SECTION 26 09 43

DISTRIBUTED DIGITAL LIGHTING CONTROLS

BASED ON DFD MASTER ELECTRICAL SPEC DATED 03/01/23

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.

1. - GENERAL

SCOPE

Provide Distributed Digital Lighting Controls (controls) as indicated on the drawings and as specified herein. The controls shall consist of a series of standalone digital load controllers and intelligent low-voltage devices dedicated to the room/space they are serving. All local devices shall be connected together via an In-Room Network, enabling digital communication between devices. Digital Lighting Control Panels, where indicated on the drawings, may also be used for lighting control as part of the overall lighting control scheme.

Include the following paragraph if a PC-based management system is required for the project. Examples of spaces typically controlled via PC-based software are corridors, lobbies, open offices, and outdoor lighting.

[The system architecture shall connect multiple In-Room local networks for centralized building-wide monitoring and management via a Global Network and PC-based software. Refer to the drawings for which rooms/spaces are to be connected to the Global Network. The system architecture shall allow standalone digital load controllers and associated devices to function in some default capacity, even if network connectivity to the Global Network is lost.]

The controls shall provide time-based, sensor-based (e.g., occupancy/vacancy and daylight sensors), and/or manual control as indicated in the lighting sequences of operation on the drawings. The controls shall turn lighting loads ON/OFF, and shall dim the lighting where indicated.

Included are the following topics:

PART 1 - GENERAL

Scope

Related Work

Reference Standards

Design/Performance Requirements

Quality Assurance

Submittals

Operation and Maintenance Data

Extra Materials

PART 2 - PRODUCTS

System Requirements

Digital Load Controllers (Room Controllers)

Digital Motion Sensors

Digital Daylight Sensors

Digital Manual Controls

Digital LED Luminaires

Digital Auxiliary Input/Output (I/O) Interface Modules

Digital Lighting Control Panels (Relay and Dimming Panels)

Configuration Tools

Network Cables

[Network Interfaces]

PART 3 - EXECUTION

Delivery, Storage, and Handling

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Auxiliary Contacts for HVAC Interlock

Installation

Free-Air Cable Installation

Field Quality Control

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Post Start-up Tuning

Warranty

Product Support and Service

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 51 13 – Interior Lighting Fixtures, Lamps, and Ballasts

REFERENCE STANDARDS

NFPA 70 National Electrical Code; National Fire Protection Association

NEMA National Electrical Manufacturers Association

FCC Federal Communications Commission – Emission Standards

UL Underwriters Laboratories, Inc. Listings

UL 2043 Standard for Fire Test for Heat and Visible Smoke Release for Discrete Products Installed in Air-Handling Spaces

UL 20 General-Use Snap Switches

UL 508 Standard for Industrial Control Equipment

UL 916 Standard for Energy Management Equipment

UL 924 Standard for Emergency Lighting and Power Equipment

DESIGN/PERFORMANCE REQUIREMENTS

Distributed Digital Lighting Controls shall accommodate the square-footage coverage requirements for each area controlled utilizing digital load controllers, digital occupancy/vacancy sensors, digital daylighting sensors, digital switches, digital lighting control panels, and accessories that suit the required lighting and electrical system parameters.

System shall conform to requirements of NFPA 70.

System shall comply with FCC emission standards specified in part 15, sub-part J for commercial and residential application.

System shall be listed under UL sections 916 and/or 508.

QUALITY ASSURANCE

Installer Qualifications: Company certified by the manufacturer and specializing in installation of Distributed Digital Lighting Control products with minimum three years documented experience.

SUBMITTALS

Shop Drawings:

Shop drawings shall include the following:

* Product Datasheets (general device descriptions, dimensions, electrical specifications, wiring details, nomenclature)
* All manufacturers shall submit to the specifying engineer a line-by-line compliance comparison between each specifications requirement and the system being proposed. Any ambiguities in the drawings or specifications shall be brought to the attention of the specifying engineer for clarification.
* Riser Diagrams – typical per room type (detailed drawings showing interconnectivity of devices)
* Other Diagrams – as needed for special operation or interaction with other system(s)
* Example Contractor Startup/Commissioning Worksheet – must be completed prior to factory start-up
* Hardware and Software Operation Manuals
* Other operational descriptions as needed

Occupancy Sensor Shop Drawings

* Symbols on drawings are diagrammatic and represent design intent only. Provide manufacturer-recommended layout drawings showing quantity and location of sensors, and associated wiring diagrams.

Closeout Submittals:

* Project Record Documents: Record actual installed locations **and settings for each** lighting control device and show interconnecting wiring.
* Operation and Maintenance Manual:
* Include approved Shop Drawings and Product Data.
* Include Sequence of Operation, identifying operation for each room or space.
* Include manufacturer's maintenance information.
* Operation and Maintenance Data: Include detailed information on device programming and setup.
* Include startup and test reports.

OPERATION AND MAINTENANCE DATA

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

EXTRA MATERIALS

Provide the following spare materials:

* One (1) ON/OFF Load Controller with three relays
* One (1) ON/OFF/Dimming Load Controller with three relays
* One (1) of each type of motion sensor used
* One (1) daylight sensor
* One (1) two-button digital wall switch
* One (1) four-button digital wall switch
* One (1) eight-button digital wall switch
1. - PRODUCTS

SYSTEM REQUIREMENTS

Lighting control zones shall consist of one or more intelligent lighting control components (digital load controllers), be capable of stand-alone operation, and be capable of being connected to a higher-level network backbone.

Network Characteristics

* In-Room Network:
* The In-Room network shall be a free topology lighting control network using physical wiring connections and communication protocol designed to control a room/space/small area of a building.
* Digital room devices connect to the In-Room network, which provides both communications and power to room devices.
* Global Network (In-Room to In-Room Network):
* The Global network shall be a linear topology network to connect In-Room networks and relay panels (if applicable) for centralized control.
* Each In-Room Network to be connected to the Global Network shall include a single network bridge, and the network bridge is the only room-based device that is connected to the Global Network.
* The Global Network shall utilize communications cabling as specified by the manufacturer. The maximum cable run for each segment (distance between In-Room Networks) shall meet manufacturer limitations.

Individual lighting zones must continue to provide a user defined default level of lighting control in the event of a system communication failure with the Global Network or the management software becoming unavailable.

All switching and dimming for a specific lighting zone shall take place within the devices located in the zone itself (i.e., not in remotely located devices such as panels) to facilitate system robustness and minimize wiring requirements. Specific applications that require centralized or remote switching shall be capable of being accommodated.

System shall be capable of using a web-based software management program that enables remote system control, status monitoring, and creation of lighting control schedules and profiles.

[Connect all noted In-Room Networks to the Global Network for building-wide monitoring and management via PC-based Management Software and/or the building automation system (BAS). Provide optional Management Software for remote system control, status monitoring, and creation of lighting control schedules and profiles.]

DIGITAL LOAD CONTROLLERS (Room Controllers)

General

Digital load controllers shall be simple to install and shall not have dip switches or potentiometers, or require special configuration.

The controllers shall include the following features:

* Standard junction box mounting.
* Low voltage connection using standard RJ-45 connectors and CAT5e cable. Other wiring topologies are acceptable if controls accomplish all requirements specified in these documents.
* Each connected load shall be capable of any of the following behaviors: Manual ON, Automatic ON, Automatic ON to 50 percent, or Automatic ON to Preset level or last level set.
* UL 2043 plenum rated.
* Manual override and LED indication for each load.
* Power supply to power the digital load controller itself and the peripheral sensors and controls connected to the In-Room Network.
* Dual voltage (120/277 VAC, 60 Hz), rated for 20A total load, derating to 16A required for some dimmed loads (forward phase dimming).
* Zero cross circuitry for each load.
* All digital parameter data programmed into an individual room controller or plug load controller shall be retained in non-volatile FLASH memory within the controller itself. Memory shall have an expected life of no less than 10 years.

ON/OFF Load Controllers

Controllers shall include the following:

* Multiple relay configurations per unit.

ON/OFF/Dimming Load Controllers

Controllers shall include the following:

* Multiple relay configurations per unit.
* Each dimming output channel shall have an independently configurable minimum and maximum calibration trim level to set the dimming range to match the true dynamic range of the connected LED driver.
* One dimming output per relay.
* 0-10V Dimming: Where indicated, one 0-10 volt analog output per relay for control of compatible LED drivers. The 0-10 volt output shall automatically close upon loss of power to the Controller to assure full light output from the controlled lighting.
* Line Voltage, Forward Phase Dimming: Where indicated, one forward phase control line voltage dimming output per relay for control of compatible LED drivers, forward phase compatible ELV, and incandescent loads.
* Each load shall have an independently configurable preset ON level for Normal Hours and After-Hours events to allow different dimmed levels to be established at the start of both Normal Hours and After-Hours events.

DIGITAL MOTION SENSORS

General

Sensors shall be available in wall, ceiling, corner-mounted, or wall-switch configurations.

Sensors shall use either passive infrared (PIR) sensing, or if dual technology, passive infrared and passive acoustic or passive infrared and ultrasonic sensing for detecting room occupancy.

Sensors shall be able to function together with other sensors in order to provide expanded coverage areas.

Features

Sensors shall be provided with the following features:

* Sensitivity Adjustment, Time Delay, Detection Technology, and Walk-Through Mode.
* Dual-Technology Sensors shall have independent configurable trigger modes to choose proper technology according to space use to eliminate false-triggers.
* Each sensor may be programmed to control specific loads within an In-Room network.
* Each sensor shall allow remote programming through a handheld commissioning tool via a two-way infrared (IR) transceiver or by configuration through a local network device.

Digital Wall Switch Motion Sensors

Digital wall switch motion sensors shall be provided with the following features:

* Shall not allow current to pass to the load when sensor is in the unoccupied (Off) condition.
* One- or two-button switches for one or two switch-legs.
* Optional daylight sensor feature for daylighting override.

DIGITAL DAYLIGHT SENSORS

Daylight sensors shall be provided with the following features:

* Digital daylighting sensors shall work with room controllers to provide automatic switching, bi-level, tri-level, or dimming daylight harvesting capabilities for any load type connected to a room controller.
* Daylighting sensors shall be interchangeable without the need for rewiring.
* Sensor light level range shall be from 1-250 foot-candles (fc).
* For switching daylight harvesting, the daylight sensor shall provide a field-selectable deadband (separation) between the “ON” setpoint and the “OFF” setpoint that will prevent the lights from cycling excessively after they turn OFF.
* For dimming daylight harvesting, the daylight sensor shall provide the option, when the daylight contribution is sufficient, of turning lights OFF or dimming lights to a field-selectable minimum level.
* Delay shall be incorporated into the photocell to prevent rapid response to passing clouds.
* Daylight sensors shall have an independently configurable fade rate for both increasing and decreasing light level in units of percent-per-second.
* Daylight Sensors shall provide adjustable cut-off time (0-120 minutes). Cut-off time is defined by the number of selected minutes the load is at the minimum output before the load turns off.
* Optional wall switch override shall allow occupants to reduce lighting level to increase energy savings or, if permitted by system administrator, raise lighting levels for a selectable period of time or cycle of occupancy.
* Each sensor shall allow remote programming through a handheld commissioning tool via a two-way infrared (IR) transceiver or by configuration through a local network device.

DIGITAL MANUAL CONTROLS

Wall Switches

Low voltage dimming and momentary pushbutton switches in 1, 2, 3, 4, 5, and 8 Button configurations.

Wall switches shall include the following features:

* Buttons may be programmed as Load or Scene Buttons.
* Buttons may be programmed as ON/OFF, ON only, or OFF only.
* Switch buttons may be bound to any load on a room controller and are not load type dependent.

Dimmer Switches

* Raise/lower dimming adjustment controls.
* Dimmer switches shall include multiple LEDS to indicate load levels.
* Dimmer switches shall be able to be ganged with multi-button switches under the same wall plate.
* Three-way and 4-way switch locations are supported for ON/OFF or Dimming control.

Digital Scene Switches

* Scene switches allow for Preset Scene recall and dimming override control.

Touch Panel Controls

Touch Panel Controls are allowed, but not required. Touch Panel Controls are used for adjusting lighting and to set up and control preset lighting scenes in the associated room/space.

Touch panel controls shall be provided with the following features:

* Full-color multi-touch capacitive touchscreen for controlling lighting and system components
* Control up to 16 dynamic lighting zones/scenes per touch screen or acting as up to 16 ON/OFF/DIM control switches
* Lighting zones/scenes can be comprised of lighting intensity, color, color temperature, and luminaire position
* Modify color and color temperature using a digital color palette and UV rating scale
* Proximity screen sensor for auto “wake-up”
* Auto dimming and user adjustable backlight
* Device shall enable configuration of all switches, dimmers, and lighting preset scenes via password protected setup screens. User programmable screen lock limiting access to all feature controls and programming
* Full alpha-numeric scene and zone naming
* Configurable interface to reflect project requirements
* Lighting zones/scenes support control of forward/reverse phase dimming, 0-10V, RGB, tunable white, and moving fixtures
* Integral astronomical time clock enables lighting scenes
* Partition status control and visualization
* Direct DMX control
* Digital motion senor control
* Digital daylight harvesting response
* Shall have the ability to control connected load through time schedules.
* RS-232/contact closure capable for 3rd party integration
* Local wireless Bluetooth connectivity with mobile app
* Device shall have a micro-USB style connector for local computer connectivity.
* Remote-mounted power supply

DIGITAL LED LUMINAIRES

Digital LED Luminaires are luminaires with embedded controls (a.k.a. “enabled” luminaires). Luminaires with embedded controls are not allowed.

DIGITAL AUXILIARY INPUT/OUTPUT (I/O) INTERFACE MODULES

General

* Operate on Class 2 power supplied by In-Room network.
* Status LEDs indicate if input is energized.
* UL 2043 plenum rated where required.

Switched Contact Closure Interface

* Utilized for automatic control via input from other sources such as switches, relay-based system, BAS, etc.
* Includes 24VDC output and input terminals for momentary or maintained third party contact closure inputs.
* Utilize input module for an Auto ON and Sweep OFF function input from other sources for the controlled area. During normal hours of operation, all local low-voltage devices are fully operational. During after hours, a timer shall be applied to all low-voltage switches or dimmers so that the room will automatically sweep off every two hours following switch activation. Provide a blink warning to alert occupants of impending OFF.
* Specific I/O devices shall have a dimming control output that can control 0-10 VDC dimmable ballasts or LED drivers by sinking up to 20 mA of current.
* Specific I/O devices shall have an input that reads a 0-10 VDC signal from an external device.
* Specific I/O devices shall have a switch input that can interface with either a maintained or momentary switch and run a switch event (e.g., toggle the lighting load) or run a local/remote control profile.
* Specific I/O devices shall sense state of low-voltage outdoor photocells.
* Specific I/O devices shall sense momentary and maintained contact closures, and either toggle a connected load after a momentary contact or ramp the load high/low during a maintained contact (stopping when the contact releases).

Serial Data Interface

* Utilized for control from A/V system to send ON/OFF/Preset commands to In-Room Network.
* Includes 24VDC output and 10 pin RS232 connection.
* Coordinate programming with the Distributed Digital Lighting Control System manufacturer’s technician and the A/V system technician for successful interface between both systems.

DIGITAL LIGHTING CONTROL PANELS (RELAY and DIMMING PANELS)

General

It is the intent of this paragraph to provide a Digital Lighting Control Panel as part of an integrated lighting control system. Contractor is responsible for confirming that the panels and associated peripheral devices such as sensors and manual controls interoperate as a single system.

Digital Lighting Control Panels shall be incorporated into the lighting control system Global Network where used.

Provide lighting control panels in the locations and capacities as indicated on the plans and schedules. Each panel shall be of modular construction and consist of the following components:

* The panel cover shall have a hinged and lockable door with restricted access to line voltage section of the panel.
* The interior construction shall provide total isolation of line voltage (Class 1) wiring from low voltage (Class 2) wiring within the assembled panel.
* Direct wired switch inputs associated with each relay shall support two-wire, momentary or maintained contact switches.
* Digital inputs shall support digital switches, digital I/O modules capable of receiving 0-5V or 0-10V analog photocell inputs, digital I/O modules capable of receiving momentary or maintained contact closure inputs, digital photocell modules, and digital occupancy sensors.
* Power supply shall be a multi-voltage transformer assembly with rated power to supply all electronics, occupancy sensors, switches, pilot lights, and photocells associated with the lighting control panel as necessary to meet the project requirements.

Relays

Relays shall provide the following ratings and features:

* Panel shall provide one 0-10VDC dimming output paired with each relay.
* Each relay shall contain an LED status light and an override pushbutton. True relay state shall be indicated by the on-board LED and shall be available to external control devices and systems via BACnet. Isolated low voltage contacts provide for true relay status feedback and pilot light indication.
* Relays shall be individually replaceable in a modular plug-in design.
* Relays shall be single-phase normally-closed latching type relays capable of switching 120/277 VAC or two-phase relays capable of switching 208/240/480 VAC loads.
* Relays shall be rated to switch up to a 30A ballast load at 277 VAC.
* Tested to 300,000 mechanical on/off cycles.
* Relay operation shall be automatically sequenced to reduce impact on the electrical distribution system when large loads are controlled simultaneously.

Digital Network Clock

* Each panel shall include a digital clock capable to issue system wide automation commands.
* The clock module shall provide astronomic capabilities, time delays, blink warning, daylight savings, and holiday functions and shall include battery backup for the clock function and for program retention. The clock capability of each panel shall employ non-volatile memory and shall retain user programming and time for a minimum of 10 years.
* The clock capability of each panel shall operate on a basis of ON/OFF or Normal Hours/After Hours to automation groups that implement pre-configured control scenarios. Scenarios shall include:
	+ Scheduled ON / OFF
	+ Manual ON / Scheduled OFF
	+ Astro ON / OFF (or Photo ON / OFF)
	+ Astro and Schedule ON / OFF (or Photo and Schedule ON / OFF)
* Schedules programmed into the clock of any one panel shall be capable of executing local schedules or Dark/Light (photocell or Astro) events for that panel in the event that global network communication is lost.

CONFIGURATION TOOLS

A configuration tool facilitates optional customization of In-Room networks.

* Provide two Configuration Tools for the project.
* Provide free, downloadable PC software for direct programming of In-Room Networks.

Features and functionality of the wireless configuration tool shall include but not be limited to:

* Optional customization of In-Room networks using two-way wireless communications or USB interface.
* Must be able to read and modify parameters for room controllers, occupancy sensors, wall switches, daylighting sensors, network bridges and relay panels, and identify room devices by type and serial number.
* Adjust or fine-tune daylighting settings established during auto-configuration, and input light level data to complete configuration of open loop daylighting controls.

NETWORK CABLES

In-Room Networks

This specification is based on CAT5e data cables for In-Room Networks. Other wiring topologies are acceptable if controls accomplish all requirements specified in these documents.

Use manufacturer's factory-tested Cat 5e cable with pre-terminated RJ-45 connectors for In-Room Networks. If manufacturer’s cables are not used, each field-terminated cable shall be tested prior to installation and testing results submitted to the Manufacturer's Representative for approval prior to proceeding with the Work.

UL 2043 plenum rated where required.

Global Network

The Global Network, where used, shall utilize communications cabling as specified by the manufacturer. The maximum cable run for each segment (distance between In-Room Networks) shall meet manufacturer limitations.

Include the following heading and five sub-paragraphs if a PC-based management system or BAS interface is required for the project.

[NETWORK INTERFACES

Global Network Bridge:

* Provide one bridge for each In-Room Network that is to be connected to the Global Network.
* UL 2043 plenum rated where required.
* Manufacturer-specified network cable shall daisy-chain all network bridges together.
* The Global Network Bridge module connects an In-Room Network to a segment of the Global Network for communication between rooms, relay panels, and a Global Management Controller or BAS.
* The Global Network Bridge shall be provided as a separate module connected on the In-Room network.
* Global Network Bridge shall make all room devices connected to the In-Room network and all device parameters visible to the Global Management Controller via the Global Network.
* The global network bridge shall link back to front-end controller for connection to building LAN for centralized programming and BAS interface (optional).
* If a network bridge loses communication with the Global Network, In-room network shall stay active and operate as normally programmed. There shall be no disruption to local control.

Global Management Controller:

* For networked applications, the system shall include at least one Global Management Controller to manage network communication. It shall be capable of serving up a graphical user interface via a standard web browser utilizing either unencrypted TCP/IP or encrypted SSL TCP/IP traffic via a configurable port.
* Each Global Management Controller shall have integral support for at least three segments of the Global Network. Each segment may alternately be connected to the Global Management Controller via external routers and switches, using standard Ethernet structured wiring. Each router shall accommodate one segment of the Global Network.

Operational features of the Controller shall include the following:

* Connection to PC or LAN via standard Ethernet TCP/IP with the option to use SSL encrypted connections for all traffic.
* Graphical user interface shall be compatible with current internet browsers and shall not require installation of any lighting control software on an end-user PC.
* Log-in security capable of restricting some users to view-only or other limited operations.
* Ability to view and modify room device operational parameters. It shall be possible to set device parameters independently for normal hours and after-hours operation including sensor time delays and sensitivities, and load response to sensor including Manual-On or Auto-On.
* Ability to set up schedules for rooms and panels, view and override current status of panel channels and relays, and assign relays to groups. Schedules shall automatically set controlled zones or areas to either a normal-hours or after-hours mode of operation. Support for a minimum of 100 unique schedules, each with up to four-time events per day. Support for annual schedules, holiday schedules and unique date-bound schedules.
* Ability to group rooms and loads for common control by schedules, switches, or network commands.

Network Equipment

Provide all necessary network components, i.e., routers, switches, repeaters, etc. as suggested by the manufacturer for a complete Global Network System.

Global Network cables shall be furnished and installed by this contractor per manufacturer requirements.

BAS Integration

Provide capabilities for integration with a Building Automation System **(**BAS**)** via BACnet protocol.

At a minimum, the following points shall be available to the BAS via BACnet IP connection to the Global Management Controller: Room occupancy state; Room schedule mode; Room switch lock control; Individual occupancy sensor state; Load ON/OFF state; Load dimming level; Panel relay state; and Global Management Controller Group schedule state.

Management Software

Every device parameter (e.g., sensor time delay and photocell setpoint) shall be available and configurable remotely from the software.

Software shall require all users to log in with a Username and Password.

Software shall provide at least three permission levels for users.

All sensitive stored information and privileged communication by the software shall be encrypted.

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

Software shall be capable of managing systems interconnected via a WAN (wide area network).]

1. - EXECUTION

DELIVERY, STORAGE, AND HANDLING

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

PROJECT CONDITIONS

Maintain environmental conditions (temperature, humidity, and ventilation) within limits recommended by manufacturer. Do not install products under environmental conditions outside manufacturer's absolute limits.

Do not install equipment until following conditions can be maintained in spaces to receive equipment:

Ambient temperature: 32 to 104 degrees F (0 to 40 degrees C).

Relative humidity: Maximum 90 percent, non-condensing.

SENSOR LAYOUTS

Confirm quantity and provide appropriate coverage by sensors on a per-space requirement. Symbols on drawings are diagrammatic and represent design intent only.

Occupancy sensors shall be installed at locations indicated on the manufacturer’s submittal layout drawings. Sensors shall be located to prevent false triggering of the lights to ON when no occupant is present.

AUXILIARY CONTACTS for HVAC INTERLOCK

Provide auxiliary dry contacts for HVAC/BAS interlock via Digital Auxiliary Input/Output (I/O) Interface Modules when required. Refer to the “Occ Sensor Interlock” column in the Air Terminal Schedule on the HVAC drawings. Provide one auxiliary contact for each HVAC zone per the Air Terminal Schedule to signal occupancy to the BAS system.

The occupancy sensors, room controllers, and auxiliary contacts shall be configured such that the sensors still detect occupancy and control the auxiliary contacts regardless of whether the lights are ON or OFF (e.g., The occupant has turned the lights OFF because there is enough daylight, but the occupant is still occupying the space, so the occupancy sensor senses the occupant and closes the auxiliary contacts for Air Terminal control).

The HVAC/BAS wiring to the auxiliary contacts shall be by the Division 23 contractor.

INSTALLATION

Install system in accordance with the approved system shop drawings and manufacturer's instructions.

Install all room/space devices using manufacturer's factory-tested Cat 5e cable with pre-terminated RJ-45 connectors.

If pre-terminated cable is not used for room/space wiring, each field-terminated cable shall be tested following installation and testing results submitted to the Manufacturer's Representative for approval prior to proceeding with the Work.

Install all room-to-room digital devices using manufacturer-supplied network wire. Network wire substitution is not permitted and may result in loss of product warranty.

Low-voltage wiring topology must comply with manufacturer's specifications.

Document final wiring locations, routing, and topology on as-built drawings.

All line-voltage connections shall be tagged to indicate circuit and switched legs.

Test all devices to ensure proper communication.

Calibrate all sensor time delays and sensitivity to guarantee proper detection of occupants and energy savings.

Adjust time delay so that controlled area remains lighted while occupied.

Provide written or computer-generated documentation on the configuration of the system including room-by-room description including:

* Sensor parameters, time delays, sensitivities, and daylighting setpoints.
* Sequence of operation, (e.g., manual ON, Auto OFF. etc.)
* Load Parameters (e.g., blink warning, etc.)

Tighten all panel Class I conductors at circuit breakers and at loads to torque ratings as marked on enclosure UL label.

All Class II cabling shall enter enclosures from within low-voltage wiring areas and shall remain within those areas. No Class I conductors shall enter a low-voltage area.

Run separate neutrals for any phase dimmed branch load circuit. Different types of dimmed loads shall have separate neutrals.

Verify all loads to be free from short circuits prior to connection to room controllers.

Control-voltage cables shall be installed in conduit. However, they may be installed free-air (without conduit) above accessible ceilings if the cable meets NEC requirements for the application, unless specified to be in conduit in other sections of the specifications. See requirements for free-air cable installation below.

Control cables for controlling HVAC and lighting equipment connected to emergency power shall be routed in raceways separate from each other.

FREE-AIR CABLE INSTALLATION

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

Cabling shall be supported at a maximum of 4-foot intervals utilizing “J-Hook” or “Bridal 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.

To reduce or eliminate Electro-Magnetic Interference (EMI), the following minimum separation distances for ‘Free-Air’ cabling installations shall be adhered to:

• Twelve (12) inches from power lines of less than 5kV.

• Thirty-nine (39) inches from power lines of 5kV or greater.

• Five (5) inches from lighting fixtures.

• Thirty-nine (39) inches from transformers and motors.

 A coil of 4 feet in each cable shall be placed in the ceiling at each ‘free-air’ wired device. These coils shall be secured (wire tied) at the last cable support before the cable reaches the device and shall be coiled from 100% to 200% of the cable recommended minimum bend radius.

 All cable 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 manufacturers minimum bend radius shall be observed in all instances. Care should be taken in the use of cable ties to secure and anchor the station cabling. Ties should not be over tightened as to compress the cable jacket. No sharp burrs should remain where excess length of the cable tie has been cut.

 All exposed vertical cable extensions to devices located below the finished ceiling shall be in conduit.

Use suitable cable fittings and connectors.

When free-air cable installation is to be permitted in exposed ceiling areas, the A/E shall identify these areas on the plan drawings.

When permitted in exposed ceiling areas as designated on the plan drawings, Free-Air wiring runs shall avoid areas of high traffic (i.e., aisle way), shall be run as close as possible to outlining walls and shall be a minimum of ten (10) feet above finished floor. Provide protection for exposed cables where subject to damage.

FIELD QUALITY CONTROL

Electrician/Low Voltage Technician: Any low voltage wiring made onsite by electrical or low voltage contractor must be verified end to end with industry standard test equipment capable of printing or producing a digital file of the testing results.

Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing. Notify Manufacturer in writing a minimum of three (3) weeks prior to system start-up and testing.

Tests and Inspections: Manufacturer's service representative or electrical/low-voltage contractor installing low voltage cabling that is not pre-terminated from the manufacturer shall perform the following inspections and prepare reports:

Tests and Inspections: Manufacturer's service representative shall perform the following inspections and prepare reports:

* Verify end-to-end testing of all low voltage wiring that is not pre-terminated from the manufacturer. Provide detailed results via paper or digital format downloadable from testing equipment.
* Verify Class I and II wiring connections by validating system performance.
* Set IP addresses and other network settings of system front-end hardware per facility’s IT. instructions.
* Verify/complete task programming for all switches, dimmers, time clocks, and sensors.
* Verify that the control of each space complies with the Lighting Sequence of Operation.
* Correct any system issues and retest.

Provide a report in table format with drawings or using a software file that can be opened in the manufacturer's system software including each room or space that has lighting control installed. Indicate the following:

* Date of test or inspection.
* Loads per space.
* Fixture Address identification.
* Quantity and Type of each device installed.
* Reports providing each device's settings.

Provide Sequence of Operation descriptions either here or on the plans. Provide separate Sequences of Operation for areas/room that are intended to operate differently than other areas/rooms. The Sequence(s) of Operation shown below are examples only and shall be edited for the intended operation for your specific project.

SEQUENCE of OPERATION

[See plans for Sequence of Operation descriptions.]

[See below for Sequence of Operation descriptions:

1. NON-DAYLIT AREAS
	1. Automatic Control
		1. Time based: ON at 6:00am, OFF at 11:00pm, seven days/week. Confirm hours with User Agency.
		2. Lights OFF during Holidays.
		3. Blink-warn before lights turn OFF.
	2. Manual control via Low Voltage Control Station.
		1. ON/OFF Button shall toggle between lights ON and OFF.
		2. Users may raise or lower levels by pressing arrow buttons from 10% to 100%. Dim settings to be retained until changed by users.
2. DAYLIT AREAS
	1. Automatic Control
		1. Time based: ON at 6:00am, OFF at 11:00pm, seven day/week. Confirm hours with User Agency.
		2. Lights OFF during Holidays.
		3. Blink-warn before lights turn OFF.
		4. Automatically dim lights down based on input from daylight sensor.
	2. Manual control via Low Voltage Control Station.
		1. ON/OFF Button shall toggle between lights ON and OFF.
		2. Users may raise or lower levels by pressing arrow buttons from 10% to 100%. Dim settings to be retained until changed by users.

POST START-UP TUNING

Adjust sensor time delays and sensitivities to meet the Owner's requirements 30 days from initial occupancy. Provide a detailed report to the Architect/Owner of post start-up activity.

WARRANTY

Manufacturer shall provide a 5-year limited warranty on products within this installation, except where otherwise noted, and consisting of a one-for-one device replacement.

PRODUCT SUPPORT AND SERVICE

Factory telephone support shall be available at no cost to the Owner following acceptance. Factory assistance shall consist of assistance in solving application issues pertaining to the control equipment.

CONSTRUCTION VERIFICATION ITEMS

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.

The Contractor, through their supplier, shall provide training on the system operation for the owner as part of this contract. The training shall consist of two (2) four-hour sessions.

END OF SECTION