 5	Title: YALE OFFICE OF FACILITIES PROCEDURE MANUAL Chapter: 01 - Yale Design Standard Division: Electrical Standards	Section: 26 51.00 Interior Lighting
		Date: 6/15/16
		Author: Office of Facilities
CC: Project Folder		

Change History

Date	Description of Change	Pages / Sections Modified	Change Approver Initials
6/15/16	Updated division section from 16511 to 26 51 00, removed references to other section	-	mgl44
10/17/14	Add section L (Network Lighting Controls)	16> - 16511, L (Interior Lighting; Network Lighting Controls)	SO


A. Summary

This section contains design criteria for interior lighting systems.


B. System Design and Performance Requirements

1. General


- a. Design lighting systems to achieve required levels of illumination while minimizing energy consumption. Select lamps and luminaires for high efficiency. Interior lighting systems must operate at the highest practical voltage level available. Specify high reflectivity interior finishes to achieve the following minimum reflectances:
 - Ceilings: 80 percent
 - Walls: 50 percent
 - Floors: 20 percent
- b. Incorporate natural day lighting in the design to greatest extent possible to replace or supplement artificial lighting.
 - (1) Use windows, clerestories, and skylights to admit light into interior spaces. Use control devices, such as blinds, diffusers, and light shelves to control distribution, brightness, and glare.
 - (2) Arrange interior lighting systems so appropriate areas can be switched off or dimmed when adequate natural light is present. Where applicable, provide control by the following means:
 - Wall switches placed for occupant convenience
 - Occupancy sensors
 - Dimming controls, which may include multi-level stepping or switching

 5	Title: YALE OFFICE OF FACILITIES PROCEDURE MANUAL Chapter: 01 - Yale Design Standard Division: Electrical Standards	Section: 26 51.00 Interior Lighting
		Date: 6/15/16
		Author: Office of Facilities
CC: Project Folder		

- Photo sensors
 - Programmable central control systems
- c. Design interior lighting systems to achieve the following levels of illumination, measured in maintained horizontal footcandles on a working surface located 30 inches above floor level, within a tolerance of plus or minus 20 percent:
- Auditoriums.....30
 - Bedrooms20
 - Classrooms50
 - Conference rooms.....40
 - Corridors.....20
 - Dining halls15
 - Elevators.....15
 - Gymnasiums (general).....30
 - Gymnasiums (varsity)50
 - Kitchens.....75
 - Laboratories.....75
 - Lecture halls30
 - Libraries (reading areas).....50
 - Libraries (stacks).....30
 - Lobbies 15
 - Locker rooms.....15
 - Lounges 15
 - Mechanical rooms.....20
 - Music rooms40
 - Offices50
 - Stairways 15
 - Storage areas.....15
 - Toilets 15
 - Waiting areas15
 - Workshops.....75


 5	Title: YALE OFFICE OF FACILITIES PROCEDURE MANUAL Chapter: 01 - Yale Design Standard Division: Electrical Standards	Section: 26 51.00 Interior Lighting
		Date: 6/15/16
		Author: Office of Facilities
CC: Project Folder		

- d. In occupancies where specialized tasks are performed (for example, at serving areas in dining halls and at mirrors in toilet rooms), the illumination levels listed in paragraph 3 might not be sufficient for adequate illumination. At such locations, increase the ambient lighting levels as necessary. Ambient lighting may also be supplemented by task lighting with the approval of the Yale University Project Manager (the ambient level should not be less than one-third the level at the task).
- e. Design exterior lighting systems to achieve a minimum illumination level of 0.5 maintained horizontal footcandles at ground level along main walkways, with a maximum uniformity ratio of 6:1. Provide luminaires at all building entrances. The Yale University Project Manager will determine lighting levels in other exterior occupancies. Coordinate all new exterior lighting with existing lighting so that areas are not lit excessively.
- f. Arrange lighting throughout all critical areas (including egress areas, assembly occupancies, health care facilities, and public safety operations) so that failure of any single element of the system, such as a lamp, ballast, switch, circuit breaker, or conductor, does not leave any portion of a critical area in darkness or illuminated at less than the levels required by code.
 - (1) Where only the normal distribution system is available, provide self-contained emergency lighting units connected to an unswitched lighting branch circuit conductor.
 - (2) Where both normal and alternate distribution systems are available, lighting fixtures must alternate between each source along the entire length of the critical area.
 - (3) Systems that use a central battery are acceptable only if wired as described in paragraph 6. b.
- g. In lighting calculations, maintenance factors (LLD x LDD) must not exceed 0.65. For high-intensity discharge fixtures, ballast factors must not exceed 0.9.
- h. Interior light sources must be fluorescent or compact fluorescent, except as follows:
 - (1) When installed in high ceiling spaces (over 12 feet) in finished areas where they are not subject to frequent switching, interior light sources must be metal halide
 - (2) When installed in high ceiling spaces (over 12 feet) in unfinished areas,

	Title: YALE OFFICE OF FACILITIES PROCEDURE MANUAL Chapter: 01 - Yale Design Standard Division: Electrical Standards	Section: 26 51.00 Interior Lighting
		Date: 6/15/16
		Author: Office of Facilities
CC: Project Folder		

such as warehouses and workshops, interior light sources must be high-pressure sodium.

- i. Exterior light sources must be metal halide. Exterior light sources installed in vehicular traffic areas, such as driveways and parking lots, must be high-pressure sodium.
- j. In areas where variable levels of illumination might be required by multiple users of the space, or for energy conservation purposes, provide multi-level switching or dimming capabilities. Such areas can include auditoriums and lecture halls, classrooms, gymnasiums, laboratories, offices, and workshops.
- k. Use motion sensors to control lighting in areas subject to extended unoccupied periods during normal hours of occupancy. Such areas include the following:
 - Classrooms
 - Conference rooms
 - Private offices
 - Bathrooms in residential colleges (locate sensors so that the interiors of toilet stalls are within the field of view)
 - Electrical, mechanical, T/D communication rooms
 - Storage areas
 - Laundry rooms
- l. Use photocell-actuated combination lighting contactors to control exterior lighting systems. Mount manual-automatic selector switches on the contactors.
- m. Coordinate luminaire locations with architectural features of space and with adjacent structural and mechanical elements.
- n. Avoid quartz-restrike capability with HID luminaires.
- o. Areas in which lighting is critical, such as means of egress, places of assembly, etc., should be provided with multiple lighting circuits fed from both normal and alternate systems so that failure of either source does not require transferring of the load.
- p. Because they are subject to accumulations of dirt and debris, avoid indirect systems. In all cases, luminaire design and placement must make it difficult for combustible debris to contact hot portions of luminaires, such as lamps and ballasts. Where the control of glare is a consideration, parabolic louvers are preferred. In rooms where two or more video display terminals are used,


	Title: YALE OFFICE OF FACILITIES PROCEDURE MANUAL Chapter: 01 - Yale Design Standard Division: Electrical Standards	Section: 26 51.00 Interior Lighting
		Date: 6/15/16
		Author: Office of Facilities
CC: Project Folder		

fixtures must have a minimum 0.7 visual comfort probability (VCP) value.

- q. Avoid custom fixtures, but minor modifications to stock fixtures are acceptable. Custom fixtures are acceptable only when necessary to preserve the architectural character of prominent spaces (for example, dining halls and common rooms in residential colleges).
- r. Avoid inefficient luminaires. Coefficients of utilization should exceed 0.7 for a room cavity ratio of 1.0.
- s. Luminaires recessed in fire-rated construction must be specifically listed for such use.
- t. Unless required to suit specific design conditions, such as wet locations, do not specify luminaires for interior spaces that are designed for exterior use.
- u. Wire four-lamp fluorescent luminaires for dual-level switching so that one ballast serves the inner pair of lamps and the other ballast serves the outer pair, whether or not such switching is called for in the project. Wire three-lamp fluorescent luminaires for multi-level switching so that the single-lamp ballast serves the middle lamp and the two-lamp ballast serves the outer lamps, whether or not such switching is called for in project. Where three-lamp fixtures are installed in continuous rows, wire them so that the middle lamps in each pair of adjacent fixtures are served by one two-lamp ballast located in either fixture.
- v. Ensure that the lighting fixture schedules shown on construction documents are in accordance with Section 01064: Electrical Regulatory and Directive Standards, Standard Detail 16500-1.

2. Lamps

- a. Avoid unusual lamps. Unless justified by specific design conditions, restrict lamp types to those commonly stocked by Physical Plant, which are identified in paragraph 2 under Equipment. For small renovation projects, fluorescent lamps must match existing lamps used in adjacent areas. For other projects, fluorescent lamps must be T-8 energy-saving types in conjunction with electronic ballasts.
- b. Do not use energy-saving lamps in cold temperature applications (below 50°F) or where fluorescent emergency lighting or dimming systems are used.
- c. Use incandescent lamps only where other sources are unsuitable.
- d. Where incandescent lamps rated at 130 volts are used on nominal 120 volt

 5	Title: YALE OFFICE OF FACILITIES PROCEDURE MANUAL Chapter: 01 - Yale Design Standard Division: Electrical Standards	Section: 26 51.00 Interior Lighting
		Date: 6/15/16
		Author: Office of Facilities
CC: Project Folder		

systems, base lighting calculations on the assumption that actual lumen output is 75 percent of the output at rated voltage.

- e. Low-pressure sodium and mercury vapor lamps are not acceptable.
- f. Avoid luminaires that use unusual lamps. Unless justified by specific design conditions, restrict lamp types to those described in this section. The use of 2-foot by 2-foot fluorescent fixtures is discouraged. Such fixtures may be used only with the approval of the Yale University Project Manager. Where such fixtures are permitted, use F17T8 lamps. U-shaped lamps are not acceptable.

3. Ballasts


- a. All ballasts must be high power factor, energy-efficient, multiple-input types, where such products are commercially available.
- b. All fluorescent ballasts must be electronic-type used in conjunction with T-8 lamps. However, energy-saving magnetic ballasts may be used for small renovation projects where adjoining areas use fluorescent fixtures equipped with magnetic ballasts.
- c. In small areas, such as toilets or portions of egress areas, where multiple fixtures are not provided, specify two-lamp fixtures with two, single-lamp ballasts so that the failure of one ballast will not leave the area in darkness.
- d. Ballasts must be remote-mounted only when considerations such as noise, temperature, radio-frequency interference, and electromagnetic fields are critical.

4. Emergency Lighting

- a. Self-contained battery-type emergency lighting systems are acceptable only where alternate distribution systems are not available.
- b. Locate emergency lighting units so that the lamps do not create excessive glare for persons traveling along egress areas to the nearest exit.
- c. Where power packs are to be added to standard fluorescent fixtures to achieve the required emergency lighting, calculations must indicate the actual lumen output of standard lamps in the emergency mode.

5. Exit Signs

Exit signs that incorporate emergency lighting heads in one unit are not acceptable because glare from the lights obscure the exit sign during emergencies.

 5	Title: YALE OFFICE OF FACILITIES PROCEDURE MANUAL Chapter: 01 - Yale Design Standard Division: Electrical Standards	Section: 26 51.00 Interior Lighting
		Date: 6/15/16
		Author: Office of Facilities
CC: Project Folder		

C. Designer Submittals

Submit the following design and construction documents.

1. Designer Submittals

- Lighting calculations or isofootcandle layouts demonstrating that required illumination footcandle levels and watts per square foot will be achieved throughout all spaces, including means of egress described in Section 00706: General Electrical Design Conditions.
- Catalog cuts


2. Construction Documents

- Shop drawings and product data
- Exit signs must be furnished with a minimum, 20-year manufacturer's warranty (exclusive of the battery)
- Operation and maintenance instructions, with parts lists

D. Product Standards

Ensure that all products conform to the following standards:

- ANSI C78.1 (with supplements), Dimensional and Electrical Characteristics of Fluorescent Lamps, Rapid Start Types
- ANSI C78.2 (with supplements), Dimensional and Electrical Characteristics of Fluorescent Lamps, Preheat Start Types
- ANSI C78.20, Characteristics of Incandescent Lamps of A, G, PS, and Similar Shapes with E26 Medium Screw Bases
- ANSI C78.21, Characteristics of Incandescent Lamps of PAR and R Shapes
- ANSI C78.1350 through C78.1359, High-Pressure Sodium Lamps
- ANSI C78.1375 through C78.1381, Metal Halide Lamps
- ANSI C82.1, Specifications for Fluorescent Lamp Ballasts
- ANSI C82.2, Methods of Measurement of Fluorescent Lamp Ballasts
- ANSI C82.3, Specifications for Fluorescent Lamp Reference Ballasts
- ANSI C82.4 (with supplement), Specifications for High-Intensity-Discharge and Low-Pressure Sodium Lamp Ballasts (Multiple-Supply Type)
- ANSI C82.5 (with supplement), Specification for High-Intensity Discharge Lamp Reference Ballasts

	Title: YALE OFFICE OF FACILITIES PROCEDURE MANUAL Chapter: 01 - Yale Design Standard Division: Electrical Standards	Section: 26 51.00 Interior Lighting
		Date: 6/15/16
		Author: Office of Facilities
CC: Project Folder		

- ANSI C82.6 (with supplement), Methods of Measurement of High-Intensity Discharge Lamp Ballasts
- UL 935, Fluorescent-Lamp Ballasts
- UL 1029, High-Intensity-Discharge-Lamp Ballasts
- NEMA LE1, Fluorescent Luminaires
- UL 1570, Fluorescent Lighting Fixtures
- UL 1571, Incandescent Lighting Fixtures
- UL 1572, High Intensity Discharge Lighting Fixtures
- UL 924, Emergency Lighting and Power Equipment

E. Manufacturers

Select luminaires that contribute to the aesthetic appeal of Yale University facilities while maintaining high standards of quality, energy efficiency, maintainability, and cost-effectiveness. The following manufacturers offer such features. However, this list does not exclude other manufacturers who, based on the experience of design professionals, might also produce acceptable luminaires.

1. Compact fluorescent downlights:


- Edison-Price
- Halo
- Lightolier
- Prescolite

2. Decorative compact fluorescent lighting:

- Kamro-Champion
- Lightolier
- Seagull
- Shaper

3. General fluorescent lighting, including troffers, wraparounds, and industrial fixtures:

- Columbia
- Day-Brite
- Lithonia
- Metalux

 5	Title: YALE OFFICE OF FACILITIES PROCEDURE MANUAL Chapter: 01 - Yale Design Standard Division: Electrical Standards	Section: 26 51.00 Interior Lighting
		Date: 6/15/16
		Author: Office of Facilities
CC: Project Folder		

4. Decorative fluorescent lighting:

- Alkco
- Architectural Lighting Systems
- Litecontrol

5. Track lighting:

- Juno, Prescolite, or Ruud (interchangeable on the same track)
- Lightolier
- Staff

6. Industrial lighting:

- Holophane
- Hubbell
- Lumark
- Sportlite

7. Lamps:

- General Electric
- Phillips
- Sylvania/Osram
- Link

8. Emergency Lights:


- Dual-Lite
- Emergi-Lite
- Lithonia

9. Exit Signs:

- Exitronix
- Hubbell
- Self-Powered Lighting (SPL)

F. Materials


1. Use prismatic acrylic (pattern 12) lenses for fluorescent fixtures, but specify polycarbonate where the fixtures are subject to physical damage. Use tempered glass lenses for high-intensity discharge fixtures.

 5	Title: YALE OFFICE OF FACILITIES PROCEDURE MANUAL Chapter: 01 - Yale Design Standard Division: Electrical Standards	Section: 26 51.00 Interior Lighting
		Date: 6/15/16
		Author: Office of Facilities
CC: Project Folder		


2. Where louvered fixtures are selected, specify acrylic louvers instead of polystyrene. Where parabolic louvers are selected, semi-specular finishes are preferred over specular finishes. Where miniature parabolic louvers are selected, the openings must be 1/2 inch by 1/2 inch by 1/2 inch.

G. Equipment

1. Use long-life, soft white or inside frosted, Type A incandescent lamps with an average life of 3,000 hours at 130 volts.
2. Use energy-saving, Type R incandescent lamps. Specify 130 volt models where available.
3. Compact fluorescent lamps must have a two-pin base, with a minimum rated lamp life of 10,000 hours. Chromaticity must be between 2700°K and 3000°K; however, 3500°K lamps may be used where necessary to match the color of T-8 fluorescent lamps. The following lamp types are preferred:
 - Twin tube, 7 watts: NEMA CFT7W/G23
 - Twin tube, 9 watts: NEMA CFT9W/G23
 - Twin tube, 13 watts: NEMA CFT13W/GX23
 - Quad type, 13 watts: NEMA CFQ13W/G24d
 - Quad type, 18 watts: NEMA CFQ18W/G24d
 - Quad type, 26 watts: NEMA CFQ26W/G24d
4. Use 265 milliamp, T-8 rapid-start fluorescent lamps wherever possible. Lamp chromaticity must be 3500°K. Lamps of 3000°K may be used with the Yale University Project Manager's approval, but other colors are not acceptable. The minimum rated lamp life must be 20,000 hours. Only four-foot lamps are acceptable in fixtures four feet or more in length. U-shaped lamps are not acceptable. The following lamp types are preferred:
 - Four-foot, bi-pin base: F32T8/3500K/RS
 - Two-foot, bi-pin base: F17T8/3500K/RS
5. Metal halide lamps must be clear-, medium-, or mogul-base only with a minimum rated lamp life of 10,000 hours. Use self-extinguishing lamps in applications, such as sports lighting or open-bottom downlighting, where damage due to impact may be anticipated. Where color uniformity within groups of lamps is important, such as walkway lighting applications, use General Electric "Halarc" series lamps. The following lamp types are preferred:


 5	Title: YALE OFFICE OF FACILITIES PROCEDURE MANUAL Chapter: 01 - Yale Design Standard Division: Electrical Standards	Section: 26 51.00 Interior Lighting
		Date: 6/15/16
		Author: Office of Facilities
CC: Project Folder		

- 50 watt, medium base, for M110 ballast
 - 70 watt, medium base, for M98 ballast
 - 100 watt, medium base, for M90 ballast
 - 175 watt, mogul base, for M57 ballast
 - 250 watt, mogul base, for M58 ballast
 - 400 watt, mogul base, for M59 ballast
 - 1000 watt, mogul base, for M47 ballast
 - 1500 watt, mogul base, for M48 ballast
- 6.** Use clear, high-pressure sodium lamps with a minimum rated lamp life of 24,000 hours. However, deluxe coated lamps with a minimum rated lamp life of 10,000 hours may be used where color rendition is important (minimum CRI 65 at 2200°K). The following lamp types are preferred:
- 35 watt, medium base, for S76 ballast
 - 50 watt, medium base, for S68 ballast
 - 70 watt, medium base, for S62 ballast
 - 100 watt, medium base, for S54 ballast
 - 150 watt, mogul base, for S55 ballast
 - 250 watt, mogul base, for S50 ballast
 - 400 watt, mogul base, for S51 ballast
 - 1000 watt, mogul base, for S52 ballast
- 7.** Ballasts:
- a. Fluorescent ballasts must be ETL/CBM certified.
 - b. Fluorescent ballasts, other than reactance type, used with interior fixtures must be labelled UL Class P.
 - c. Fluorescent ballasts that are not used for dimming or cold weather applications must meet or exceed Federal Ballast Efficacy Factor requirements for fixtures intended for use in commercial buildings.
 - d. Fluorescent ballasts must carry an "A" rating in the manufacturer's sound classifications; however, ballasts for 800 milliamp lamps may carry "B" rating.
 - e. Use integrated circuit fluorescent electronic ballasts.
 - f. Fluorescent ballasts used where ambient temperatures fall below 50°F must be

 5	Title: YALE OFFICE OF FACILITIES PROCEDURE MANUAL Chapter: 01 - Yale Design Standard Division: Electrical Standards	Section: 26 51.00 Interior Lighting
		Date: 6/15/16
		Author: Office of Facilities
CC: Project Folder		

labelled for cold weather operation.

- g. Fluorescent ballasts used in dimming applications must be listed for use with the specific dimming controls provided, unless labeled for connection to Class 2 limited energy circuits.
 - h. Where fluorescent ballast operation will interfere with radio reception, specify ballasts with radio interference filters.
 - i. Use weatherproof ballasts only where directly exposed to weather. Use UL Type 2 outdoor ballasts for installation in exterior lighting fixtures.
- 8.** Use regulating, high-intensity discharge lamp ballasts with a minimum starting temperature of -20°F. For interior use, use enclosed, potted-type HID ballasts with the lowest available sound rating.
 - 9.** Do not provide luminaries with fuses.
 - 10.** Do not provide luminaries with receptacle outlets.
 - 11.** Fixtures must be hard-wired. Cord-and-plug connected luminaires are not acceptable, except in high-ceiling HID applications.
 - 12.** Self-contained emergency lighting units must operate from a maintenance-free, lead-calcium battery with an automatic charger. The units must be 6 VDC, except where high capacity is required to illuminate long distances or large areas, in which case 12 VDC units are acceptable. Use the following standard PAR 36, sealed-beam lamps:
 - Halogen: 6 watts minimum
 - Tungsten: 9 watts minimum
 - 13.** Battery power pack emergency lighting units must be hard-wired. Cord-and-plug connected units are not acceptable.
 - 14.** Power packs for standard fluorescent fixtures must be compatible with lamps and ballasts furnished with the fixture. Power packs must contain a battery, a charger, and control circuitry in one housing and be suitable for high-temperature operation. Power packs must be capable of being wired to switched fixtures without unnecessary emergency operation. Power packs must have LED indications to show the condition of their control circuit and batteries and have an audible alarm for component failure.
 - 15.** For energy conservation and low maintenance requirements, use Light-Emitting

 5	Title: YALE OFFICE OF FACILITIES PROCEDURE MANUAL Chapter: 01 - Yale Design Standard Division: Electrical Standards	Section: 26 51.00 Interior Lighting
		Date: 6/15/16
		Author: Office of Facilities
CC: Project Folder		

Diode (LED) exit signs with a maximum consumption of two watts per face. To permit visibility within a 170° field of view, furnish exit signs that have red letters with prismatic diffusers for even illumination across all parts of all letters.


16. Exit signs must operate on 120 VAC or 277 VAC power. If not connected to an emergency distribution system, specify exit signs with battery backups that include a charger and control circuitry. Specify batteries as described paragraphs 12 and 14.

H. Preparation

Protect luminaires from wall and ceiling finishing operations. Do not install the exposed portions of luminaires until the finishes have been applied to the surrounding areas and allowed to dry.

I. Installation Guidelines

1. Install lamps only in positions indicated in the lamp designation code.
2. Do not install high-intensity discharge lamps with scratched bulbs.
3. Do not energize high-intensity discharge lamps until they are enclosed within fixtures.
4. Bond all ballast cases to the equipment grounding conductor.
5. Luminaires installed in occupancies, such as laboratories and workshops, must be oriented parallel to benches and centered over the edge of the working surface. Space luminaires to maintain a maximum uniformity ratio of 2:1.
6. Use a maximum six-foot length of flexible metal conduit to connect luminaires located in suspended ceilings to branch circuit wiring.
7. Where dual-level or multi-level switching is provided, wire luminaires so that each switch controls corresponding lamps in all luminaires controlled by the switch.
8. Connect emergency lighting and exit sign units to unswitched conductors fed from the same branch circuit serving normal lighting in the protected area.
9. Do not mount emergency lighting and exit sign units higher than 10 feet above the finished floor unless provisions are made for the maintenance of such units.
10. Center exit signs on building elements, such as corridors and doorways.
11. Luminaires must be fitted with swivels or otherwise adjusted so they hang plumb and true. Pendent Luminaires must not be chain hung.

 5	Title: YALE OFFICE OF FACILITIES PROCEDURE MANUAL Chapter: 01 - Yale Design Standard Division: Electrical Standards	Section: 26 51.00 Interior Lighting
		Date: 6/15/16
		Author: Office of Facilities
CC: Project Folder		

J. Quality Control

1. After the lamps have been in service for 100 hours, obtain footcandle measurements during periods of darkness at a sufficient number of locations to demonstrate that the design criteria have been met. Submit the results to Yale University.
2. Where ballast noise is audible above the normal ambient noise, use sound level meter capable of measuring as low as 35 dBA to test the ballast noise level in accordance with the ballast manufacturer's specifications. Provide replacement ballasts where ballast noise is excessive. Where heat dissipation is not a concern, a resilient pad may be installed between the ballast and fixture.
3. Test emergency lighting units by opening the circuit breakers that serve normal lighting in the areas protected by the emergency lighting units.
4. Test exit signs by opening the circuit breakers that serve normal lighting in the areas served by the exit signs.

K. Cleaning and Adjusting


Clean and adjust luminaires at the end of the construction period.

L. Network Lighting Controls

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Digital-network lighting control system and associated components:
 1. Power panels.
 2. Fluorescent electronic dimming ballasts.
 3. LED drivers.
 4. Power interfaces.
 5. Main units.
 6. Lighting control modules.
 7. Energy meter.
 8. Digital dimming ballast and switching modules.
 9. Lighting management hubs.
 10. Lighting management system computers.

 5	Title: YALE OFFICE OF FACILITIES PROCEDURE MANUAL Chapter: 01 - Yale Design Standard Division: Electrical Standards	Section: 26 51.00 Interior Lighting
		Date: 6/15/16
		Author: Office of Facilities
CC: Project Folder		

11. Lighting management system software.
12. Control stations.
13. Low-voltage control interfaces.
14. Wired sensors.
15. Wireless sensors.
16. Accessories.

1.2 ADMINISTRATIVE REQUIREMENTS

A. Coordination:


1. Coordinate the placement of sensors and wall controls with millwork, furniture, equipment, etc. installed under other sections or by others.
2. Coordinate the placement of wall controls with actual installed door swings.
3. Coordinate the placement of daylight sensors with windows, skylights, and luminaires to achieve optimum operation. Coordinate placement with ductwork, piping, equipment, or other potential obstructions to light level measurement installed under other sections or by others.
4. Where motorized window treatments are to be controlled by the lighting control system provided under this section, coordinate the work with other trades to provide compatible products.
5. Coordinate the work to provide luminaires and lamps compatible with the lighting controls to be installed.
6. Notify Architect of any conflicts or deviations from the contract documents to obtain direction prior to proceeding with work.

B. Preinstallation Meeting: Conduct on-site meeting with lighting control system manufacturer prior to commencing work as part of manufacturer's standard startup services. Manufacturer to review with installer:

1. All components and locations.

C. Sequencing

1. Do not install sensors and wall controls until final surface finishes and painting are complete.


 5	Title: YALE OFFICE OF FACILITIES PROCEDURE MANUAL Chapter: 01 - Yale Design Standard Division: Electrical Standards	Section: 26 51.00 Interior Lighting
		Date: 6/15/16
		Author: Office of Facilities
CC: Project Folder		

1.3 SUBMITTALS

- A. Product Data: Include ratings, configurations, standard wiring diagrams, dimensions, colors, service condition requirements, and installed features.
 - 1. Occupancy/Vacancy Sensors: Include detailed basic motion detection coverage range diagrams.
- B. Shop Drawings:
 - 1. Provide schematic system riser diagram indicating component interconnections. Include requirements for interface with other systems.
 - 2. Provide detailed sequence of operations describing system functions.
- C. System Performance-Verification Documentation: Include as part of the base bid additional costs for manufacturer's enhanced documentation detailing start-up procedures and functional tests performed along with test results.
- D. Project Record Documents: Record actual installed locations and settings for lighting control system components.
- E. Operation and Maintenance Data: Include detailed information on lighting control system operation, equipment programming and setup, replacement parts, and recommended maintenance procedures and intervals.
- F. Warranty: Submit sample of manufacturer's warranty and documentation of final executed warranty completed in Owner's name and registered with manufacturer.
- G. Maintenance contracts.
- H. Software: One copy of software provided under this section.

1.4 QUALITY ASSURANCE

- A. Conform to requirements of NFPA 70.
- B. Maintain at the project site a copy of each referenced document that prescribes execution requirements.
- C. Manufacturer Qualifications:
 - 1. Company with not less than ten years of experience manufacturing lighting control systems of similar complexity to specified system.
 - 2. Registered to ISO 9001, including in-house engineering for product design activities.

 5	Title: YALE OFFICE OF FACILITIES PROCEDURE MANUAL Chapter: 01 - Yale Design Standard Division: Electrical Standards	Section: 26 51.00 Interior Lighting
		Date: 6/15/16
		Author: Office of Facilities
CC: Project Folder		

3. Qualified to supply specified products and to honor claims against product presented in accordance with warranty.

D. Maintenance Contractor Qualifications: Manufacturer's authorized service representative.

1.5 DELIVERY, STORAGE, AND HANDLING

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

1.6 WARRANTY

A. Manufacturer's Standard Warranty, With Manufacturer Start-Up:

1. Lighting Control System Components, Except Lighting Management System Computer, Ballasts and Ballast Modules:

a. First Two Years:

1) 100 percent replacement parts coverage, 100 percent manufacturer labor coverage to troubleshoot and diagnose a lighting issue.

2) First-available on-site or remote response time.

b. Telephone Technical Support: Available 24 hours per day, 7 days per week, excluding manufacturer holidays.

2. Lighting Management System Computer: One year 100 percent parts coverage, one year 100 percent manufacturer labor coverage.


3. Ballasts and Ballast Modules: Five years 100 percent parts coverage, no manufacturer labor coverage.

B. Include as part of the base bid additional costs for manufacturer's enhanced warranty with manufacturer start-up; coverage to include items listed under manufacturer's standard warranty with manufacturer start-up above, plus the following upgrades:

1. Lighting Control System Components, Except Lighting Management System Computer, Ballasts and Ballast Modules:

a. First Two Years:

1) Upgrade from first-available to 72-hour on-site or remote

 5	Title: YALE OFFICE OF FACILITIES PROCEDURE MANUAL Chapter: 01 - Yale Design Standard Division: Electrical Standards	Section: 26 51.00 Interior Lighting
		Date: 6/15/16
		Author: Office of Facilities
CC: Project Folder		

response time.

- 2) Upgrade from first-available to 24-hour on-site or remote response time.
 - 3) Additional annual scheduled preventive maintenance visit.
- b. Additional Coverage for Years 3-5: 50 percent replacement parts coverage, no manufacturer labor coverage.
 - c. Additional Coverage for Years 6-8: 25 percent replacement parts coverage, no manufacturer labor coverage.
- C. Extended 100 Percent Warranty Coverage with Technology Support Plan: Beginning two years after system startup completion, provide additional 100 percent replacement parts and manufacturer labor coverage for the components and duration specified in Part 3 under "Maintenance" as part of maintenance contract.

PART 2 PRODUCTS

2.1 MANUFACTURERS


A. Other Acceptable Manufacturers:

1. Lutron.

2.2 DIGITAL-NETWORK LIGHTING CONTROL SYSTEM - GENERAL REQUIREMENTS


A. Include as part of the base bid additional costs for manufacturer's sensor layout and tuning services:

1. Lighting control manufacturer to design occupancy/vacancy and/or daylight sensor layout (wired and/or wireless sensors) that provides adequate coverage and performs according to required sequence of operations.
2. Lighting control manufacturer to visit site for preinstallation meeting and system startup; lighting control manufacturer may direct Contractor regarding sensor relocation should conditions require a deviation from locations indicated.
3. Any additional sensors or hardware required to meet sequence of operations to be furnished by lighting control manufacturer at no


 5	Title: YALE OFFICE OF FACILITIES PROCEDURE MANUAL Chapter: 01 - Yale Design Standard Division: Electrical Standards	Section: 26 51.00 Interior Lighting
		Date: 6/15/16
		Author: Office of Facilities
CC: Project Folder		

additional cost.

4. Lighting control manufacturer to provide up to two additional post-startup on-site service visits for fine-tuning of sensor calibration.
- B. Provide products listed, classified, and labeled by Underwriter's Laboratories Inc. (UL) as suitable for the purpose indicated.
- C. Unless specifically indicated to be excluded, provide all required equipment, conduit, boxes, wiring, connectors, hardware, supports, accessories, software, system programming, etc. as necessary for a complete operating system that provides the control intent indicated.
- D. Shade Control Requirements:
1. Capable of operating shades independently, without use of external group controllers.
 2. Capable of controlling shade speed for tracking within plus or minus 0.125 inch (3.17 mm) throughout entire travel.
 3. Provide 10 year power failure memory for preset stops, open and close limits, shade grouping and sub grouping and system configuration.
 4. Capable of synchronizing multiple shade electronic drive units of the same size to start, stop and move in unison.
 5. Capable of controlling any shade electronic drive unit via keypads and contact closure inputs without separate group controller.
 6. Capable of operating any group or sub group of shade electronic drive units within subsystem via keypads and interfaces.
 7. Capable of one-touch control of shades via keypad, lighting control, or handheld remote.
 8. Capable of stopping shades within accuracy of 0.125 inch (3.17 mm) at any point between open and close limits.
 9. Capable of storing up to 250 programmable stop points, including open, close, and any other position.
 10. Capable of recalling presets via keypad, contact closure input, infrared receiver, lighting management system software, or other lighting control system interface.


 5	Title: YALE OFFICE OF FACILITIES PROCEDURE MANUAL Chapter: 01 - Yale Design Standard Division: Electrical Standards	Section: 26 51.00 Interior Lighting
		Date: 6/15/16
		Author: Office of Facilities
CC: Project Folder		

11. Capable of controlling lights and shades from single wall control button.
- E. Design lighting control equipment for 10 year operational life while operating continually at any temperature in an ambient temperature range of 32 degrees F (0 degrees C) to 104 degrees F (40 degrees C) and 90 percent non-condensing relative humidity.
- F. Electrostatic Discharge Tolerance: Design and test equipment to withstand electrostatic discharges without impairment when tested according to IEC 61000-4-2.
- G. Dimming and Switching (Relay) Equipment:
 1. Designed so that electrolytic capacitors operate at least 36 degrees F (20 degrees C) below the capacitor's maximum temperature rating when the device is under fully loaded conditions at maximum rated temperature.
 2. Inrush Tolerance:
 - a. Utilize load-handling thyristors (SCRs and triacs), field effect transistors (FETs) and isolated gate bipolar transistors (IGBTs) with maximum current rating at least two times the rated operating current of the dimmer/relay.
 - b. Capable of withstanding repetitive inrush current of 50 times the operating current without impacting lifetime of the dimmer/relay.
 3. Surge Tolerance:
 - a. Panels: Designed and tested to withstand surges of 6,000 V, 3,000 amps according to IEEE C62.41.2 and IEC 61000-4-5 without impairment to performance.
 - b. Other Power Handling Devices: Designed and tested to withstand surges of 6,000 V, 200 amps according to IEEE C62.41.2 without impairment to performance.
 4. Power Failure Recovery: When power is interrupted and subsequently restored, within 3 seconds lights to automatically return to same levels (dimmed setting, full on, or full off) as prior to power interruption.
 5. Dimming Requirements:
 - a. Line Noise Tolerance: Provide real-time cycle-by-cycle compensation for incoming line voltage variations including changes in RMS voltage (plus or minus 2 percent change in RMS voltage per


 5	Title: YALE OFFICE OF FACILITIES PROCEDURE MANUAL Chapter: 01 - Yale Design Standard Division: Electrical Standards	Section: 26 51.00 Interior Lighting
		Date: 6/15/16
		Author: Office of Facilities
CC: Project Folder		

cycle), frequency shifts (plus or minus 2 Hz change in frequency per second), dynamic harmonics, and line noise.

- 1) Systems not providing integral cycle-by-cycle compensation to include external power conditioning equipment as part of dimming system.
- b. Incorporate electronic "soft-start" default at initial turn-on that smoothly ramps lights up to the appropriate levels within 0.5 seconds.
- c. Utilize air gap off to disconnect the load from line supply.
- d. Control all light sources in smooth and continuous manner. Dimmers with visible steps are not acceptable.
- e. Load Types:
 - 1) Assign a load type to each dimmer that will provide a proper dimming curve for the specific light source to be controlled.
 - 2) Provide capability of being field-configured to have load types assigned per circuit.
- f. Minimum and Maximum Light Levels: User adjustable on a circuit-by-circuit basis.
- g. Line Voltage Dimmers:
 - 1) Dimmers for Magnetic Low Voltage (MLV) Transformers:
 - (a) Provide circuitry designed to control and provide a symmetrical AC waveform to input of magnetic low voltage transformers per UL 1472.
 - (b) Dimmers using unipolar load current devices (such as FETs or SCRs) to include DC current protection in the event of a single device failure.
 - 2) Dimmers for Electronic Low Voltage (ELV) Transformers: Operate transformers via reverse phase control. Alternately, forward phase control dimming may be used if dimming equipment manufacturer has recommended specific ELV transformers being provided.
 - 3) Dimmers for Neon and Cold Cathode Transformers:

 5	Title: YALE OFFICE OF FACILITIES PROCEDURE MANUAL Chapter: 01 - Yale Design Standard Division: Electrical Standards	Section: 26 51.00 Interior Lighting
		Date: 6/15/16
		Author: Office of Facilities
CC: Project Folder		

- (a) Magnetic Transformers: Listed for use with normal (low) power factor magnetic transformers.
 - (b) Electronic Transformers: Must be supported by the ballast equipment manufacturer for control of specific ballasts being provided.
 - h. Low Voltage Dimming Modules:
 - 1) Coordination Between Low Voltage Dimming Module and Line Voltage Relay: Capable of being electronically linked to a single zone.
 - 2) Single low voltage dimming module; capable of controlling the following light sources:
 - (a) 0-10V analog voltage signal.
 - (1) Provide Class 2 isolated 0-10V output signal conforming to IEC 60929.
 - (2) Sink current according to IEC 60929.
 - (3) Source current.
 - (b) 10-0V reverse analog voltage signal.
 - (c) DSI digital communication.
 - (d) DALI broadcast communication per IEC 60929:
 - (1) Logarithmic intensity values complying with IEC 60929.
 - (2) Linear intensity values for use with LED color intensity control.
 - (e) PWM per IEC 60929.
- 6. Switching Requirements:
 - a. Rated Life of Relays: Minimum of 1,000,000 cycles at fully rated current for all lighting loads.
 - b. Switch load in a manner that prevents arcing at mechanical contacts when power is applied to and removed from load circuits.
 - c. Provide output fully rated for continuous duty for inductive,

 5	Title: YALE OFFICE OF FACILITIES PROCEDURE MANUAL Chapter: 01 - Yale Design Standard Division: Electrical Standards	Section: 26 51.00 Interior Lighting
		Date: 6/15/16
		Author: Office of Facilities
CC: Project Folder		

capacitive, and resistive loads.

H. Device Finishes:

1. Wall Controls: Match finishes specified for wiring devices in Section 26 2726, unless otherwise indicated.
2. Standard Colors: Comply with NEMA WD1 where applicable.
3. Color Variation in Same Product Family: Maximum delta E of 1, CIE L*a*b color units.
4. Visible Parts: Exhibit ultraviolet color stability when tested with multiple actinic light sources as defined in ASTM D4674. Provide proof of testing upon request.


I. Interface with building automation system specified.

2.3 POWER PANELS


A. Provide power panels with configurations as indicated on the drawings.

B. General Requirements:

1. Listed to UL 508 as industrial control equipment.
2. Comply with UL 508A and IEC 60669-2-1 as applicable.
3. Delivered and installed as a listed factory-assembled panel.
4. Field wiring accessible from front of panel without removing dimmer assemblies or other components.
5. Passively cooled via free-convection, unaided by fans or other means.
6. Shipped with each dimmer in mechanical bypass position by means of jumper bar inserted between input and load terminals. Jumpers to carry full rated load current and be reusable at any time. Mechanical bypass device to allow for switching operation of connected load with dimmer removed by means of circuit breaker.
7. All power panels and dimmer panels shall have a main circuit breaker. The main breaker shall be lockable.
8. Provided with branch circuit protection for each input circuit unless the panel is a dedicated feed-through type panel or otherwise indicated on the drawings.
9. Branch Circuit Breakers:

 5	Title: YALE OFFICE OF FACILITIES PROCEDURE MANUAL Chapter: 01 - Yale Design Standard Division: Electrical Standards	Section: 26 51.00 Interior Lighting
		Date: 6/15/16
		Author: Office of Facilities
CC: Project Folder		

- a. Listed to UL 489 as molded case circuit breaker for use on lighting circuits.
 - b. Provided with visual trip indicator.
 - c. Provide circuit breakers with interrupting capacity as required to provide the short circuit current rating indicated, but not less than:
 - 1) 10,000 rms symmetrical amperes at 120 VAC.
 - 2) 14,000 rms symmetrical amperes at 277 VAC for dimming.
 - 3) 18,000 rms symmetrical amperes at 277 VAC for switching.
 - d. Thermal-magnetic construction for overload, short-circuit, and over-temperature protection. Use of breakers without thermal protection requires dimmers/relays to have integral thermal protection to prevent failures when overloaded or ambient temperature is above rating of panel.
 - e. Equipped with provision for tag-out/lock-out devices to secure circuit breakers in off position when servicing loads.
 - f. Replaceable without moving or replacing dimmer/relay assemblies or other panel components.
 - g. Listed as switch duty (SWD) so that loads can be switched on and off by breakers.
10. Provide panels with listed short circuit current rating not less than the available fault current at the installed location as indicated on the drawings.
- a. Minimum Short Circuit Current Rating (SCCR): 25,000 Amps.
11. Panel Processor:
- a. Provide the following capabilities:
 - 1) Operate circuit directly from panel processor for system diagnostics and provide feedback of system operation.
 - 2) Electronically assign each circuit to any zone in lighting control system.
 - 3) Determine normal/emergency function of panel and set emergency lighting levels.

 5	Title: YALE OFFICE OF FACILITIES PROCEDURE MANUAL Chapter: 01 - Yale Design Standard Division: Electrical Standards	Section: 26 51.00 Interior Lighting
		Date: 6/15/16
		Author: Office of Facilities
CC: Project Folder		

- b. Where indicated on the drawings, panels to provide two control links. Each circuit to be capable of transferring control based on independent programming between architectural control system and theatrical controls utilizing the USITT DMX-512 1990 or ESTA DMX-512A protocol.
- c. React to changes from control within 20 milliseconds.


12. Diagnostics and Service:

- a. Replacing dimmer/relay does not require re-programming of system or processor.
- b. Include diagnostic LEDs for dimmers/relays to verify proper operation and assist in system troubleshooting.
- c. Include tiered control scheme for dealing with component failure that minimizes loss of control for occupant.
 - 1) If lighting control system fails, lights to remain at current level. Panel processor provides local control of lights until system is repaired.
 - 2) If panel processor fails, lights to remain at current level. Circuit breakers can be used to turn lights off or to full light output, allowing non-dim control of lights until panel processor is repaired.
 - 3) If dimmer fails, factory-installed mechanical bypass jumpers to allow each dimmer to be mechanically bypassed. Mechanical bypass device to allow for switching operation of connected load with dimmer removed by means of circuit breaker.


C. Product(s):

1. Specification Grade Dimming Panels:

- a. Mounting: Surface.
- b. Dimmers designed and tested specifically to control incandescent/tungsten, magnetic low voltage, electronic low voltage, neon/cold cathode, fluorescent dimming ballasts, and non-dim loads.
- c. Unless otherwise indicated or required, utilize universal 16 A continuous-use listed dimmers.

 5	Title: YALE OFFICE OF FACILITIES PROCEDURE MANUAL Chapter: 01 - Yale Design Standard Division: Electrical Standards	Section: 26 51.00 Interior Lighting
		Date: 6/15/16
		Author: Office of Facilities
CC: Project Folder		

- d. For loads requiring 0-10V, PWM, or DSI control, utilize compatible multiple load type low voltage dimming modules.
 - e. Limit current rise time to minimum 350 microseconds as measured from 10 to 90 percent of load current waveform and minimum 525 microseconds as measured from 0 to 100 percent of load current waveform at 50 percent rated dimmer capacity at a 90 degree conduction angle. Current rise time to be minimum 400 microseconds as measured from 10 to 90 percent of load current waveform and minimum 600 microseconds as measured from 0 to 100 percent of load current waveform at 100 percent rated dimmer capacity at a 90 degree conduction angle.
 - f. Load faults only affect the given circuit.
2. Modular Dimming Panels:
- a. Provide surface-mounted or flush-mounted enclosures as indicated.
 - b. Unless otherwise indicated or required, utilize multiple load type 16 A feed continuous-use listed dimming/switching modules.
 - c. For switching only circuits, utilize relays rated for minimum of 1,000,000 cycles at fully rated current for all lighting loads.
 - d. For loads requiring 0-10V, PWM, or DSI control, utilize compatible multiple load type low voltage dimming modules.
3. Modular Combination Panels:
- a. Provide surface-mounted or flush-mounted enclosures as indicated.
 - b. Unless otherwise indicated or required, utilize multiple load type 16 A feed continuous-use listed dimming/switching modules.
 - c. For switching only circuits, utilize relays rated for minimum of 1,000,000 cycles at fully rated current for all lighting loads.
 - d. For loads requiring 0-10V, PWM, or DSI control, utilize compatible multiple load type low voltage dimming modules.
4. Relay Panels:
- a. Provide surface-mounted or flush-mounted enclosures as indicated.
 - b. Switching Requirements:

 5	Title: YALE OFFICE OF FACILITIES PROCEDURE MANUAL Chapter: 01 - Yale Design Standard Division: Electrical Standards	Section: 26 51.00 Interior Lighting
		Date: 6/15/16
		Author: Office of Facilities
CC: Project Folder		

- 1) Rated Life of Relay: Minimum 1,000,000 cycles at fully rated current for all lighting loads.
- 2) Switch load in a manner that prevents arcing at mechanical contacts when power is applied to and removed from load circuits.
- 3) Provide output fully rated for continuous duty for inductive, capacitive, and resistive loads.


5. DC Dimming Panels:

- a. Mounting: Surface.
- b. Meet recommended electrical noise levels of MRI system manufacturers.
- c. Operate lamps free from audible noise and flicker throughout entire dimming range.
- d. In case of control system failure, supervisory circuit to shut down power to load.
- e. Automatically detect and compensate for lamp failures to maintain consistent DC voltage level.

2.4 FLUORESCENT ELECTRONIC DIMMING BALLASTS


A. General Requirements:

1. Designed for 10 year operational life while operating at maximum case temperature and 90 percent non-condensing relative humidity.
2. Designed and tested to withstand electrostatic discharges without impairment when tested according to IEC 61000-4-2.
3. Lamp Starting Method: Programmed rapid start.
4. Maximum Inrush Current: 7 amperes for 120V ballasts and 3 amperes for 277V ballasts.
5. Current Crest Factor (CCF): Less than 1.7.
6. Comply with ANSI C82.11 and list and label as complying with UL 935.
7. Designed to not interfere with infrared devices operating at frequencies between 38 kHz and 42 kHz.
8. Manufactured in a facility that employs ESD reduction practices in


 5	Title: YALE OFFICE OF FACILITIES PROCEDURE MANUAL Chapter: 01 - Yale Design Standard Division: Electrical Standards	Section: 26 51.00 Interior Lighting
		Date: 6/15/16
		Author: Office of Facilities
CC: Project Folder		

compliance with ANSI/ESD S20.20.

9. Inaudible in a 27 dBA ambient.
 10. No visible change in light output with a variation of plus or minus 10 percent line voltage input.
 11. Actively prevent overheating in T5-HO linear fluorescent lamp applications.
 12. Ballasts to track evenly across multiple lamp lengths and all light levels.
 13. Comply with IEC 61347-2-3 as applicable.
- B. 3-Wire Control:
1. Provide integral fault protection to prevent ballast failure in the event of a mis-wire.
- C. Digital Control:
1. Monitor and report lamp and ballast status.
 2. Lights automatically return to the setting prior to power interruption.
 3. Each ballast responds independently to:
 - a. Up to 32 occupant sensors.
 - b. Up to 64 personal control inputs.
 - c. Two daylight sensors.
 4. Unique internal reference number visibly displayed on ballast cover.
 5. Averages two independent daylight harvesting inputs internally.
 6. Responds to digital load shed command. (Example: If light output is at 30 percent and a load shed command of 10 percent is received, the ballast automatically sets the maximum light output at 90 percent and lowers current light output by three percent to 27 percent).
- D. Product(s):
1. 3-Wire Control, One Percent Dimming:
 - a. Dimming Range: 100 percent to one percent relative light output for T4 compact and T5-HO lamps.
 - b. Surge Tolerance: Designed and tested to withstand surges of 6,000 V

 5	Title: YALE OFFICE OF FACILITIES PROCEDURE MANUAL Chapter: 01 - Yale Design Standard Division: Electrical Standards	Section: 26 51.00 Interior Lighting
		Date: 6/15/16
		Author: Office of Facilities
CC: Project Folder		

- according to IEEE C41.2 without impairment of performance.
- c. Total Harmonic Distortion (THD): Less than 10 percent.
2. 3-Wire and Digital Control, One Percent Dimming:
 - a. Dimming Range: 100 percent to less than one percent relative light output for T8, T5 and T5HO, and five percent relative light output for T5 twin-tube lamps.
 - b. Surge Tolerance: Designed and tested to withstand surges of 6,000 V according to IEEE C41.2 without impairment of performance.
 - c. Total Harmonic Distortion (THD): Less than 10 percent.
 3. 3-Wire and Digital Control, Ten Percent Dimming:
 - a. Dimming Range: 100 to ten percent relative light output for T8, T5, T5HO, and T5 twin-tube, and five percent relative light output for T4 compact lamps.
 - b. Surge Tolerance: Designed and tested to withstand surges of 4,000 V according to IEEE C41.2 without impairment of performance.
 - c. Total Harmonic Distortion (THD): Less than 15 percent.
 - d. Digital Control:
 - 1) Connect without interface (except for T4 compact lamp ballasts) to:
 - (a) Occupancy sensors.
 - (b) Daylight sensor.
 - (c) Personal control input (keypad or infrared receiver).
 - 2) Provide a 20V DC source to power connected sensors.
 - 3) Generate digital communication commands to distribute ballast and sensor data on the digital bus.
 4. Digital Control, One Percent Dimming:
 - a. Dimming Range: 100 to less than one percent relative light output for T8, and one percent relative light output for T5 and T5HO lamps.
 - b. Surge Tolerance: Designed and tested to withstand surges of 4,000 V according to IEEE C41.2 without impairment of performance.

 5	Title: YALE OFFICE OF FACILITIES PROCEDURE MANUAL Chapter: 01 - Yale Design Standard Division: Electrical Standards	Section: 26 51.00 Interior Lighting
		Date: 6/15/16
		Author: Office of Facilities
CC: Project Folder		

c. Total Harmonic Distortion (THD): Less than 10 percent.


5. 2-Wire Control:

- a. Dimming Range: 100 to five percent relative light output for T4 compact and T8 lamps.
- b. Surge Tolerance: Designed and tested to withstand surges of 6,000 V according to IEEE C41.2 without impairment of performance.
- c. Total Harmonic Distortion (THD): Less than 20 percent.

2.5 LED DRIVERS

A. General Requirements:

1. Designed for 10 year operational life while operating at maximum case temperature and 90 percent non-condensing relative humidity.
2. Designed and tested to withstand electrostatic discharges without impairment when tested according to IEC 61000-4-2.
3. Maximum Inrush Current: 2 amperes for 120V and 277V drivers.
4. UL 8750 recognized or listed as applicable.
5. Comply with IEC 61347-2-13 as applicable.
6. Surge Tolerance: Designed and tested to withstand surges of 4,000 V according to IEEE C62.41.2 without impairment of performance.
7. Manufactured in a facility that employs ESD reduction practices in compliance with ANSI/ESD S20.20.
8. Class A sound rating; Inaudible in a 27 dBA ambient.
9. No visible change in light output with a variation of plus or minus 10 percent line voltage input.
10. Total Harmonic Distortion (THD): Less than 20 percent; comply with ANSI C82.11.
11. Drivers to track evenly across multiple lamp lengths and all light levels.
12. Constant Current Drivers:
 - a. Support from 200 mA to 2.1 A (in 10 mA steps) to ensure a compatible driver exists.
 - b. Support LED arrays up to 40W or 50 W (710 mA to 1.05 A in 10 mA

 5	Title: YALE OFFICE OF FACILITIES PROCEDURE MANUAL Chapter: 01 - Yale Design Standard Division: Electrical Standards	Section: 26 51.00 Interior Lighting
		Date: 6/15/16
		Author: Office of Facilities
CC: Project Folder		

steps).

13. Constant Voltage Drivers:

- a. Support from 10 V to 40 V (in 0.5 V steps) to ensure a compatible driver exists.
- b. Support LED arrays up to 40W.

14. Configuration tool available to optimize the following for LED fixtures:

- a. Light level.
- b. Efficiency.
- c. Thermal performance.

B. 3-Wire Control:

1. Dimming Range: 100 to one percent relative light output.
2. Provide integral fault protection to prevent driver failure in the event of a mis-wire.
3. Operate from input voltage of 120 V through 277 V at 60 Hz.


C. Digital Control:

1. Dimming Range: 100 to one percent relative light output.
2. Lights automatically return to the setting prior to power interruption.
3. Operate from input voltage of 120 V through 277 V at 60 Hz.
4. Each driver responds independently to:
 - a. Up to 32 occupant sensors.
 - b. Up to 16 daylight sensors.
5. Responds to digital load shed command. (Example: If light output is at 30 percent and a load shed command of 10 percent is received, the ballast automatically sets the maximum light output at 90 percent and lowers current light output by three percent to 27 percent).

D. Forward Phase Control (Neutral Wire Required):

1. Dimming Range: 100 to one percent relative light output.


2.6 POWERINTERFACES

 5	Title: YALE OFFICE OF FACILITIES PROCEDURE MANUAL Chapter: 01 - Yale Design Standard Division: Electrical Standards	Section: 26 51.00 Interior Lighting
		Date: 6/15/16
		Author: Office of Facilities
CC: Project Folder		


- A. Provide power interfaces as indicated or as required to control the loads as indicated.
- B. General Requirements:
 - 1. Phase independent of control input.
 - 2. Rated for use in air-handling spaces as defined in UL 2043.
 - 3. Utilize air gap off to disconnect the load from line supply.
 - 4. Diagnostics and Service: Replacing power interface does not require re-programming of system or processor.

2.7 MAIN UNITS

- A. Provide main units with configuration and quantity of zones as indicated or as required to control the loads as indicated.
- B. Connects to lighting management hub via RS485.
- C. Finish: As specified for wall controls in "Device Finishes" under DIGITAL-NETWORK LIGHTING CONTROL SYSTEM - GENERAL REQUIREMENTS article above.
- D. Engrave units with button, zone, and scene descriptions as indicated on the drawings.
- E. Integrated Wireless Capability:
 - 1. Provide wireless communication inputs for:
 - a. Occupancy sensors.
 - b. Daylight sensors.
 - c. Wireless controller.
 - 2. RF Range: 30 feet (9 m) between sensor and compatible RF receiving device(s).
 - 3. RF Frequency: 434 MHz; operate in FCC governed frequency spectrum for periodic operation; continuous transmission spectrum is not permitted.
- F. Preset Lighting Control with Zone Override:
 - 1. Intensity for each zone indicated by means of one illuminated bar graph per zone.

 5	Title: YALE OFFICE OF FACILITIES PROCEDURE MANUAL Chapter: 01 - Yale Design Standard Division: Electrical Standards	Section: 26 51.00 Interior Lighting
		Date: 6/15/16
		Author: Office of Facilities
CC: Project Folder		

2. User-programmable zone and scene names.
3. Utilize air gap off to disconnect the load from line supply.
4. Astronomical time clock and programmer interface provides access to:
 - a. Scene selections.
 - b. Fade zone to a level.
 - c. Fine-tuning of preset levels with scene raise/lower.
 - d. Lock out scenes and zones.
 - e. Fine-tuning of light levels with individual zone raise/lower.
 - f. Terminal block for wired infrared signal input.
 - g. Enable/disable wall station.
5. Light intensity with real time energy savings by digital display.
6. Fade time indicated by digital display for current scene while fading.
7. Integral wide angle infrared receiver.
8. For temporary local overrides, individual raise/lower buttons to allow zones to be adjusted without altering scene values stored in memory.
9. Direct Low-Voltage Control of Digital Ballasts and LED drivers (120V, 220/240V, 277V and/or 347V Lighting):
 - a. Electronically link a digital fluorescent lighting ballast to a zone for both dimming and turning on/off.
 - b. Electronically assign daylight sensors to digital ballasts and line voltage dimmers for proportional daylight harvesting.
 - c. Single integral controller with Class 1 or Class 2 isolated digital output signal conforming to IEC 60929; capable of direct control without interface.
10. Creates daylighting rows independent of control zones.
11. Capable of re-zoning without re-wiring using programming display on unit.
12. Outputs can be virtually mapped to other device's outputs.
13. Zone raise/lower buttons capable of controlling local lighting loads

 5	Title: YALE OFFICE OF FACILITIES PROCEDURE MANUAL Chapter: 01 - Yale Design Standard Division: Electrical Standards	Section: 26 51.00 Interior Lighting
		Date: 6/15/16
		Author: Office of Facilities
CC: Project Folder		

connected to the main unit or remote lighting zones in the system.

G. Preset Shade Control with Zone Override:

1. Preset expandable shade control: Provide up to three columns of shade control.
2. For temporary local overrides, individual raise/lower buttons to allow zones to be adjusted without altering scene values stored in memory.


H. Provides one direct-wired occupancy sensor connection without interface or powerpack.

2.8 LIGHTING CONTROL MODULES


A. Provide lighting control modules as indicated or as required to control the loads as indicated.

B. General Requirements:

1. Listed to UL 508 as industrial control equipment.
2. Delivered and installed as a listed factory-assembled panel.
3. Passively cooled via free-convection, unaided by fans or other means.
4. Mounting: Surface.
5. Connection without interface to wired:
 - a. Occupancy sensors.
 - b. Daylight sensors.
 - c. IR receivers for personal control.
6. Connects to lighting management hub via RS485.
7. LED status indicators confirm communication with occupancy sensors, daylight sensors, and IR receivers.
8. Contact Closure Input:
 - a. Directly accept contact closure input from a dry contact closure or sold-state output without interface to:
 - 1) Activate scenes.
 - (a) Scene activation from momentary or maintained closure.
 - 2) Enable or disable after hours.

 5	Title: YALE OFFICE OF FACILITIES PROCEDURE MANUAL Chapter: 01 - Yale Design Standard Division: Electrical Standards	Section: 26 51.00 Interior Lighting
		Date: 6/15/16
		Author: Office of Facilities
CC: Project Folder		

- (a) Automatic sweep to user-specified level after user-specified time has elapsed.
 - (b) System will provide occupants a visual warning prior to sweeping lights to user-specified level.
 - (c) Occupant can reset timeout by interacting with the lighting system.
 - 3) Activate or deactivate demand response (load shed).
 - (a) Load shed event will reduce lighting load by user-specified amount.
- 9. Emergency Contact Closure Input:
 - a. Turn all zones to full output during emergency state via direct contact closure input from UL 924 listed emergency lighting interface, security system or fire alarm system.
 - b. Allow configurable zone response during emergency state.
 - c. Disable control operation until emergency signal is cleared.
- 10. Supplies power for control link for keypads and control interfaces.
- 11. Distributes sensor data among multiple lighting control modules.
- 12. Capable of being controlled via wireless sensors and controls.
- C. Switching Lighting Control Modules:
 - 1. Switching:
 - a. Rated Life of Relay: Minimum of 1,000,000 cycles at fully rated current for all lighting loads.
 - b. Load switched in manner that prevents arcing at mechanical contacts when power is applied to and removed from load circuits.
 - c. Fully rated output continuous duty for inductive, capacitive, and resistive loads.
 - d. Module to integrate up to four individually controlled zones, each with a capacity of up to 16 amps of high in-rush lighting load (magnetic fluorescent ballast, electronic fluorescent ballast, incandescent, magnetic low-voltage, electronic low-voltage, neon/cold cathode and motor loads).

 5	Title: YALE OFFICE OF FACILITIES PROCEDURE MANUAL Chapter: 01 - Yale Design Standard Division: Electrical Standards	Section: 26 51.00 Interior Lighting
		Date: 6/15/16
		Author: Office of Facilities
CC: Project Folder		


- e. Utilize air gap off, activated when user selects "off" at any control to disconnect the load from line supply.

D. 0-10V Lighting Control Modules:

1. Coordination Between Low Voltage Dimming Module and Line Voltage Relay: Capable of being electronically linked to single zone.
2. Single low voltage dimming module; capable of controlling following light sources:
 - a. 0-10V analog voltage signal.
 - 1) Provide Class 2 isolated 0-10V output signal conforming to IEC 60929.
 - 2) Sink current per IEC 60929.
 - b. 10V-0V analog voltage signal.
 - 1) Provide Class 2 isolated 0-10V output signal conforming to IEC 60929.
 - 2) Sink current per IEC 60929.
3. Switching:
 - a. Rated Life of Relay: Minimum of 1,000,000 cycles at fully rated current for all lighting loads.
 - b. Load switched in manner that prevents arcing at mechanical contacts when power is applied to and removed from load circuits.
 - c. Fully rated output continuous duty for inductive, capacitive, and resistive loads.
 - d. Module to integrate up to four individually controlled zones, each with a capacity of up to 16 amps of high in-rush lighting load (magnetic fluorescent ballast, electronic fluorescent ballast, incandescent, magnetic low-voltage, electronic low-voltage, neon/cold cathode and motor loads).
 - e. Utilize air gap off, activated when user selects "off" at any control to disconnect the load from line supply.

E. Digital Fixture Lighting Control Modules:

1. Provide smart diagnostics for system verification.

 5	Title: YALE OFFICE OF FACILITIES PROCEDURE MANUAL Chapter: 01 - Yale Design Standard Division: Electrical Standards	Section: 26 51.00 Interior Lighting
		Date: 6/15/16
		Author: Office of Facilities
CC: Project Folder		


2. Provide testing capability using manual override buttons.
 3. Each low-voltage digital communication link to support up to 64 ballasts or LED drivers capable of NFPA 70 Class 1 or Class 2 installation.
- F. Total Light Management Control Module (Digital Lighting and Shades Control):
1. Ten fused 30W (60W peak) 24V DC outputs provide power to compatible shades, drapery drive units, keypads, and accessories.
 2. Provide power for 10 to 30 shades dependent on shade dimensions.
 3. Provide smart diagnostics for system verification.
 4. Provide testing capability using manual override buttons.
 5. Each low-voltage digital communication link to support up to 64 ballasts capable of NFPA 70 Class 1 or Class 2 installation.

2.9 ENERGY METER


A. General Requirements:

1. Provides accurate, real-time energy metering and verification capability through front-end PC-based software.
2. Factory-calibrated; not requiring preventative/scheduled maintenance or cleaning/decontamination procedures.
3. Accepts up to three sets of current sensors to monitor up to three loads of the same voltage with one meter.
4. Contains direct-read 8-digit LCD display of cumulative kWh.
5. Current Sensors: Split-core; capable of being placed up to 500 feet (152 m) from the meter without power interruption.
6. Connects to server via Ethernet.
7. UL listed.
8. Accuracy: Plus/minus 0.5 percent, certified to ANSI C12.20.
9. NEMA 12 housing.
10. Provide voltage and current ratings suitable for the installed location.

2.10 DIGITAL DIMMING BALLAST AND SWITCHING MODULES

 5	Title: YALE OFFICE OF FACILITIES PROCEDURE MANUAL Chapter: 01 - Yale Design Standard Division: Electrical Standards	Section: 26 51.00 Interior Lighting
		Date: 6/15/16
		Author: Office of Facilities
CC: Project Folder		


- A. Provide digital dimming ballast and switching modules as indicated or as required to control the loads as indicated.
- B. General Requirements:
1. Provide continuous 3-wire signal dimming to compatible 3-wire electronic dimming ballasts.
 2. Utilize air gap off to disconnect the load from line supply.
 3. Connect without interface to:
 - a. Occupancy sensor.
 - b. Daylight sensor.
 - c. Personal control input (wall station or infrared receiver).
 4. Generate digital communication commands to distribute ballast and sensor data on the digital bus.
 5. If power is interrupted and subsequently restored, lights automatically return to the setting prior to power interruption.
 6. Each ballast module responds independently to:
 - a. Up to 32 occupancy sensors.
 - b. Up to 64 personal control inputs.
 - c. Two daylight sensors.
 7. Unique internal reference number visible displayed on module cover.
 8. Averages two independent daylight harvesting inputs internally.
 9. Responds to digital load shed command.
 - a. Sets high end trim.
 - b. Automatically scales light output proportional to load shed command. (Example: If light output is at 30 percent and a load shed command of 10 percent is received, the ballast to automatically set the maximum light output at 90 percent and lower current light output by 3 percent to 27 percent).
 10. Provide integral fault protection to prevent ballast module failure in the event of a mis-wire.
- C. Product(s):

 5	Title: YALE OFFICE OF FACILITIES PROCEDURE MANUAL Chapter: 01 - Yale Design Standard Division: Electrical Standards	Section: 26 51.00 Interior Lighting
		Date: 6/15/16
		Author: Office of Facilities
CC: Project Folder		


1. 3-Wire Ballast Module, 2 Amp:
 - a. Integrates up to 2 amps of 3-wire electronic dimming ballasts into digital control system as a single zone.
2. 3-Wire Ballast Module, 16 Amp:
 - a. Integrates up to 16 amps of 3-wire electronic dimming ballasts into digital control system as a single zone.
 - b. Integrates up to 16 amps of switched high intensity discharge (HID) lighting load into digital control system as a single zone.
3. Switching Power Module, 16 Amp:
 - a. Integrates up to 16 amps of high in-rush lighting load (magnetic fluorescent ballast, electronic fluorescent ballast, HID, incandescent, magnetic low-voltage, electronic low-voltage, neon/cold cathode and motor loads) into digital control system as a single zone.

2.11 LIGHTING MANAGEMENT HUBS


- A. Provided in a pre-assembled NEMA listed enclosure with terminal blocks listed for field wiring.
- B. Connects to controls and power panels via RS485.
- C. Enables light management software to control and monitor compatible dimming ballasts and ballast modules, power panels, power modules, and window treatments.
 1. Utilizes Ethernet connectivity to light management computer utilizing one of the following methods:
 - a. Dedicated network.
 - b. Dedicated VLAN.
 - c. Shared network with Building Management System (BMS).
 - d. Corporate network where managed switches are configured to allow multicasting and use of IGMP.
- D. Integrates control station devices, power panels, shades, preset lighting controls, and external inputs into a single customizable lighting control system with:
 1. Multiple Failsafe Mechanisms:

 5	Title: YALE OFFICE OF FACILITIES PROCEDURE MANUAL Chapter: 01 - Yale Design Standard Division: Electrical Standards	Section: 26 51.00 Interior Lighting
		Date: 6/15/16
		Author: Office of Facilities
CC: Project Folder		

- a. Power failure detection via emergency lighting interface.
 - b. Protection: Lights go to full on if ballast wires are shorted.
 - c. Distributed architecture provides fault containment. Single hub failure or loss of power does not compromise lights and shades connected to other lighting management hubs.
2. Manual overrides.
 3. Automatic control.
 4. Central computer control and monitoring.
 5. Integration with BMS via BACnet.
- E. Furnished with astronomical time clock.
- F. Furnished with solar clock to track the position of the sun to control the shades to limit penetration of direct sunlight.
- G. Maintains a backup of the programming in a non-volatile memory capable of lasting more than ten years without power.
- H. BACnet Integration License:
1. Provide ability to communicate by means of native BACnet IP communication (does not require interface) to lighting control system from a user-supplied 10BASE-T or 100BASE-T Ethernet network.
 2. Requires only one network connection per system.
 3. Lighting control system to be BACnet Test Laboratory (BTL) listed.
 4. Basic BACnet integration license:
 - a. The BACnet integrator can command:
 - 1) Area light output.
 - 2) Area enable or disable after hours mode.
 - 3) Area load shed level.
 - 4) Area load shed enable/disable.
 - 5) Area shade group presets and levels.
 - 6) Enable/Disable:
 - (a) Automated solar adaptive shade control.

 5	Title: YALE OFFICE OF FACILITIES PROCEDURE MANUAL Chapter: 01 - Yale Design Standard Division: Electrical Standards	Section: 26 51.00 Interior Lighting
		Date: 6/15/16
		Author: Office of Facilities
CC: Project Folder		

- (b) Cloudy day/shadow override mode for automated shade control.
 - (c) Brightness override mode for automated shade control.
 - (d) Area occupancy sensors.
 - (e) Area daylighting.
- 7) Daylighting level.
- 8) Area occupied and unoccupied level
- 9) Occupancy sensor timeouts.
- b. The BACnet integrator can monitor:
- 1) Area on/off status.
 - 2) Area occupancy status.
 - 3) Area fault.
 - (a) Lamp failures.
 - (b) Control devices not responding.
 - 4) Area load shed status.
 - 5) Area instantaneous energy usage and maximum potential power usage.
 - 6) Area shade group presets and levels.
 - 7) Cloudy day and shadow sensor status.
 - 8) Light levels from window mounted sensors.
 - 9) Enable/Disable:
 - (a) Status of automated solar adaptive shade control.
 - (b) Status of cloudy day/shadow override for automated shade control.
 - (c) Status of brightness override for automated shade control.
 - (d) Area occupancy sensors.
 - (e) Daylighting.
 - 10) Daylighting level.

 5	Title: YALE OFFICE OF FACILITIES PROCEDURE MANUAL Chapter: 01 - Yale Design Standard Division: Electrical Standards	Section: 26 51.00 Interior Lighting
		Date: 6/15/16
		Author: Office of Facilities
CC: Project Folder		


- 11) Light levels from photo sensors and window mount shadow sensors.
- 12) Area occupied and unoccupied level.
- 13) Occupancy sensor timeouts.
- c. Shade assignment and grouping to be discoverable with third party building management software.

2.12 LIGHTING MANAGEMENT SYSTEM COMPUTERS


A. Computers:

1. System PC (Desktop/Laptop):
 - a. Suitable for occasional programming, monitoring, and control of digital network lighting controls.
 - b. Unless otherwise indicated, computer(s) to be provided by lighting control system manufacturer.
 - c. Quantity: As indicated on the drawings.
 - d. Location(s): As indicated on the drawings.
 - e. Minimum Hardware Requirements:
 - 1) Processor: Single Intel® Xeon® processor with minimum speed of 2.0 GHz.
 - 2) 1 GB RAM.
 - 3) 80 GB hard drive (30 GB for application).
 - 4) One 10/100/1000 Ethernet network interface for communication with lighting management hubs.
 - 5) 17 inch (43 cm) monitor with 1024 x 768 resolution.
 - 6) 48X CD/DVD-ROM drive.
 - 7) 4 USB 2.0 ports.
 - f. Minimum Software Requirements:
 - 1) Licensed installation of US English 32-bit or 64-bit Microsoft® Windows® Server 2008 with Service Pack 1.

2. Server:

 5	Title: YALE OFFICE OF FACILITIES PROCEDURE MANUAL Chapter: 01 - Yale Design Standard Division: Electrical Standards	Section: 26 51.00 Interior Lighting
		Date: 6/15/16
		Author: Office of Facilities
CC: Project Folder		


- a. Suitable for 24 hour per day, 7 day per week programming, monitoring, control, and data logging of digital-network lighting controls.
 - b. Suitable to handle client machine request in multi-computer systems.
 - c. Unless otherwise indicated, computer to be provided by lighting control system manufacturer.
 - d. Minimum Hardware Requirements:
 - 1) Processor: Single Intel® Xeon® processor with minimum speed of 2.0 GHz.
 - 2) 2 GB Ram.
 - 3) 80 GB hard drive (30 GB for application).
 - 4) Two 10/100/1000 Ethernet network interfaces - one for communication with lighting management hubs and one for communication with corporate intranet to allow access from system PCs and/or energy saving display terminals. Only one Ethernet network interface is required if all lighting management hubs and client PCs are on the same network.
 - 5) 17 inch (43 cm) monitor with 1024 x 768 resolution.
 - 6) 48X CD/DVD-ROM drive.
 - 7) 4 USB 2.0 ports.
 - e. Minimum Software Requirements:
 - 1) Licensed installation of US English 32-bit or 64-bit Microsoft® Windows® Server 2008 with Service Pack 1.
3. Energy Savings Display Terminals:
- a. Suitable for displaying energy savings data on user-supplied display.
 - b. Unless otherwise indicated, computer(s) to be provided by lighting control system manufacturer.
 - c. Quantity: As indicated on the drawings.
 - d. Location(s): As indicated on the drawings.
 - e. Minimum Hardware Requirements:

 5	Title: YALE OFFICE OF FACILITIES PROCEDURE MANUAL Chapter: 01 - Yale Design Standard Division: Electrical Standards	Section: 26 51.00 Interior Lighting
		Date: 6/15/16
		Author: Office of Facilities
CC: Project Folder		


- 1) Processor: Single Intel® Xeon® processor with minimum speed of 2.0 GHz.
 - 2) 1 GB RAM.
 - 3) 80 GB hard drive (30 GB for application).
 - 4) One 10/100/1000 Ethernet network interface for communication with lighting management hubs.
 - 5) 17 inch (43 cm) monitor with 1024 x 768 resolution.
 - 6) 48X CD/DVD-ROM drive.
 - 7) 4 USB 2.0 ports.
- f. Minimum Software Requirements:
- 1) Licensed installation of US English 32-bit or 64-bit Microsoft® Windows® Server 2008 with Service Pack 1.
4. Computers Provided by Lighting Control System Manufacturer:
Computer software to be preinstalled and tested prior to shipping.

2.13 LIGHTING MANAGEMENT SYSTEM SOFTWARE

- A. Provide system software license and hardware that is designed, tested, manufactured, and warranted by a single manufacturer.
- B. Configuration Setup Software:
 1. Suitable to make system programming and configuration changes.
 2. Windows-based, capable of running on either central server or a remote client over TCP/IP connection.
 3. Allows manufacturer (either remotely or with on-site service call) or end-user (with training) to:
 - a. Capture system design:
 - 1) Geographical layout.
 - 2) Load schedule zoning.
 - 3) Shade grouping.
 - 4) Equipment schedule.


 5	Title: YALE OFFICE OF FACILITIES PROCEDURE MANUAL Chapter: 01 - Yale Design Standard Division: Electrical Standards	Section: 26 51.00 Interior Lighting
		Date: 6/15/16
		Author: Office of Facilities
CC: Project Folder		

- 5) Equipment assignment to lighting management hubs.
 - 6) Daylighting design.
 - b. Define the configuration for the following in each area:
 - 1) Lighting scenes.
 - 2) Shade group presets.
 - 3) Control station devices.
 - 4) Interface and integration equipment.
 - 5) Occupancy/after hours.
 - 6) Partitioning.
 - 7) Daylighting.
 - 8) Emergency lighting.
 - 9) Night lights.
 - c. Startup:
 - 1) Addressing.
 - 2) Daylighting.
 - 3) Provide customized conditional programming.
- C. Control and Monitor Software:
1. Basic System View: The system navigation and status reporting is performed using a tree view of the building.
 2. Optional Graphical Floor Plan View: The system navigation and status reporting is performed using customized CAD based drawings of the building. Pan and zoom feature allows for easy navigation. Basic system view is always available.
 3. Control of Lights:
 - a. Area lights can be monitored for on/off status.
 - b. All lights in an area can be turned on/off or sent to a specific level.
 - c. For areas that have been zoned, these areas may be sent to a predefined lighting scene, and individual zones may be controlled.
 - d. Area lighting scenes can be modified in real-time, changing the levels


 5	Title: YALE OFFICE OF FACILITIES PROCEDURE MANUAL Chapter: 01 - Yale Design Standard Division: Electrical Standards	Section: 26 51.00 Interior Lighting
		Date: 6/15/16
		Author: Office of Facilities
CC: Project Folder		

that zones go to when a scene is activated.

- e. High and low end of area lighting can be tuned/trimmed.
 - f. Control and monitor area partition status.
4. Control of Shades:
 - a. Area shades can be monitored for current preset or position.
 - b. Area shades can be opened/closed, sent to a preset, or sent to a specific position.
 5. Occupancy:
 - a. Area occupancy can be monitored.
 - b. Area occupancy can be disabled to override occupancy control or in case of occupancy sensor problems.
 - c. Area occupancy settings including level that lights turn on to when area is occupied, and level that lights turn off to when area is unoccupied can be changed in real-time.
 6. Daylighting:
 - a. Daylighting can be enabled/disabled. Can be used to override the control currently taking place in the space.
 - b. Daylight target levels can be changed for each daylit area.
 - c. Daylight status can be monitored.
 7. Load Shedding: Allows the building manager to monitor whole building lighting power usage and apply a customized load shed reduction to selected areas, thereby reducing a building's power usage; load shedding triggered via Quantum software, BACnet, or OpenADR.
 8. Scheduling: Schedule time of day and astronomic time clock events to automate functions.
 9. Reporting: Provide reporting capability that allows the building manager to gather real-time and historical information about the system as follows:
 - a. Energy Reports: Show a comparison of cumulative energy used over a period of time for one or more areas or meter groups.

 5	Title: YALE OFFICE OF FACILITIES PROCEDURE MANUAL Chapter: 01 - Yale Design Standard Division: Electrical Standards	Section: 26 51.00 Interior Lighting
		Date: 6/15/16
		Author: Office of Facilities
CC: Project Folder		

- b. Power Reports: Show power usage trend over a period of time for one or more areas or meter groups.
 - c. Activity Report: Show what activity has taken place over a period of time for one or more areas. Activity includes occupant activities (e.g. wall controls being pressed), building manager operation (e.g. controlling/changing areas using the control and monitor tool), and device failures (e.g. keypads or ballasts that are not responding).
 - 1) Include shade related activities (e.g. automatic movements from Hyperion algorithm, manual overrides from personal controls, automatic overrides from sensors).
 - d. Lamp Failure Report: Shows which areas are currently reporting lamp failures.
 - e. Shade Level Report: Shows the shade level for any shade group in the system over any historical 24 hour period.
 - f. Shade Position Report: Shows the percentage of time shade groups in the system are at each position.
 - g. Sensor Level Report: Shows the light level in footcandles of any photosensor in the system.
 - h. Alert Activity Report: Capable of generating historical reports of all alert activity within the system.
10. Diagnostics: Allows the building manager to check on the status of all equipment in the lighting control system. Devices to be listed with a reporting status of OK, missing, or unknown.
11. Alerts and Alarms: Monitors the system for designated events/triggers and automatically generates alerts according to configured response criteria.
- a. Capable of monitoring for the following events/triggers:
 - 1) A failed piece of equipment (e.g. ballast, control, sensor, etc.); alert cleared when equipment is replaced.
 - 2) A lamp outage (for compatible digital electronic dimming ballasts only); alert cleared when lamp is replaced.
 - 3) Low battery conditions in battery-operated sensors and controls;


	Title: YALE OFFICE OF FACILITIES PROCEDURE MANUAL Chapter: 01 - Yale Design Standard Division: Electrical Standards	Section: 26 51.00 Interior Lighting
		Date: 6/15/16
		Author: Office of Facilities
CC: Project Folder		

alert cleared when battery is replaced.

- 4) Luminaires with lamp operating hours in excess of designated time.
 - 5) A load shed event; alert generated for beginning and end of trigger.
 - 6) Energy usage higher than designated threshold target.
 - 7) Potential light level condition discrepancies (daylight sensors not agreeing with expected lighting status).
- b. Capable of generating alerts through visible changes in software or through email messages.
 - c. Capable of customizing the frequency of alerts and providing notifications immediately or through daily, weekly, or monthly summaries.
 - d. Capable of sending different alerts to different system users.
 - e. Capable of generating historical reports of all alert activity within the system.

12. Administration:

- a. Users: Allows new user accounts to be created and existing user accounts to be edited.
 - 1) Supports Active Directory (LDAP) tying user accounts to network accounts.
- b. Area and feature access can be restricted based on login credentials with three levels of access rights (Admin, Programmer, Controller) and customized access levels available.
- c. Publish Graphical Floor Plan: Allows admin user to publish new graphical floor plan files, allowing users to monitor the status of lights, occupancy of areas, and daylighting status.
- d. Back-Up Project Database: Allows admin user to back up the project database that holds all the configuration information for the system, including keypad programming, areas scenes, daylighting, occupancy programming, emergency levels, night lights, and time clock.

 5	Title: YALE OFFICE OF FACILITIES PROCEDURE MANUAL Chapter: 01 - Yale Design Standard Division: Electrical Standards	Section: 26 51.00 Interior Lighting
		Date: 6/15/16
		Author: Office of Facilities
CC: Project Folder		

e. Publish Project Database: Allows admin user to send a new project database to the server and download the new configuration to the system. The project database holds all the configuration information for the system, including keypad programming, area scenes, daylighting, occupancy programming, emergency levels, night lights, and time clock.

13. Virtual Global Buttons: Provide global scene control or modes of operation across entire system.

14. Provides control/monitoring of partition status to automatically reconfigure how the space operates based on the partition's open/closed status.

D. Energy Savings Display Software:

1. Provide software from a single manufacturer that can collect and display real-time and historical energy savings data from all of the components in the lighting control system or from the meters in the system.

2. Energy savings data to be accessible for display on computer terminal or user-supplied display monitor via energy savings display software.

3. Software to be capable of displaying:

a. Current savings in percent and kW.

b. Historic energy savings in kWh saved, money saved, coal not burned, and carbon dioxide not emitted.

c. Historical views in time periods of three hours, one day, one week, one month, and one year.

d. Configurable energy usage baseline and user-defined working hours for energy saving calculations.

e. Comparisons of historical periods (days, weeks, months, years).


f. Local weather conditions.

E. Web Services Integration License:


1. Provide ability to communicate by means of XML web services

2. Web services integrator can monitor:

a. Area instantaneous power usage.

 5	Title: YALE OFFICE OF FACILITIES PROCEDURE MANUAL Chapter: 01 - Yale Design Standard Division: Electrical Standards	Section: 26 51.00 Interior Lighting
		Date: 6/15/16
		Author: Office of Facilities
CC: Project Folder		


- b. Area instantaneous power savings.
 - c. Area energy savings.
 - d. Area energy usage.
 - e. Area maximum power usage.
- 3. Initiate load shed event using OpenADR protocol in an auto-Demand-Response event without additional interfaces or gateways.
- 4. Supports both push and pull for integration with third party systems and energy dashboards.
- F. Mobile Control and Programming Software License:
 - 1. Allows mobile control and programming of system via an Apple iPad.
 - 2. Provides users the ability to:
 - a. Control and monitor area lighting scenes, zones, and shade presets.
 - b. Easily identify zones and shade groups.
 - c. Edit area lighting scenes, shade presets, scene fade rates, and scene delay rates.
 - d. Restrict user access by area.
 - e. Restrict users from ability to make changes.
 - f. Historical logging of who made changes available in control and monitor software.
 - 3. Connects to system via WiFi.
 - 4. Can connect directly to processor or through computer (server) in the system.
- G. Personal Web-Based Control Software:
 - 1. Lighting Control: Allows the user to use a web browser on their personal PC, laptop, or some mobile devices (supporting 1024 by 768 resolution) to control one or more lights in their area.
 - a. The user may select between full on, full off, or a favorite light level.
 - b. The user may raise/lower the currently selected lighting level in the area.

 5	Title: YALE OFFICE OF FACILITIES PROCEDURE MANUAL Chapter: 01 - Yale Design Standard Division: Electrical Standards	Section: 26 51.00 Interior Lighting
		Date: 6/15/16
		Author: Office of Facilities
CC: Project Folder		


2. Shade Control: Allows the user to use a web browser on their personal PC, laptop, or some mobile devices (supporting 1024 by 768 resolution) to control one or more shades in their area.
 - a. The user may select open, closed, or a favorite shade position.
 - b. The user may raise/lower a selected shade group in the area.
3. Supports up to 10,000 users.
4. Each user to have a login name and password sent from administrator via email when user account created.
5. Supported Browsers: Microsoft Internet Explorer (versions 7 and higher), Mozilla Firefox (versions 3 and higher), Apple Safari (versions 4 and higher), Google Chrome (versions 8 and higher).

H. Automated Shade Control Software:


1. Objectives:
 - a. Uses open loop solar adaptive algorithm to minimize the penetration depth of direct sunlight.
 - b. Optimizes energy savings from daylight.
 - c. Provides manual override capability for occupants via wall-mounted keypad or simple remote control.
 - d. Provides automatic override capability utilizing a local sensor in dark conditions or when excessive brightness occurs.
 - e. Maximizes occupants connectivity with outdoors by optimizing view.
 - f. Provides diffuse daylight and minimizes direct sunlight in the space to reduce solar heat gain and maximize occupant comfort in the space.
 - g. Reduces glare.
 - h. Shades along same facade to start, stop and track in unison to maintain a consistent exterior aesthetic.
 - i. Provides optional presets to allow shades to align with architectural elements of the facade.
 - j. Provides a preset, also referred to as visor position, to limit maximum amount of light entering a space.

	Title: YALE OFFICE OF FACILITIES PROCEDURE MANUAL Chapter: 01 - Yale Design Standard Division: Electrical Standards	Section: 26 51.00 Interior Lighting
		Date: 6/15/16
		Author: Office of Facilities
CC: Project Folder		

- k. Provides configurable dark and bright override positions.
- 2. Hardware: Independent operation of solar tracking program through non-Windows based operating system provided in one or more lighting management hubs.
- 3. Control Software:
 - a. Incorporates a solar tracking software that:
 - 1) Calculates the sun's position in the sky relative to the building and then calculates when shade movement is necessary by facade.
 - 2) Calculates the position of the shade to limit direct sunlight penetration to a predetermined limit.
 - b. Controlled using the following inputs for startup:
 - 1) Building location.
 - 2) Facade orientation.
 - 3) Window dimensions.
 - 4) Solar depth of penetration.
 - 5) Number of shade movements per day.
 - 6) Visor position of shades.
 - 7) Optional presets that align shades with architectural features of the facade.
 - 8) Light level thresholds for dark and bright override.
 - 9) Shade position for dark and bright override.
 - 10) Window position on wall.
 - c. Requires minimal long term maintenance and service. Does not require user to make daily changes to programming or overall system functionality, unless desired by owner.
- 4. PC Graphic User Interface: Provides access to all adjustable parameters of solar depth of penetration and number of shade movements per day.
- 5. Override:
 - a. Manual:

 5	Title: YALE OFFICE OF FACILITIES PROCEDURE MANUAL Chapter: 01 - Yale Design Standard Division: Electrical Standards	Section: 26 51.00 Interior Lighting
		Date: 6/15/16
		Author: Office of Facilities
CC: Project Folder		


- 1) Temporary override of the control program capability through optional manual keypads, remote controls, or end-user control software.
 - 2) Keypads, remote controls, or end-user control software to be capable of providing manual control of shades in a particular area.
 - 3) Time of manual override to be programmable.
- b. Automatic overrides achievable via rooftop cloudy day sensors or radio window sensors:
- 1) Rooftop Cloudy Day Sensors:
 - (a) Provides automatic override of system on dark cloudy days.
 - (b) During dark conditions, shades to go to predetermined visor position to maximize view and available daylight.
 - 2) Radio Window Sensors:
 - (a) Product(s):
 - (1) Lutron Radio Window Sensor; Model LRF2-SSM-XX (mullion mount sensor pair).
 - (2) Lutron Radio Window Sensor; Model LRF2-SSW-WH (window mount).
 - (b) Monitors exterior light conditions and provides automatic override of system on dark cloudy days or in the presence of shadows from neighboring buildings and rooftop mechanical equipment.
 - (c) During dark conditions, shades to go to predetermined dark override position to maximize view and available daylight.
 - (d) Monitors exterior light conditions and provides automatic override of system during excessive brightness.
 - (e) During excessive bright conditions, shades to go to predetermined bright override position to maximize occupant comfort.
 - (f) Capable of having one or multiple sensors per facade for more localized detection of exterior light conditions.

 5	Title: YALE OFFICE OF FACILITIES PROCEDURE MANUAL Chapter: 01 - Yale Design Standard Division: Electrical Standards	Section: 26 51.00 Interior Lighting
		Date: 6/15/16
		Author: Office of Facilities
CC: Project Folder		

- (g) Capable of having one sensor control one shade group or multiple shade groups.
- (h) Software enables the ability to adjust thresholds, timeouts, and shade movement frequency globally or per area to meet the unique preferences of different individuals.
- (i) Sensor to not require external power packs, power wiring, or communication wiring.
- (j) Sensor to be easily mountable to mullion (mullion mount sensor pair) or window (window mount) and can be easily removed and repositioned without marring or damaging window surface.
- (k) Provides typical battery lifetime of 10 years when installed per manufacturer instructions.
- (l) Communicates directly to compatible sensor module to ensure reliable RF communications.
- (m) RF Frequency: 434 MHz.
- (n) RF Range: 30 feet (9 m) between sensor and compatible RF receiving device(s).
- (o) Intuitive test mode to provide instant system verification of associated shades and programmed visor position.

2.14 CONTROL STATIONS


- A. Provide control stations with configuration as indicated or as required to control the loads as indicated.
- B. Wired Control Stations:
 - 1. General Requirements:
 - a. Class 2 (low voltage).
 - b. UL listed.
 - c. Control stations can be replaced without reprogramming.
 - d. Finish: As specified for wall controls in "Device Finishes" under DIGITAL-NETWORK LIGHTING CONTROL SYSTEM - GENERAL REQUIREMENTS article above.

 5	Title: YALE OFFICE OF FACILITIES PROCEDURE MANUAL Chapter: 01 - Yale Design Standard Division: Electrical Standards	Section: 26 51.00 Interior Lighting
		Date: 6/15/16
		Author: Office of Facilities
CC: Project Folder		


2. Product(s):

a. Multi-Scene Wired Control:

- 1) Allows control of any devices part of the lighting control system.
- 2) Utilize RS485 wiring for low-voltage communication.
- 3) Functionality:
 - (a) Upon button press, LEDs to immediately illuminate.
 - (b) LEDs to reflect the true system status. LEDs to remain illuminated if the button press was properly processed or LEDs to turn off if the button press was not processed.
 - (c) Allows for easy reprogramming without replacing unit.
 - (d) Replacement of units does not require reprogramming.
- 4) Provide faceplates with concealed mounting hardware.
- 5) Engrave wall stations with button, zone, and scene descriptions as indicated on the drawings.
- 6) Silk-screened borders, logos, and graduations to use graphic process that chemically bonds graphics to faceplate, resistant to removal by scratching and cleaning.
- 7) Software Configuration:
 - (a) Customizable control station device button functionality:
 - (1) Buttons can be programmed to perform single defined action.
 - (2) Buttons can be programmed to perform defined action on press and defined action on release.
 - (3) Buttons can be programmed using conditional logic off of a state variable such as time of day or partition status.
- 8) Control station device LEDs to support logic that defines when it is illuminated:
 - (a) Scene logic (logic is true when all zones are at defined levels).

 5	Title: YALE OFFICE OF FACILITIES PROCEDURE MANUAL Chapter: 01 - Yale Design Standard Division: Electrical Standards	Section: 26 51.00 Interior Lighting
		Date: 6/15/16
		Author: Office of Facilities
CC: Project Folder		

- (b) Room logic (logic is true when at least one zone is on).
- (c) Pathway (logic is true when at least one zone is on).
- (d) Last scene (logic is true when spaces are in defined scenes).
- 9) Contact Closure Interface: Accepts both momentary and maintained contact closures.
- 10) Provide integral infrared receiver for personal control where indicated.
- b. Single-Scene or Zoned Wired Control:
 - 1) Turn an individual fixture or group of fixtures on and off.
 - 2) Raise and lower light levels.
 - 3) Recall favorite light levels.
- c. Four-Button Preset Wallstation:
 - 1) Recall four scenes plus all on or all off for one group of fixtures.
 - 2) Master raise/lower control for entire group of fixtures.
 - 3) Integral IR receiver for personal control.
 - 4) Immediate local LED response upon button activation to indicate that a system command has been requested.
- d. Wired Keyswitch:
 - 1) Allows control of any devices part of the lighting control system.
 - 2) Utilize RS485 wiring for low-voltage communication.
 - 3) Functionality:
 - (a) Allows for easy reprogramming without replacing unit.
 - (b) Requires key insertion to activate actions.
 - 4) Provide faceplates with concealed mounting hardware.
 - 5) Engrave wall stations with button, zone, and scene descriptions as indicated on the drawings.
 - 6) Silk-screened borders, logos, and graduations to use graphic process that chemically bonds graphics to faceplate, resistant to removal by scratching and cleaning.

 5	Title: YALE OFFICE OF FACILITIES PROCEDURE MANUAL Chapter: 01 - Yale Design Standard Division: Electrical Standards	Section: 26 51.00 Interior Lighting
		Date: 6/15/16
		Author: Office of Facilities
CC: Project Folder		

7) Software Configuration:

(a) Customizable control station device button functionality:


- (1) Key positions can be programmed to perform single defined action.
- (2) Key positions can be programmed using conditional logic off of a state variable such as time of day or partition status.

e. Slider Control:

- 1) Allows control of any lighting zone in the system via intuitive analog slider control.
- 2) Utilize RS485 wiring for low-voltage communication.
- 3) Available in 1 to 16 zone configurations.
- 4) Available with or without a take switch to activate the slider scene.
- 5) Optional keypad ganging.
- 6) Slider zones can be chained in partitioned spaces.
- 7) Provide faceplates with concealed mounting hardware.
- 8) Provide customizable engraving of faceplate as indicated on the drawings.
- 9) Functionality:
 - (a) Full range dimming of individual zones or groups of zones.
 - (b) Zone levels indicated by slider position.
 - (c) Integrates with multi-scene wired control.

C. Wireless (Radio Frequency) Controls:


1. Quantity: As indicated on the drawings.
2. Communicates via radio frequency to compatible dimmers, switches, and plug-in modules.
3. Does not require external power packs, power or communication wiring.
4. Allows for easy reprogramming without replacing unit.

 5	Title: YALE OFFICE OF FACILITIES PROCEDURE MANUAL Chapter: 01 - Yale Design Standard Division: Electrical Standards	Section: 26 51.00 Interior Lighting
		Date: 6/15/16
		Author: Office of Facilities
CC: Project Folder		


5. Button Programming:
 - a. Single action.
 - b. Toggle action.
 - c. Defined action on press and defined action on release.
 6. Includes LED to indicate button press or programming mode status.
 7. Models available with integral night light.
 8. Mounting:
 - a. Capable of being mounted with a table stand or directly to a wall under a faceplate.
 - b. Faceplates: Provide concealed mounting hardware.
 9. Power: Battery-operated with minimum ten-year battery life.
- D. Infrared Handheld Controls:
1. Product(s):
 - a. Four-Scene Wireless Infrared Transmitter: Operates up to 50 feet (15 m) line-of-sight to receiver.
 - b. Single-Scene Wireless Infrared Transmitter: Operates up to 12 feet (3.7 m) line-of-sight to receiver.
 2. Quantity: As indicated on the drawings.
 3. Designed for use in conjunction with compatible infrared receiver and lighting control; compatibility dependent on that receiver, not transmitter.
 4. Learnable by other variable frequency remote controls.
 - 5.

2.15 LOW-VOLTAGE CONTROL INTERFACES

- A. Provide low-voltage control interfaces as indicated or as required to control the loads as indicated.
- B. Connects to lighting management hub via RS485.
- C. UL listed.
- D. Contact Closure Interface:

 5	Title: YALE OFFICE OF FACILITIES PROCEDURE MANUAL Chapter: 01 - Yale Design Standard Division: Electrical Standards	Section: 26 51.00 Interior Lighting
		Date: 6/15/16
		Author: Office of Facilities
CC: Project Folder		

1. The contact closure input device to accept both momentary and maintained contact closures.
 2. The contact closure output device can be configured for maintained or pulsed outputs.
 3. Contact closure can be programmed using conditional logic off of a state variable such as time of day or partition status.
- E. Wallbox Input Closure Interface:
1. Mounts in wallbox behind contact closure keypad to provide interface for up to eight contact closure inputs.
 2. The contact closure input device to accept both momentary and maintained contact closures.
- F. RS232 and Ethernet Interface:
1. Provide ability to communicate via Ethernet or RS232 to audiovisual equipment, touchscreens, etc.
 2. Allow creation of custom output strings.
 3. Provide control of:
 - a. Light scene selections.
 - b. Fine-tuning of light scene levels with raise/lower.
 - c. Shade group presets.
 - d. Fine-tuning of shade preset levels with raise/lower.
 - e. Simulate system wall station button presses and releases.
 4. Provide status monitoring of:
 - a. Light scene status.
 - b. Shade group status.
 - c. Wall station button presses and releases.
 - d. Wall station LEDs.
 5. Provide ability to send custom output strings.
- G. DMX Interface:
1. Provide ability to:

 5	Title: YALE OFFICE OF FACILITIES PROCEDURE MANUAL Chapter: 01 - Yale Design Standard Division: Electrical Standards	Section: 26 51.00 Interior Lighting
		Date: 6/15/16
		Author: Office of Facilities
CC: Project Folder		

- a. Map a single zone intensity to a single DMX512 lighting channel.
- b. Map a single zone intensity to three DMX512 channels for RGB/CMY color control.
- c. Map a single zone intensity to a single DMX512 integration channel.
- d. Smoothly transition from one color to another in a cross fade.
- e. Automatically sequence through a variety of colors.
- f. Download, program, and customize a color wheel for each unit.

H. Sensor Modules:

1. Wired Modules:

- a. Provide wired inputs for:
 - 1) Occupancy sensors.
 - 2) Daylight sensors.
 - 3) IR receivers for personal control.
 - 4) Digital ballast wall stations.

2. Wireless Modules:


- a. Provide wireless communication inputs for:
 - 1) Occupancy sensors.
 - 2) Daylight sensors.
 - 3) Wireless controller.
- b. RF Range: 30 feet (9 m) between sensor and compatible RF receiving devices.
- c. RF Frequency: 434 MHz; operates in FCC governed frequency spectrum for periodic operation; continuous transmission spectrum is not permitted.

3. Communicate sensor information to wired low-voltage digital link for use by compatible devices.


2.16 WIRED SENSORS

A. Wired Occupancy Sensors:

1. General Requirements:

 5	Title: YALE OFFICE OF FACILITIES PROCEDURE MANUAL Chapter: 01 - Yale Design Standard Division: Electrical Standards	Section: 26 51.00 Interior Lighting
		Date: 6/15/16
		Author: Office of Facilities
CC: Project Folder		

- a. Connects directly to compatible ballasts and modules without the need of a power pack or other interface.
 - b. Turns off or reduces lighting automatically after reasonable time delay when a room or area is vacated by the last person to occupy the space.
 - c. Accommodates all conditions of space utilization and all irregular work hours and habits.
 - d. Comply with UL 94.
 - e. Self-Adaptive: Continually adjusts sensitivity and timing to ensure optimal lighting control for any use of the space.
 - f. Furnished with field-adjustable controls for time delay and sensitivity to override any adaptive features.
 - g. Provide capability to:
 - 1) Add additional timeout system-wide without need to make local adjustment on sensor.
 - 2) Group multiple sensors.
 - h. Power Failure Memory: Settings and learned parameters to be saved in non-volatile memory and not lost should power be interrupted and subsequently restored.
 - i. Furnished with all necessary mounting hardware and instructions.
 - j. Class 2 devices.
 - k. Ceiling-Mounted Sensors: Indicate viewing directions on mounting bracket.
 - l. Wall-Mounted Sensors: Provide swivel-mount base.
 - m. Color: White.
2. Wired Passive Infrared Sensors:
 - a. Utilize multiple segmented lens, with internal grooves to eliminate dust and residue build-up.
 - b. Ceiling-Mounted Sensors: Provide customizable mask to block off unwanted viewing areas.

 5	Title: YALE OFFICE OF FACILITIES PROCEDURE MANUAL Chapter: 01 - Yale Design Standard Division: Electrical Standards	Section: 26 51.00 Interior Lighting
		Date: 6/15/16
		Author: Office of Facilities
CC: Project Folder		

c. Product(s): (“*” job conditions/design to specify type)

- 1) Type *__ - Ceiling-Mounted Passive Infrared Sensor, 450 square feet (42 sq m): Coverage of 450 square feet (42 sq m) with ceiling height of 8 to 12 feet (2.4 to 3.7 m); 360 degree field of view.
- 2) Type *__ - Ceiling-Mounted Passive Infrared Sensor, 1500 square feet (140 sq m): Coverage of 1500 square feet (140 sq m) with ceiling height of 8 to 12 feet (2.4 to 3.7 m); 360 degree field of view.
- 3) Type *__ - Wall-Mounted Passive Infrared Sensor: Coverage of 1600 square feet (149 sq m) with ceiling height of 8 to 12 feet (2.4 to 3.7 m); 110 degree field of view.

3. Wired Ultrasonic Sensors:

a. Utilize an operating frequency of 32kHz or 40kHz, crystal-controlled to operate within plus/minus 0.005 percent tolerance.


b. Product(s): (“*” job conditions/design to specify type)

- 1) Type *__ - Ceiling-Mounted Ultrasonic Sensor, 500 square feet (46 sq m): Coverage of 500 square feet (46 sq m) with ceiling height of 8 to 12 feet (2.6 to 3.7 m); 180 degree field of view.
- 2) Type *__ - Ceiling-Mounted Ultrasonic Sensor, 1000 square feet (93 sq m): Coverage of 1,000 square feet (93 sq m) with ceiling height of 8 to 12 feet (2.6 to 3.7 m); 180 degree field of view.
- 3) Type *__ - Ceiling-Mounted Ultrasonic Sensor, 2000 square feet (186 sq m): Coverage of 2000 square feet (186 sq m) with ceiling height of 8 to 12 feet (2.6 to 3.7 m); 360 degree field of view.

4. Wired Dual Technology Sensors:


a. Passive Infrared: Utilize multiple segmented lens, with internal grooves to eliminate dust and residue build-up.

b. Ultrasonic: Utilize an operating frequency of 32kHz or 40kHz, crystal-controlled to operate within plus/minus 0.005 percent

 5	Title: YALE OFFICE OF FACILITIES PROCEDURE MANUAL Chapter: 01 - Yale Design Standard Division: Electrical Standards	Section: 26 51.00 Interior Lighting
		Date: 6/15/16
		Author: Office of Facilities
CC: Project Folder		

tolerance.

- c. Ceiling-Mounted Sensors: Provide customizable mask to block off unwanted viewing areas.
- d. Isolated Relay: Provide an internal additional isolated relay with Normally Open, Normally Closed, and Common outputs for use with HVAC control, Data Logging and other control options where indicated.
- e. Integral Photocell: Provide an integral photocell with adjustable sensitivity to prevent lights from turning on when there is sufficient natural light where indicated.
- f. Product(s), Without Isolated Relay and Integral Photocell: (“*” job conditions/design to specify type)
 - 1) Type *__ - Ceiling-Mounted Dual Technology Sensor, 500 square feet (46 sq m): Coverage of 500 square feet (46 sq m) with ceiling height of 8 to 12 feet (2.6 to 3.7 m); 180 degree field of view.
 - 2) Type *__ - Ceiling-Mounted Dual Technology Sensor, 1000 square feet (93 sq m): Coverage of 1000 square feet (93 sq m) with ceiling height of 8 to 12 feet (2.6 to 3.7 m); 180 degree field of view.
 - 3) Type *__ - Ceiling-Mounted Dual Technology Sensor, 2000 square feet (186 sq m): Coverage of 2000 square feet (186 sq m) with ceiling height of 8 to 12 feet (2.6 to 3.7 m); 360 degree field of view.
 - 4) Type *__ - Wall-Mounted Dual Technology Sensor: Coverage of 1600 square feet (149 sq m) with ceiling height of 8 to 12 feet (2.4 to 3.7 m); 110 degree field of view.
- g. Product(s), With Isolated Relay and Integral Photocell: (“*” job conditions/design to specify type)
 - 1) Type *__ - Ceiling-Mounted Dual Technology Sensor, 500 square feet (46 sq m): Coverage of 500 square feet (46 sq m) with ceiling height of 8 to 12 feet (2.6 to 3.7 m); 180 degree field of view; with isolated relay and integral photocell.

 5	Title: YALE OFFICE OF FACILITIES PROCEDURE MANUAL Chapter: 01 - Yale Design Standard Division: Electrical Standards	Section: 26 51.00 Interior Lighting
		Date: 6/15/16
		Author: Office of Facilities
CC: Project Folder		


- 2) Type *__ - Ceiling-Mounted Dual Technology Sensor, 1000 square feet (93 sq m): Coverage of 1000 square feet (93 sq m) with ceiling height of 8 to 12 feet (2.6 to 3.7 m); 180 degree field of view; with isolated relay and integral photocell.
- 3) Type *__ - Ceiling-Mounted Dual Technology Sensor, 2000 square feet (186 sq m): Coverage of 2000 square feet (186 sq m) with ceiling height of 8 to 12 feet (2.6 to 3.7 m); 360 degree field of view; with isolated relay and integral photocell.
- 4) Type *__ - Wall-Mounted Dual Technology Sensor: Coverage of 1600 square feet (149 sq m) with ceiling height of 8 to 12 feet (2.4 to 3.7 m); 110 degree field of view; with isolated relay and integral photocell.

B. Sensor Power Packs:


1. Provide sensor power packs where required for power connection to sensors.
2. For ease of mounting, installation and future service, power pack(s) to be able to mount through a 1/2 inch knockout in a standard electrical enclosure and be an integrated, self-contained unit consisting internally of an isolated load switching control relay and a transformer to provide low-voltage power. Transformer is to provide power to a minimum of three sensors.
3. Plenum-rated.
4. Control Wiring Between Sensors and Control Units: Class 2, 18-24 AWG, stranded UL Classified, PVC insulated or TEFLON jacketed cable suitable for use in plenums, where applicable.

C. Infrared Receivers:

1. Use Class 2 wiring for low voltage communication.
2. Can be replaced without reprogramming.
3. 360 degree reception of wireless infrared remote controls
4. Immediate local LED response upon reception of handheld transmitter communication.
5. Mountable on lighting fixtures or recessed acoustical ceiling tiles.

 5	Title: YALE OFFICE OF FACILITIES PROCEDURE MANUAL Chapter: 01 - Yale Design Standard Division: Electrical Standards	Section: 26 51.00 Interior Lighting
		Date: 6/15/16
		Author: Office of Facilities
CC: Project Folder		

6. Constructed via sonic welding.
 7. Color: White.
- D. Wired Daylight Sensors:
1. Digital Interior Daylight Sensor:
 - a. Use Class 2 wiring for low voltage communication.
 - b. Can be replaced without reprogramming.
 - c. Open-loop basis for daylight sensor control scheme.
 - d. Stable output over temperature from 32 degrees F (0 degrees C) to 104 degrees F (40 degrees C).
 - e. Partially shielded for accurate detection of available daylight to prevent fixture lighting and horizontal light component from skewing sensor detection.
 - f. Provide linear response from 0 to 500 foot-candles.
 - g. Integral IR receiver for personal control.
 - h. Mountable on lighting fixtures or recessed acoustical ceiling tiles.
 - i. Constructed via sonic welding.
 - j. Color: White.
 2. Daylight Control Package:
 - a. Controller:
 - 1) Automatically switches a dry contact according to changes in ambient light levels.
 - 2) Fully adjustable separate high and low set-points, with an adjustable dead band between set points to prevent unwanted cycling.
 - 3) Input time delay to prevent unwanted cycling due to intermittent light level fluctuations.
 - 4) Signal/set-point and relay status indication.
 - 5) Sensor calibration input.
 - b. Sensors:

 5	Title: YALE OFFICE OF FACILITIES PROCEDURE MANUAL Chapter: 01 - Yale Design Standard Division: Electrical Standards	Section: 26 51.00 Interior Lighting
		Date: 6/15/16
		Author: Office of Facilities
CC: Project Folder		

- 1) Class 2, three-wire analog devices.
- 2) Provision for zero or offset based signal.
- 3) Indoor Photo Sensors: With fresnel lens and 60 degree cone of response; sensor range of 0 to 750 foot-candles.
- 4) Outdoor Photo Sensors: Weatherproof, with hood over aperture to shield sensor from direct sunlight; sensor range of 0 to 750 foot-candles.
- 5) Atrium Photo Sensors: With translucent dome and 180 degree field of view; sensor range of 2 to 2,500 foot-candles.
- 6) Skylight Photo Sensors: With translucent dome and 180 degree field of view; sensor range of 10 to 7,500 foot-candles.

E. Infrared Partition Sensors:

1. Provide contact closure based on status of the partition wall (open/close) enabling automatic linking of controls.


2.17 WIRELESS SENSORS

A. General Requirements:


1. Operational life of 10 years without the need to replace batteries when installed per manufacturer's instructions.
2. Communicates directly to compatible RF receiving devices through use of a radio frequency communications link.
3. Does not require external power packs, power wiring, or communication wiring.
4. Capable of being placed in test mode to verify correct operation from the face of the unit.
5. RF Range: 30 feet (9 m) between sensor and compatible RF receiving device(s).
6. Electromagnetic Interference/Radio Frequency Interference (EMI/RFI) Limits: Comply with FCC requirements of CFR, Title 47, Part 15, for Class B application.

B. Wireless Occupancy/Vacancy Sensors:


1. General Requirements:

 5	Title: YALE OFFICE OF FACILITIES PROCEDURE MANUAL Chapter: 01 - Yale Design Standard Division: Electrical Standards	Section: 26 51.00 Interior Lighting
		Date: 6/15/16
		Author: Office of Facilities
CC: Project Folder		

- a. Provides a clearly visible method of indication to verify that motion is being detected during testing and that the unit is communicating to compatible RF receiving devices.
- b. Utilize multiple segmented lens, with internal grooves to eliminate dust and residue build-up.
- c. Sensing Mechanism: Passive infrared coupled with technology for sensing fine motions. Signal processing technology detects fine-motion passive infrared (PIR) signals without the need to change the sensor's sensitivity threshold.
- d. Provide optional, readily accessible, user-adjustable controls for timeout, automatic/manual-on, and sensitivity.
- e. Turns off lighting after reasonable and adjustable time delay once the last person to occupy the space vacates a room or area. Provide adjustable timeout settings of 1, 5, 15, and 30 minutes.
- f. Capable of turning dimmer's lighting load on to an optional locked preset level selectable by the user. Locked preset range to be selectable on the dimmer from 1 percent to 100 percent.
- g. Color: White.
- h. Provide all necessary mounting hardware and instructions for both temporary and permanent mounting.
- i. Provide temporary mounting means to allow user to check proper performance and relocate as needed before permanently mounting sensor. Temporary mounting method to be design for easy, damage-free removal.
- j. Sensor lens to illuminate during test mode when motion is detected to allow installer to verify coverage prior to permanent mounting.
- k. Ceiling-Mounted Sensors:
 - 1) Provide surface mounting bracket compatible with drywall, plaster, wood, concrete, and compressed fiber ceilings.
 - 2) Provide recessed mounting bracket compatible with drywall and compressed fiber ceilings.
 - 3) Provide customizable mask to block off unwanted viewing areas.

 5	Title: YALE OFFICE OF FACILITIES PROCEDURE MANUAL Chapter: 01 - Yale Design Standard Division: Electrical Standards	Section: 26 51.00 Interior Lighting
		Date: 6/15/16
		Author: Office of Facilities
CC: Project Folder		

1. Wall-Mounted Sensors: Provide wall or corner mounting brackets compatible with drywall and plaster walls.
2. Wireless Combination Occupancy/Vacancy Sensors:
 - a. Ceiling-Mounted Sensors: Programmable to operate as an occupancy sensor (automatic-on and automatic-off), an occupancy sensor with low light feature (automatic-on when less than one foot candle of ambient light available and automatic-off), or a vacancy sensor (manual-on and automatic-off).
 - b. Wall-Mounted Sensors: Programmable to operate as an occupancy sensor (automatic-on and automatic-off), or a vacancy sensor (manual-on and automatic-off).
 - c. Product(s): (“*” job conditions/design to specify type)
 - 1) Type *__ - Ceiling-Mounted Occupancy/Vacancy Sensor: Coverage from 324 square feet (30.2 sq m) to 676 square feet (62.4 sq m) depending on ceiling height from 8 to 12 feet (2.4 to 3.7 m); 360 degree field of view.
 - 2) Type *__ - Wall-Mounted Occupancy/Vacancy Sensor: Minor motion coverage of 1500 square feet (139.4 sq m) and major motion coverage of 3000 square feet (278.7 sq m) with mounting height of 6 to 8 feet (1.6 to 2.4 m); 180 degree field of view.
 - 3) Type *__ - Corner-Mounted Occupancy/Vacancy Sensor: Minor motion coverage of 1225 square feet (113.8 sq m) and major motion coverage of 2500 square feet (232.3 sq m) with mounting height of 6 to 8 feet (1.6 to 2.4 m); 90 degree field of view.
 - 4) Type *__ - Hallway Occupancy/Vacancy Sensor: Major motion coverage of up to 150 feet (45.7 m) with mounting height of 6 to 8 feet (1.6 to 2.4 m); narrow field of view.
3. Wireless Vacancy-Only Sensors:
 - a. Operates only as a vacancy sensor (manual-on and automatic-off) in accordance with California Title 24 requirements.
 - b. Product(s): (“*” job conditions/design to specify type)
 - 1) Type *__ - Ceiling-Mounted Vacancy-Only Sensor: Coverage


 5	Title: YALE OFFICE OF FACILITIES PROCEDURE MANUAL Chapter: 01 - Yale Design Standard Division: Electrical Standards	Section: 26 51.00 Interior Lighting
		Date: 6/15/16
		Author: Office of Facilities
CC: Project Folder		

from 324 square feet (30.2 sq m) to 676 square feet (62.4 sq m) depending on ceiling height from 8 to 12 feet (2.4 to 3.7 m); 360 degree field of view.

- 2) Type *__ - Wall-Mounted Vacancy-Only Sensor: Minor motion coverage of 1500 square feet (139.4 sq m) and major motion coverage of 3000 square feet (278.7 sq m) with mounting height of 6 to 8 feet (1.6 to 2.4 m); 180 degree field of view.
- 3) Type *__ - Corner-Mounted Vacancy-Only Sensor: Minor motion coverage of 1225 square feet (113.8 sq m) and major motion coverage of 2500 square feet (232.3 sq m) with mounting height of 6 to 8 feet (1.6 to 2.4 m); 90 degree field of view.
- 4) Type *__ - Hallway Vacancy-Only Sensor: Major motion coverage of up to 150 feet (45.7 m) with mounting height of 6 to 8 feet (1.6 to 2.4 m); narrow field of view.

C. Wireless Daylight Sensors:

1. Open-loop basis for daylight sensor control scheme.
2. Stable output over temperature from 32 degrees F (0 degrees C) to 104 degrees F (40 degrees C).
3. Partially shielded for accurate detection of available daylight to prevent fixture lighting and horizontal light component from skewing sensor detection.
4. Provide linear response from 0 to 10,000 foot-candles.
5. Color: White.
6. Mounting:
 - a. Provide surface mounting bracket compatible with drywall, plaster, wood, concrete, and compressed fiber ceilings.
 - b. Provide all necessary mounting hardware and instructions for both temporary and permanent mounting.
 - c. Provide temporary mounting means to allow user to check proper performance and relocate as needed before permanently mounting sensor. Temporary mounting method is to be designed for easy, damage-free removal.

 5	Title: YALE OFFICE OF FACILITIES PROCEDURE MANUAL Chapter: 01 - Yale Design Standard Division: Electrical Standards	Section: 26 51.00 Interior Lighting
		Date: 6/15/16
		Author: Office of Facilities
CC: Project Folder		

7. Meets California Title 24 requirements.

2.18 ACCESSORIES

A. Emergency Lighting Interface:

1. Provides total system listing to UL 924 when used with lighting control system.
2. Senses all three phases of building power.
3. Provides an output to power panels or digital ballast interfaces if power on any phase fails and sends all lights controlled by these devices to an emergency light level setting. Lights to return to their previous intensities when normal power is restored.
4. Accepts a contact closure input from a fire alarm control panel.

B. Provide power supplies as indicated or as required to power system devices and accessories.


1. Product(s):
 - a. Junction box-mounted power supply for shades, keypads, and accessories, and for providing additional low voltage power to communication link; with miswire and thermal protection.
 - b. Plug-in power supply for shades, drapery drive units, keypads, and accessories, and for providing additional low voltage power to communication link; with miswire protection; powered from standard receptacle using cord 6 feet (1.8 m) in length.
 - c. Ten output power supply panel for shades, drapery drive units, keypads and accessories, and for providing additional low voltage power to communication link.
 - d. Power supply for keypads and accessories (not for shades/window treatments), and for providing additional low voltage power to communication link.

2.19 SOURCE QUALITY CONTROL

A. See Section 01 4000 - Quality Requirements, for additional requirements.

B. Factory Testing:

1. Perform full-function factory testing on all completed assemblies.

 5	Title: YALE OFFICE OF FACILITIES PROCEDURE MANUAL Chapter: 01 - Yale Design Standard Division: Electrical Standards	Section: 26 51.00 Interior Lighting
		Date: 6/15/16
		Author: Office of Facilities
CC: Project Folder		

Statistical sampling is not acceptable.

2. Perform full-function factory testing on 100 percent of all ballasts and LED drivers.
3. Perform factory audit burn-in of all dimming assemblies and panels at 104 degrees F (40 degrees C) at full load for two hours.
4. Perform factory burn-in of 100 percent of all ballasts at 104 degrees F (40 degrees C).


PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that field measurements are as shown on the drawings.
- B. Verify that ratings and configurations of system components are consistent with the indicated requirements.
- C. Verify that mounting surfaces are ready to receive system components.
- D. Verify that conditions are satisfactory for installation prior to starting work.

3.2 INSTALLATION

- A. Perform work in a neat and workmanlike manner in accordance with NECA 1 and, where applicable, NECA 130, except for mounting heights specified in those standards.
- B. Install products in accordance with manufacturer's instructions.
- C. Provide dedicated network between lighting management system computer and lighting management hubs.
- D. Define each dimmer/relay load type, assign each load to a zone, and set control functions.
- E. Sensor Locations: Locate in accordance with layout provided by lighting control manufacturer as part of sensor layout and tuning services specified in Part 2 under "DIGITAL-NETWORK LIGHTING CONTROL SYSTEM - GENERAL REQUIREMENTS". Lighting control manufacturer may direct Contractor regarding sensor relocation should conditions require a deviation from locations indicated.
- F. Mount exterior daylight sensors to point due north with constant view of daylight.

 5	Title: YALE OFFICE OF FACILITIES PROCEDURE MANUAL Chapter: 01 - Yale Design Standard Division: Electrical Standards	Section: 26 51.00 Interior Lighting
		Date: 6/15/16
		Author: Office of Facilities
CC: Project Folder		


- G. Ensure that daylight sensor placement minimizes sensor view of electric light sources. Locate ceiling-mounted and luminaire-mounted daylight sensors to avoid direct view of luminaires.
- H. Automated Shade Control Sensors:
 - 1. Mount rooftop cloudy day sensors to point in the direction of each facade.
 - 2. Ensure that window shadow sensor placement provides an unobstructed view of outdoors. Do not place at a skylight or above indirect luminaires.
- I. Lamp Burn-In: Operate lamps at full output for prescribed period per manufacturer's recommendations prior to use with any dimming controls. Replace lamps that fail prematurely due to improper lamp burn-in.
- J. Lamp Lead Lengths: Do not exceed 3 feet (0.9 m) for T4 4-pin compact and T5 BIAX lamps and 7 feet (2.1 m) for T5, T5-HO, T8 U-bend, and T8 linear fluorescent lamps.
- K. LED Light Engine/Array Lead Length: Do not exceed 100 feet (31 m).
- L. System and Network Integration Consultation: Include as part of the base bid additional costs for lighting control system manufacturer to conduct meeting with facility representative and other related equipment manufacturers to discuss equipment and integration procedures.
- M. Identify system components in accordance with Section 26 0553.

3.3 FIELD QUALITY CONTROL

- A. See Section 01 4000 - Quality Requirements, for additional requirements.
- B. See article "SYSTEM STARTUP" below for requirements related to testing and inspection.
- C. Correct defective work, adjust for proper operation, and retest until entire system complies with contract documents.


3.4 SYSTEM STARTUP

- A. Provide services of a manufacturer's certified service representative to perform system startup.
- B. Manufacturer's Startup Services:
 - 1. Manufacturer's certified service representative to conduct minimum of

 5	Title: YALE OFFICE OF FACILITIES PROCEDURE MANUAL Chapter: 01 - Yale Design Standard Division: Electrical Standards	Section: 26 51.00 Interior Lighting
		Date: 6/15/16
		Author: Office of Facilities
CC: Project Folder		

three site visits to ensure proper system installation and operation.

2. Conduct first visit to review requirements with installer as specified in Part 1 under "Administrative Requirements".
3. Conduct second site visit upon completion of lighting control system to perform system startup and verify proper operation:
 - a. Verify sensor locations, in accordance with layout provided by lighting control manufacturer as part of sensor layout and tuning services specified in Part 2 under "DIGITAL-NETWORK LIGHTING CONTROL SYSTEM - GENERAL REQUIREMENTS"; lighting control manufacturer may direct Contractor regarding sensor relocation should conditions require a deviation from locations indicated.
 - b. Verify connection of power wiring and load circuits.
 - c. Verify connection and location of controls.
 - d. Energize lighting management hubs and download system data program.
 - e. Address devices.
 - f. Verify proper connection of panel links (low voltage/data) and address panel.
 - g. Download system panel data to dimming/switching panels.
 - h. Check dimming panel load types and currents and supervise removal of by-pass jumpers.
 - i. Verify system operation control by control.
 - j. Verify proper operation of manufacturer's interfacing equipment.
 - k. Verify proper operation of manufacturer's supplied PC and installed programs.
 - l. Configure initial groupings of ballast for wall controls, daylight sensors and occupancy sensors.
 - m. Provide initial rough calibration of sensors; fine-tuning of sensors is responsibility of Contractor unless provided by lighting control manufacturer as part of sensor layout and tuning services where

 5	Title: YALE OFFICE OF FACILITIES PROCEDURE MANUAL Chapter: 01 - Yale Design Standard Division: Electrical Standards	Section: 26 51.00 Interior Lighting
		Date: 6/15/16
		Author: Office of Facilities
CC: Project Folder		

specified in Part 2 under "DIGITAL-NETWORK LIGHTING CONTROL SYSTEM - GENERAL REQUIREMENTS".

- n. Obtain sign-off on system functions.
 - o. After Hours Startup: Include as part of the base bid additional costs to perform manufacturer's startup procedures outside normal working hours (Monday through Friday, 7am to 5pm).
4. Conduct third site visit to train Owner's representative on system capabilities, operation, and maintenance, as specified in Part 3 under "Closeout Activities".

3.5 ADJUSTING

- A. On-Site Scene and Level Tuning: Include as part of the base bid additional costs for lighting control manufacturer to visit site to conduct meeting with Engineer to make required lighting adjustments to the system for conformance with original design intent.
- B. Sensor Fine-Tuning: Lighting control manufacturer to provide up to two additional post-startup on-site service visits for fine-tuning of sensor calibration as part of sensor layout and tuning services specified in Part 2 under "DIGITAL-NETWORK LIGHTING CONTROL SYSTEM - GENERAL REQUIREMENTS".

3.6 CLEANING


- A. Clean exposed surfaces to remove dirt, paint, or other foreign material and restore to match original factory finish.

3.7 COMMISSIONING

- A. See contract documents for commissioning requirements.

3.8 CLOSEOUT ACTIVITIES

- A. Demonstration:
 - 1. On-Site Performance-Verification Walkthrough: Include as part of the base bid additional costs for lighting control manufacturer to provide on-site demonstration of system functionality to commissioning agent.
- B. Training:
 - 1. Include services of manufacturer's certified service representative to

 5	Title: YALE OFFICE OF FACILITIES PROCEDURE MANUAL Chapter: 01 - Yale Design Standard Division: Electrical Standards	Section: 26 51.00 Interior Lighting
		Date: 6/15/16
		Author: Office of Facilities
CC: Project Folder		

perform on-site training of Owner's personnel on operation, adjustment, and maintenance of lighting control system as part of standard system start-up services.


- a. Include training on software to be provided:
 - 1) Configuration software used to make system programming and configuration changes.
 - 2) Control and monitor.
 - 3) Energy savings display software.
 - 4) Personal web-based control software.
2. Customer-Site Solution Training Visit: Include as part of the base bid additional costs for lighting control manufacturer to provide one day(s) of additional on-site system training.

3.9 PROTECTION

- A. Protect installed products from subsequent construction operations.

3.10 MAINTENANCE

- A. See manufacturers' documents for additional requirements relating to maintenance service.
- B. Software Maintenance Agreement shall be included as part of the base bid additional costs for manufacturer to provide quarterly compatibility testing results for PC-based lighting control software and new patches issued for Microsoft Operating System, Database, and Browser tools.
 1. If new Microsoft patches create a software conflict, manufacturer to provide lighting control software patches to ensure continued operation.
- C. Provide to Owner, a proposal as an alternate to the base bid, a separate maintenance contract for the service and maintenance of lighting control system for eight years, beginning two years after system startup completion, to include the work described below.
 1. Technology Support Plan:
 - a. Upgrade to 100 percent replacement parts warranty coverage for lighting control system components, excluding system computer and ballasts.

	Title: YALE OFFICE OF FACILITIES PROCEDURE MANUAL Chapter: 01 - Yale Design Standard Division: Electrical Standards	Section: 26 51.00 Interior Lighting
		Date: 6/15/16
		Author: Office of Facilities
CC: Project Folder		

- b. Upgrade to 100 percent replacement parts warranty coverage for lighting control system components and ballasts, excluding system computer.
 - c. Upgrade to 100 percent manufacturer labor coverage.
 - d. Annual scheduled maintenance visit.
 - e. First-available on-site or remote response time.
 - f. 72-hour on-site or remote response time.
 - g. 24-hour on-site or remote response time.
 - h. Telephone Technical Support: 24 hours per day, 7 days per week, excluding manufacturer holidays.
 - i. Includes warranty upgrade of initial 2 year coverage to Gold level.
 - j. Includes warranty upgrade of initial 2 year coverage to Platinum level.
- D. System Optimization Visit: Include as part of the base bid additional costs for lighting control system manufacturer to visit site six months after system start-up to evaluate system usage and discuss opportunities to make efficiency improvements that will fit with the current use of the facility.

“END OF SECTION”