, components, accessories, etc. as required for a complete lighting controls system.

### All lighting control devices on a project with a digital lighting control package shall be manufactured by the same company that makes the digital lighting control system being proposed for the project. The controls shall be completely and fully compatible with the light fixtures.

### General System Requirements:

#### Provide system architecture based upon: (1) networkable intelligent lighting controls, (2) standalone lighting control zones using distributed intelligence, and (3) optional system backbone for remote, time based and global operation.

#### Lighting control devices shall have individually addressable communications capability.

#### System must be capable of direct interface with networked luminaires such that either low voltage network cabling or wireless RF communications can be used to connect luminaires to the control components of the system.

#### System luminaires and lighting controls shall support individual (i.e. unique) configuration of device settings and properties, with configurations residing within the luminaires and control devices themselves.

#### Lighting Control Zones (LCZs): LCZs consist of one or more networked luminaires and intelligent lighting control devices and shall be capable of providing automatic control from sensors and manual control from local wall stations. These capabilities shall be provided without requiring connection to a higher-level system backbone; this capability is referred to as ‘distributed intelligence’.

#### System luminaires and controls shall have distributed intelligence programming stored in non-volatile memory, such that following any loss of power the lighting control zones shall operate according to their defined default settings and sequence of operations.

#### The lighting control zones shall be capable of network connectivity with a higher-level system backbone to provide time-based control, remote control from inputs and or systems external to the control zone, and remote configuration and monitoring through a software interface.

#### The system shall provide a means to connect the lighting control system to a system software interface and building management system via BACnet/IP.

#### All system devices shall support firmware updates, either remotely or from within the applications space, for purposes of upgrading functionality, ‘fixing bugs’, etc., at a later date.

### Wired System Requirements:

#### Connections to devices within a networked lighting control zone and to backbone components shall be with a single type of low voltage network cable, which shall be compliant with 4-conductor RS-485, or CAT5e specifications or higher. To prevent wiring errors and provide cost savings, the use of mixed types of low voltage network cables shall not be permitted.

#### Devices in an area shall be connected via a flexible topology such as “daisy-chain”, t-tapped, or star configuration, such that one error in wiring will not render all down-stream devices disabled or non-responsive. A system requiring all individual networked devices to be connected back to a central component in a “hub-and-spoke” topology shall not be permitted.

#### Provide wired network wall stations with preset scenes that can activate a specific combination of light levels across multiple local and global channels, as required.

#### Three-way / multi-way control wall stations shall be capable of controlling the same local and global control zones, so as to support ‘multi-way’ preset scene and profile scene controls from multiple entrance locations within the space.

#### Following proper installation and provision of power, all networked devices connected together with low voltage network cable shall form a functional lighting control zone without requiring any ‘significant level’ of programming, regardless of the programming mechanism (e.g. software application, handheld remote, pushbutton). The “out of box” default sequence of operation is intended to provide typical sequence of operation to minimize the system startup and programming requirements and to also have functional lighting control operation prior to system startup and programming.

#### Once software is installed, system shall be able to automatically discover all connected devices without requiring any provisioning of system or zone addresses.

#### All networked devices shall have the ability to detect improper communication wiring and blink its LED in a specific cadence as to alert installation/startup personnel.

### Wireless System Requirements:

#### Wireless systems are generally preferred only in renovation projects. Wired systems are expected for new construction applications. Comply with wireless requirements as noted below.

#### No wired connections between networked devices shall be required for the purposes of system communications.

#### Multiple wireless networking protocols shall be supported:

##### A standard based, distributed star topology type of protocol for 900 MHz communication, so as to support lighting control applications and IoT applications.

##### A Bluetooth standard protocol for 2.4 GHz communication that supports direct connection to a smartphone and tablet device, so as to support device configuration, control applications, and IoT without requiring the use of a system backbone.

##### Point-to-point 434 MHz connectivity.

#### Wireless network shall be self-healing, such that the loss of backbone or local communication between devices does not result in the loss of control of the lights in the space.

#### Wireless network communication shall support uniform and instant response such that all luminaires in a lighting control zone respond immediately and synchronously in response to a sensor or wall station signal.

#### To support the system architecture requirement for distributed intelligence, wireless network communication shall support communication of control signals from sensors and wall stations to networked luminaires and wireless load control devices, without requiring any communication, interpretation, or translation of information through a backbone device such as a wireless access point, communication bridge or gateway.

#### All wireless communication between lighting control components shall support the following four tiers of security measures:

##### Data Encryption

##### Firmware Protection

##### Authenticated User Access

##### Mutual Device Authentication

#### For typical environmental conditions and building construction materials encountered within commercial indoor lighting environments, wireless networked devices shall be capable of communicating at least 70 feet between devices to wireless access points and at least 60 feet between devices with embedded wireless transceivers under typical site conditions.

#### Wireless devices shall meet the general performance, technical, and form-factor requirements of the wired devices outlined in this specification. This includes wireless occupancy sensors, local controllers, power packs, auxiliary devices, etc.

### Functionality with Emergency Lighting:

#### Networked control devices intended for control of egress and/or emergency light sources shall not require the use of additional, externally mounted UL924 shunting and/or 0-10V disconnect devices, so as to provide a compliant sequence of operation. The following types of wired networked control devices shall be provided for egress and/or emergency light fixtures:

##### Low-Voltage power sensing: These devices shall automatically provide 100% light level upon detection of loss of power sensed via the low voltage network cable connection.

##### UL924 Listed Line-Voltage power sensing: These devices shall be listed as emergency relays under the UL924 standard, and shall automatically close the load control relay and provide 100% light output upon detection of loss of power sensed via line voltage connection to normal power.

### System Integration Capabilities:

#### The system shall interface with third party building management systems (BMS) to support two-way communication using the industry standard BACnet/IP or BACnet MS/TP protocols. The following system integration capabilities shall be available via BACnet/IP and BACnet MS/TP protocols:

##### The system shall support control of individual devices, including, but not limited to, control of relay and dimming output.

##### The system shall support reading of individual device status information. The available status will depend on the individual device type and capabilities, which may include but not be limited to, relay state, dimming output, power measurement, occupancy sensor status, and photocell sensor states or readings. All system devices shall be available for polling for devices status.

##### Provide as a minimum on all projects, a single, normally open, dry contact for HVAC control zone indication that signals space occupancy. Type SPDT relay is preferred.

#### The system shall support activation and integration with third-party audio-visual (AV) systems deployed in learning spaces, conference rooms, auditoriums, etc. System interface shall be via dry contact closure output signals or digital commands via RS-232/RS-485. AV system integration shall be coordinated with the UNL AV Support team.

## MANUFACTURERS

### Subject to compliance with requirements, provide lighting control equipment and lighting sensors and components from the following manufacturers, all equipment should be from one consistent manufacturer:

#### Acuity Brands Lighting, Inc. (nLight)

#### Hubbell Building Automation (NX)

#### Intelligent Lighting Controls, ILC

#### Lutron Electronics Company, Inc. (Quantum-wired, Vive-wireless)

#### Wattstopper

### For renovation projects involving only a portion of an existing building, consideration should be given to maintaining consistency of controls manufacturer with the previously installed systems, if present. Basis of Design should be based on the manufacturer already present in the building with other acceptable manufacturers listed as alternates as necessary to provide competitive bidding. Coordinate with UNL Project Manager if the existing system’s manufacturer is not one listed above. In all cases, where new controls are provided where existing fixtures will be connected, the new controls must be fully compatible with the existing fixtures.

## OCCUPANCY SENSORS, SWITCHES, AND CONTROL STATIONS

### General

#### Requirements in this section apply to both wall and ceiling mounted occupancy sensors.

#### System shall support the following types of occupancy sensors:

##### On/Off Occupancy Sensing

##### Partial-On Occupancy Sensing

##### Partial-Off Occupancy Sensing

##### Vacancy Sensing (Manual-On, Automatic-Off)

#### Occupancy time delays before automatic dimming or shutting off of lights shall be specifiable for control zones between 15 seconds to 2 hours.

#### Baseline occupancy sensors shall consist of passive infrared (PIR) technology.

#### Where a second method of sensing is required or called for to adequately detect maintained occupancy (i.e. rooms with obstructions, like restrooms) dual technology devices shall be provided. Dual technology devices shall incorporate PIR and one other passive technology (i.e. passive microphonic or passive acoustic sensors) all integrated into one housing.

#### Dual technology devices shall have only one of two technologies require motion to detect occupancy.

#### Sensing technologies shall be acoustically passive, meaning they do not actively broadcast sound waves of any frequency. Ultrasonic or microwave-based technology are not allowed.

#### Provide the necessary sensor types and quantities per room in project on a room by room basis. Sensors shall behave as detailed in the Lighting Controls Application Matrix.

#### Sensor Rating:

##### Standalone (where applicable): provide with accessory power pack, sensor power supply, and load switching relay, connected to switched load. Power pack relay shall be rated 20 amps.

##### Networked (where applicable): provide power via lighting control system network bus. Includes dual (2) integral RJ45 jacks for in-series connection between system devices with splitter included. Must interface with associated system power packs, dimmer packs, or direct to enabled luminaires as required for the Project.

#### Modes: Provide all low voltage sensors with both occupancy sensor (auto on/off) and vacancy sensors (manual-on, auto-off) adjustable modes.

#### Occupancy sensors with automatic adaptive sensitivity and automatic timer adjustments will be considered but are not required.

#### Housings & Mounting: Sensor shall flush mount horizontally positioned to ceiling surface, or vertically positioned to wall surface. Devices shall recess into single-gang switch box and fit a standard GFI style opening. Occupancy sensors subject to abuse (such as wall type switches) shall have tamper resistant housing. Provide integral swivel mounted for field adjustments where directional sensors are to be used.

#### Finish: White, unless otherwise noted. All devices shall be available in a multitude of colors: ivory, white, light almond, gray, black, red, etc.

#### Provide integral LED to visually indicate motion detection.

#### All sensors and switches shall have the ability to detect when it is not receiving valid communication and blink its LED in a pattern to visually indicate a potential wiring issue.

#### Coverage: Occupancy sensors shall have clearly defined coverage patterns suitable for the application. Position sensors evenly throughout the space as required to provide complete coverage of the space while minimizing nuisance ‘false’ tripping situations.

#### Multiple occupancy sensors shall be capable of controlling the same local zones. The capability shall combine occupancy sensing coverage from multiple sensors without consuming multiple control zones.

#### Auxiliary Relay: all occupant sensors shall have auxiliary relay for interface with building automation system. Integral or remote mounted relays are acceptable. Provide SPDT, dry contact closure connectivity.

#### Embedded Sensors: Network systems with embedded fixture sensors shall be considered but are not required. Embedded sensors shall meet all the general requirements of performance and features as outlined in this specification.

### Wall Devices:

#### Wall mounted devices shall be made available with custom button labeling and engraving.

#### Devices shall recess into single-gane switch box.

#### Devices shall feature mechanical push-buttons and feature tactile, LED user feedback during button presses.

#### Device custom labels from the factory shall be available.

#### Wall mounted control devices shall support multiple controlled zones, on/off, or on/off/dimming, reset level scene types, etc. as applicable.

#### Wall Control Stations:

##### Device shall have a graphics based, 3.5” nominal, capacitive full color touchscreen.

##### Device shall be powered with Class 2 low voltage supplied locally via a directly wired power supply.

##### Unit shall have a micro-USB style connector for local computer connectivity.

##### Devices shall enable user supplied screen saver image to be uploaded within one of the following formats: jpeg, png, gif, bmp, and tif.

##### From graphic screen devices shall enable configuration of all switches, dimmers, control zones, and lighting preset scenes.

##### Access to system controls and programming shall be via password protected setup screens. Multiple levels of access via different passwords shall be provided.

## DAYLIGHTING SENSORS & PHOTOCELLS

**NOTE TO SPECIFIER: RECEPTACLES ARE FIGURE 8 TYPE-CHANGE COLOR AS DESIRED. FOR HARD USE SPECIFICATION GRADE USE 26352 FOR RECTANGULAR TYPE AND 5352 FOR FIGURE 8 TYPE.**

### General

* + - 1. Provide control system, where applicable, consisting of photo sensors and compatible control modules, power packs, contactors, and relays as require for automatic control of lighting loads where available light (daylight) is available.

### Daylighting Controls:

#### System shall be capable of integrating with occupancy sensors and manual override controls. Provide all components necessary to fully integrate the daylighting controls into the lighting control system.

#### Daylighting Controls shall be considered for all open office spaces with adequate natural lighting, public corridors, waiting areas, entrances, etc.

* + - 1. Controls shall be solid state with light level sensing units to automatically adjust the output of the controlled light fixtures. Sensors shall control light fixtures directly or through associated load controllers.
			2. Controls shall have adjustable sensitivity and output settings to tailor lighting control to the specific space and application.
			3. Daylighting sensors shall have well defined coverage patters and capacities suitable for application.

### Photocells:

#### Low voltage, ceiling mounted photocells, typical. Include with following features:

##### Sensing daylight and electrical lighting levels, the sensor adjust the indoor electrical lighting levels. As daylight increases, the lights are dimmed via 0-10V output to the connected luminaires.

##### The photocells shall continuously dim the controlled zone light fixtures automatically, such that a minimum light level consisting of both electric light and daylight sources is maintained at the task height.

##### Trim levels and activation set-point of the sensor shall be field adjustable.

##### Delay shall be incorporated to prevent rapid response to passing clouds.

##### Mounting: Sensor shall flush mount horizontally to ceiling surface.

##### Finish: White, unless otherwise noted.

##### Sensor Rating:

###### Standalone (where applicable): provide with accessory power pack, sensor power supply, and load switching relay, connected to switched load. Power pack relay shall be rated 20 amps.

###### Networked (where applicable): provide powered via lighting control system network bus. Includes dual (2) integral RJ45 jacks for in-series connection between system devices via CAT 5E cabling. Splitter included. Must interface with associated system power packs, dimmer packs, or direct to enabled luminaires as required for the Project.

#### Dimming Photo Sensors: Photo sensor units with integral controller compatible with specified dimming drivers, for direct continuous dimming for multiple drivers as required for the space controlled.

* + 1. Accessories: Where indicated, provide compatible accessory wall switches for manual override control. Provide dimming capabilities where shown on drawings.

## POWER PACKS AND DISTRIBUTED LIGHTING CONTROLS

**NOTE TO SPECIFIER: REVISE OR DELETE PARAGRAPH 2.5.1 AS REQUIRED. DELETE THIS PARGRAPHS IF MULTI-OUTLET SURFACE ASSEMBLIES OR POWER POLES ARE SPECIFIED ON THE DRAWINGS.**

### Description: self-contained, low voltage, Class 2 transformer and relay compatible with specified low voltage occupancy sensors for switching of line voltage loads. Power packs shall incorporate one optional Class 1 relay, optional 0-10VDC dimming output, and contribute low voltage Class 2 power to the rest of the system.

### Power packs shall accept 120-277 VAC and carry a plenum rating.

### Provide quantity and configuration of power packs with all associated wiring and accessories as required to control the load indicated on the drawings.

### Load rating: capable of a full 16-amp (minimum) switching load of all normal power lighting load types, with option 0-10V dimming output capable of up to 100mA of sink current.

### Communications: power packs to connect to lighting control relay system via low voltage network cabling with RJ-45 connectors or wirelessly, as applicable.

### Provide power packs with integral latching relay.

### Programming: power pack programming parameters shall be available and configurable remotely from the system software and locally via device push-buttons, dip switches, etc.

### Secondary and alternative power pack configurations (dimming, UL924 rated, secondary relays, etc.) shall be provided as required per project specifications and shall adhere to load rating paragraph above.

### Power Pack Mounting: Power packs shall be securely mounted through a threaded ½ inch chase nipple or be capable of being secured within a luminaire driver channel. All Class 1 wiring shall pass through the chase nipple without any exposure of wire leads. Where required by Code, power pack must be installed inside standard electrical enclosure and with provided UL recognized support to junction box.

### Distributed Lighting Controls: Where implemented, distributed lighting controls that users do not regularly interact with (relays, power packs, network bridges, auxiliary devices, etc.) shall be conveniently located in a concealed space suspended ceiling or other accessible locations where they can be maintained and serviced. Generally, such concealed distributed controls should be located above or nearly above the main door into the controlled space. Label all boxes associated with the room lighting controls for easy identification.

## SYSTEM MANAGEMENT, LIGHTING CONTROL PANELS, AUXILIARY COMPONENTS

### System Management Interface:

#### System shall provide a web-based management interface that provides remote system control, live status monitoring, and configuration capabilities of lighting control settings and schedules.

#### Management interface must be compatible with industry-standard web browser clients, including, but not limited to, Microsoft Internet Explorer®, Apple Safari®, Google Chrome®, Mozilla Firefox®.

#### Management interface shall require all users to login with a User Name and Password, and shall support creation of multiple unique user accounts.

#### Management interface shall support at least three permission levels for users: read-only, read & change settings, and full administrative system access.

#### Management interface shall be capable of restricting access for user accounts to specific devices within the system.

#### All system devices shall be capable of being given user-defined names.

#### The following device identification information shall be displayed in the Management interface: model number, model description, serial number or network ID, manufacturing date code, custom label(s), and parent network device.

#### Management interface shall be able to read the live status of a networked luminaire or intelligent control device and shall be capable of displaying luminaire on/off status, dim level, power measurement, device temperature, PIR occupancy sensor status, microphonic occupancy sensor status, remaining occupancy time delay, photocell reading, and active Profiles.

#### Management interface shall be able to read the current active settings of a networked luminaire or intelligent control device and shall be capable of displaying dimming trim levels, occupancy sensor and photocell enable/disable, occupancy sensor time delay and light level settings, occupancy sensor response (normal or vacancy), and photocell setpoints and transition time delays.

#### Management interface shall be able to change the current active settings and default settings for an individual networked luminaire or intelligent control device.

#### Management interface shall be capable of applying settings changes for a zone of devices or a group of selected devices using a single “save” action that does not require the user to save settings changes for each individual device.

#### A printable network inventory report shall be available via the management interface.

#### A printable report detailing all system profiles shall be available via the management interface.

#### All sensitive information stored by the software shall be encrypted.

#### All system software updates must be available for automatic download and installation via the internet.

### Smartphone & Tablet Programming:

#### Application interface shall be provided for both Apple iOS® and Android operating systems that allows configuration of lighting control settings.

#### The application shall support the configuration and control of wired networked control devices via a Bluetooth® Low Energy (BLE) Programming Device or WiFi connection.

#### Application shall support a security pin-code or password to access the lighting controls.

#### The application shall provide indication of signal strength where multiple Bluetooth Low Energy Programming Devices are available for configuration.

#### The application shall indicate the number of wired networked control devices connected to the local daisy-chain zone.

#### The application shall provide on/off/dimming control of all control groups.

#### The application shall provide the ability to identify all individual luminaires and control devices.

#### Programming capabilities through the application shall include, but not be limited to, the following:

##### Switch/occupancy/photosensor zone configuration

##### Manual/automatic on modes

##### Turn-on dim level

##### Occupancy sensor time delays

##### Dual technology occupancy sensors sensitivity

##### Photosensor calibration adjustment and auto-setpoint

##### Multiple photosensor zone offset

##### Trim level settings

##### Preset scene creation and copy for scene capable devices.

##### Application of custom device labels to the Bluetooth Low Energy Programming Devices and individual connected lighting control devices.

### System Controller: where needed for larger wired systems, provide as follows:

#### System Controller shall be multi-tasking, real-time digital control processor consisting of modular hardware with plug-in enclosed processors, communication controllers, and power supplies.

#### System Controller shall have 32-bit microprocessor operating at a minimum of 1 GHz.

#### System Controller shall have minimum of 512MB memory, with a minimum of 4GB non-volatile flash, to support its own operating system and databases.

#### System Controller shall perform the following functions:

##### Time-based control of downstream wired and wireless network devices.

##### Linking into an Ethernet network.

##### Integration with Building Management Systems (BMS) and Heating, Ventilation and Air Conditioning (HVAC) equipment.

##### Connection to various software interfaces, including management interface, historical database and analytics interface, and visualization interface.

#### System Controller shall have an integral web server to support configuration, diagnostics and hosting of software interfaces.

#### Device shall have option for a graphical touch screen to support configuration and diagnostics.

#### Device shall have multiple RJ-45 networked lighting control ports for connection to any of the following:

##### The graphical touch screen

##### Wired communication bridges

##### Direct connection to networked wired luminaires and intelligent lighting control devices (up to 128 total devices per port)

#### Device shall automatically detect all networked devices connected to it.

#### Device shall have an internal time clock used for astronomical and standard schedules.

#### Device shall have 2 switched RJ-45 10/100 BaseT Ethernet ports for local area network (LAN) connection.

##### Ethernet connection shall support daisy chain wiring or other approved topology to other lighting control system LAN devices.

##### Ethernet connection shall support IPv4 and shall be capable of using a dedicated static or DHCP assigned IP address.

#### Device shall have 2 x USB 2.0 Expansion ports for 802.11 Wi-Fi Adapter enabling wireless connectivity including:

##### Hot Spot

##### Access Point

##### Client

#### Each System Controller shall be capable of managing and operating at least 750 networked devices (wired or wireless).

##### Multiple System Controllers may be networked together via LAN connection to scale the system up to 20,000 networked devices.

#### System Controller shall support BACnet/IP and BACnet MS/TP protocols to directly interface with BMS and HVAC equipment without the need for additional protocol translation gateways.

##### BACnet MS/TP shall support 9600 to 115200 baud rate.

##### System Controller shall be BACnet Testing Laboratory (BTL listed) using Device Profile BACnet Building Controller (B-BC) with outlined enhanced features.

#### System controller shall contain a “FIPS 140-2 Level 1 Inside” cryptographic module.

#### System controller shall support RESTful API control of BACnet objects, user management, date and time, and file management.

#### System controller shall be available within a NEMA 1 enclosure with Class 1 and Class 2 separation

#### Enclosure shall support power input power of 120-277VAC.

### Lighting Control Panels: Generally, distributed network lighting controls with power packs, power supplies, interfaces, etc. are to be provided above suspended ceilings and accessible locations through the project. However, where project requirements call for more traditional control panels provide as follows:

#### Relay and dimming panel shall be available with 4, 8, 12, 16, 24, 32, 40 or 48 individual relays per panel, with an equal number of individual 0-10V dimming outputs.

#### Optional Field Configurable Relays (FCR) used shall have the following required properties:

###### Configurable in the field to operate with single-, double-, or triple-pole relay groupings.

###### Configurable in the field to operate with normally closed or normally open behavior.

###### Provides visual status of current state and manual override control of each relay.

###### Listed for the following minimum ratings:

40A @ 120-480VAC Ballast

16A @ 120-277VAC Electronic

20A @ 120-277VAC Tungsten

20A @ 48VDC Resistive

2HP @ 120VAC

3HP @ 240-277VAC

65kA SCCR @ 480VAC

#### The 0-10 dimming outputs shall support a minimum of 50mA sink current per output.

#### Relay and dimming outputs shall be individually programmable to support all standard sequence of operations as defined in this specification.

#### Panel shall be UL924 listed for control of emergency lighting circuits.

#### Panel shall power itself from an integrated 120-277 VAC

#### Panel shall provide a configurable low-voltage sensor input with the following properties:

###### Configurable to support any of the following input types:

Indoor & Outdoor Photocells

Occupancy Sensor

Contact Closure

#### Low voltage sensor input shall provide +24VDC power for the sensor so that additional auxiliary power supplies are not required.

#### Sensor input supports all standard sequence of operations as defined in this specification.

#### Panel shall provide a contact closure input for each group of relays that acts as a panel override to activate the normally configured state of all relays (i.e., normally open or normally closed) in the panel. This input is intended to provide an interface to alarm systems, fire panels, or BMS system to override the panel.

#### Panel shall supply current limited low voltage power to other networked devices connected via low voltage network cable.

#### Panel shall be available with NEMA 1 rated enclosure with the following mounting and cover options:

##### Surface-mounted for all panel sizes, flush mounted as required per project. Provide with hinged cover with keyed lock.

### Auxiliary Components: As required, provide auxiliary control system components as needed and as described below:

#### Auxiliary Input / Output (I/O) Devices:

##### Devices shall be plenum rated and be inline wired, screw mountable, or have an extended chase nipple for mounting to a ½” knockout.

##### Communication and low voltage power shall be delivered to devices via standard low voltage network cabling with RJ-45 connectors or other low-voltage physical medium.

##### Auxiliary Input/Output Devices shall be specified as an input or output device with the following options:

###### Contact closure or Pull High input

Input shall be programmable to support maintained or momentary inputs that can activate local or global scenes and profiles, activate lights at a preconfigured level, ramp light level up or down, or toggle lights on/off.

##### 0-10V analog input

###### Input shall be programmable to function as a daylight sensor.

##### RS-232/RS-485 digital input

###### Input supports activation of up to 4 local or global scenes and profiles, and on/off/dimming control of up to 16 local control zones.

##### 0-10V dimming control output, capable of sinking up to 20mA of current

###### Output shall be programmable to support all standard sequence of operations supported by system.

##### Digital control output:

###### Output shall be programmable to support light intensity control, as well as optional correlated color temperature (CCT) control, of the connected luminaire.

#### Embedded Sensors:

##### Network system shall have embedded sensors consisting of occupancy sensors and/or dimming photocells that can be embedded into luminaire such that only the lens shows on luminaire face.

##### Occupancy sensor detection pattern shall be suitable for 7.5’ to 20’ mounting heights.

##### Embedded sensors shall support the following device options:

###### Occupancy Sensing technology: PIR only or Dual Tech acoustic

###### Daylight Sensing Option: Occupancy only, Daylight only, or combination Occupancy/Daylight sensor

#### Communication Bridge (where applicable or needed for the system functionality):

##### Device shall surface mount to a standard 4” x 4” square junction box.

##### Device shall have 8 RJ-45 ports for connection to lighting control zones (up to 128 devices per port), additional network bridges, and System Controller.

##### Device shall be capable of aggregating communication from multiple lighting control zones for purposes of minimizing backbone wiring requirements back to System Controller.

##### Device shall be powered with Class 2 low voltage supplied locally via a directly wired power supply, or powered via low voltage network connections from powered lighting control devices (e.g. power packs).

##### Bridge shall be capable of redistributing power from its local supply and connected lighting control zones with excess power to lighting control zones with insufficient local power. This architecture also enables loss of power to a particular area to be less impactful on network lighting control system.

## SEQUENCE OF OPERATIONS

### Follow general guidance found in the Lighting Controls Application Matrix for sequence of operations expectations on a space-by-space basis. Adjustments to these requirements may be needed per specific project requirements.

### Provide sensors with continuous & smooth dimming shall be provided to support partial-on sequences, including multiple partial-on dimming levels.

### To accommodate diverse types of environments, occupancy and vacancy time delays before dimming or shutting off lights shall be specifiable for control zones between 15 seconds to 2 hours.

### Normal occupancy sensor functionality is expected as follows:

#### Utilize PIR for initial space occupancy detection, turning the lights on, which requires a person to physically enter the space. Once the lighting is on, both PIR and the secondary technology (where applicable) are used to maintain the occupancy state. Both technologies must report an unoccupied state for lighting to turn off. When it happens that a room is detected vacant and the lighting is turned off with an occupant still present, a grace timer will allow either technology that the detects occupancy within a small-time frame (i.e. 30 seconds) to turn the lights back on before reverting to PIR initialization.

#### Alternatively, sensors in the space are setup for manual on functionality. In this case, once lights are manually turned on, all steps described in Paragraph 8.a. above after initial detection shall be followed.

### Occupancy Sensors shall function according to the following sequencing:

#### Occupancy sensors shall automatically turn lights on to a designated level when occupancy is detected.

#### Occupancy sensors shall automatically turn lights off or to a dimmed state (partial-off)) when vacancy occurs or if sufficient daylight is detected.

#### To provide additional energy savings the system shall also be capable of combining Partial-Off and Full-Off operation by dimming the lights to a designated level when vacant and then turning the lights off completely after an additional amount of time.

#### Photocell readings, if enabled in the Occupancy Sensing control zone, shall be capable of automatically adjusting the light level during occupied or unoccupied conditions as necessary to further reduce energy usage. Additional requirements and details for photocell sensing capabilities are indicated under Photocell Sensing Capabilities.

#### The use of a wall station shall change the dimming level or turn lights off as selected by the occupant. The lights shall optionally remain in this manually-specified light level until the zone becomes vacant; upon vacancy the normal sequence of operation, as defined above, shall proceed.

### Vacancy Sensors shall function according to the following sequencing:

#### The use of a wall station is required turn lights on. The system shall be capable of programming the zone to turn on to either to a designated light level or the previous user light level. Initially occupying the space without using a wall station shall not result in lights turning on.

#### Occupancy sensors shall automatically turn lights off or to a dimmed state (partial-off) when vacancy occurs or if sufficient daylight is detected.

#### To provide additional energy savings and an enhanced occupant experience, the system shall also be capable of dimming the lights when vacant and then turning the lights off completely after an additional amount of time.

#### To minimize occupant impact in case the area or zone is still physically occupied following dimming or shutoff of the lights due to detection of vacancy, the system shall support an “automatic grace period” immediately following detection of vacancy, during which time any detected occupancy shall result in the lights reverting to the previous level. After the grace period has expired, the use of a wall station is required to turn lights on.

#### Photocell readings, if enabled in the Occupancy Sensing control zone, shall be capable of automatically adjusting the light level during occupied or unoccupied conditions as necessary to further reduce energy usage. Additional requirements and details for photocell sensing capabilities are indicated under Photocell Sensing Capabilities.

#### At any time, the use of a wall station shall change the dimming level or turn lights off as selected by the occupant. The lights shall optionally remain in this manually-specified light level until the zone becomes vacant; upon vacancy the normal sequence of operation, as defined above, shall proceed.

### Photocell Sensors shall function according to the following sequencing:

#### Photocell sensing devices shall be configurable to control a local zone.

#### The system shall support the following type of photocell-based control:

##### Continuous Dimming: The control zone automatically adjusts its dimming output in response to photocell readings, such that a minimum light level consisting of both electric light and daylight sources is maintained at the task. The photocell response shall be configurable to adjust the photocell setpoint and dimming rates.

### Schedule Capabilities:

#### System shall support the creation of time schedules for time-of-day override of devices including offsets from dusk and dawn.

#### System shall support blink warning and timed extension capabilities where occupant sensors are not present. At the end of a scheduled period, the system shall be capable of providing a visible “blink warning” prior to the end of the schedule. Wall stations may be programmed to provide timed overrides that turn the lights on for an additional period of time. Timed override duration shall be programmable for each individual device, zone of devices, or customized group of devices, from 5 mins to 12 hrs.

### Standard Programming Parameters: Unless noted otherwise, provide lighting controls with the following presets, time-outs, etc.:

#### Time outs for occupancy sensors: 15 minutes.

#### Time outs for vacancy sensors: 15 minutes.

#### “Blink Warning” deadline: 5 minutes prior to shut off.

#### Light Level Combination of Artificial & Daylighting Sources: 40 foot-candles (40FC)

## SYSTEM WIRING

**NOTE TO SPECIFIER: REVISE OR DELETE PARAGRAPHS 2.7.1 & 2.7.2 AS REQUIRED. DELETE THESE PARAGRAPHS IF THESE DEVICES ARE SPECIFIED ON THE DRAWINGS.**

### Provide all line voltage waiting per NEC, and Division 26 specification.

### Provide all low voltage wiring in conduit where concealed in walls, above hard lid ceilings, or in exposed ceiling applications.

### Provide all low voltage wiring above accessible ceilings in conduit, j-hooks, or cable tray system as applicable.

### All system wiring splices, taps, and terminations shall be enclosed in electrical boxes, device covers, or device jacks that have no exposed contacts or live surfaces.

### Cables entering boxes or device enclosures shall be protected by properly sized grommets. Route all conductors and cables to avoid sharp edges, burrs, rough surfaces, etc., as required.

### All low voltage cabling shall be plenum rated. System shall have the option of pre-terminated low voltage network cabling supplied with hardware by lighting control manufacture for all cables shorter than 150 feet. Provide lengths necessary for installation, cables shall be as short as practical with a minimum 10’ cable lengths. Cables longer than 150 feet shall be terminated by a low voltage technician or qualified contractor.

### Communication and low voltage power shall be delivered to each device via standard low voltage network cabling with RJ-45 connectors.

**~~NOTE TO SPECIFIER: REVISE OR DELETE PARAGRAPHS ON UNDERFLOOR DUCTS AND FITTINGS AS REQUIRED.~~**

# EXECUTION

## EXAMINATION

### Verify that outlet boxes are installed in proper locations and at proper mounting heights and are properly sized to accommodate devices and conductors in accordance with NFPA 70.

### Verify that branch circuit wiring installation is complete, tested, and ready for connection to lighting control devices.

### Verify that the service voltage and ratings of lighting control devices are appropriate for the service voltage and load requirements at the location to be installed.

### Inspect each lighting control device for damage and defects.

### Test occupancy sensors for proper operation, including time delays and ambient light thresholds. Test daylighting controls to verify proper operation, including light level measurements and time delays where applicable.

### Verify that all conditions of are satisfactory for installation of lighting control devices prior to starting work.

## INSTALLATION

### Comply with NECA 1 and where applicable NECA 130.

### Install the networked lighting control system per manufacturer instructions.

### Coordinate layout and installation of ceiling-mounted devices with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, smoke detectors, fire-suppression devices, and partition assemblies.

### Coordinate layout and installation of wall-mounted devices with other construction, thermostats, door frames, sidelights, countertops, etc., before installation begins. Install all lighting control devices plumb, level, and held securely in place.

### Upon installation, adjust occupancy sensor settings to minimize undesired activations and to achieve desired functions as indicated by the sequence of operations and/or basis of design.

### Networked Controls Coordination:

#### The Contractor shall hold a pre-construction meeting with the local representative from the lighting control system manufacturer prior to the start of construction. The meeting should include the UNL Project Manager, and FPC engineering staff. The meeting shall be documented, and the record turned over to the UNL Project Manager. Meeting shall discuss overall project scope, schedule, logistics, and delve into technical considerations for installation of the lighting control system as required.

#### Locate all power packs above accessible ceilings near fixtures being controlled. In exposed structure areas, locate device in junction box.

#### Daisy-chain all network lighting control devices to network bridge devices or similar switches per manufacturer recommendations. Provide quantity of bridges such that each room/space is a separate lighting control zone that appears in programming software.

#### After construction, the Contractor shall provide the Owner a record drawing set detailing the locations of all control devices located above ceilings and the luminaire or groups of luminaires being controlled by each device.

### Occupancy Sensor Locations:

#### Locations indicated as requiring occupancy sensor control are only intended to indicate which rooms or areas require occupancy sensor control It shall be the contractors and manufacturer’s responsibility to provide the proper quantity and locations of devices as required for complete coverage of respective room or controlled area. Sensors(s) shall be located such that detection does not extend beyond corresponding room or area.

#### Locate all occupancy sensors ceiling mounted at least 4 feet form air supply ducts or other sources of heavy air flow as per manufacturer’s recommendations, in order to minimize false triggers.

### Daylighting Control Photo Sensor Locations:

#### Locations indicated as requiring daylight harvesting are diagrammatic and only intended to indicate which rooms or areas require devices. Provide quantity and locations as required for proper control of respective room or area based on manufacturer’s recommendations.

#### Adjust daylighting controls under optimum lighting conditions after all room finishes, furniture, and window treatments have been installed to achieve desired operation as indicated or as directed by the Project Manager. Record settings in written report to be included with submittals. Re-adjust controls calibrated prior to installation of final room finishes, furniture, and window treatments that do not function properly as determined by the Project Manager.

## COMMISSIONING & RETUNING

### The lighting control system shall be in place, functional, and tested, prior to demonstration to the inspector, UNL Project Manager, and commissioning agent, as applicable. Complete operational function shall be demonstrated to the inspector, UNL Project Manager, and commissioning agent, as applicable. A factory authorized representative shall be present during demonstration to provide adjustment and programming modifications, as necessary.

### Verify normal operation of each lighting control per lighting control sequence of operations.

### Replace or repair, then retest all malfunctioning lighting controls. Repeat procedure until units operate properly.

### Program spaces per the sequence of operations document. Design light level shall be used to set high end trim as well as daylight harvesting photocell set points. Assist commissioning agent in system testing and verification.

### Occupancy Adjustments: After Substantial Completion, but not more than 90 days after Final Acceptance, re-adjust occupancy sensors for Owner’s actual pattern of use. In addition, when requested within twelve (12) months from date of Substantial Completion, provide on-site assistance in adjusting sensors to suit actual occupied conditions. Provide up to two (2) visits to Project during other-than-normal occupancy hours for this purpose.

### For occupancy and motion sensors, verify operation at outer limits of detector range. Set time delay to suit Owner’s operations.

### For daylighting controls, adjust set points and dead band controls to suit Owner’s operations.

## TRAINING

### Upon completion of all physical work and programming, after user acceptance of functional performance, and after commissioning efforts are complete, on-site training shall be provided by an instructor thoroughly familiar with the installed system. Training will be provided to the Owner’s operating personnel who have responsibility for the lighting and control systems. The training shall focus on operation and maintenance of the installed system.

### Training sessions shall be conducted by a Factory authorized lighting system representative.

### Training sessions shall be video recorded for review later by staff who are not present at the live training. Recordings shall be via high quality video with high quality audio, provide microphones for instructors and similar elements as necessary. Pre-recorded video will be considered as acceptable if submitted for review prior to training session and accepted by the Project Manager. Provide recordings in electronic form to Project Manager upon completion.

### Provide minimum of two (2) four-hour training sessions on-site. Dates & times of training per Project Manager requirements. Pre-recorded training videos are not a substitute for live training sessions.

END OF SECTION 262726