



San Francisco
International
Airport

A&E Standards

Electrical – Lighting

Division 26 – Electrical

PREFACE

PURPOSE OF THIS DOCUMENT

The intent of this document is to disseminate the San Francisco International Airport's (SFO's or Airport's) expectations regarding the information presented to designers, engineers, general contractors and other industry specialists. The material provided in the following sections includes the minimal requirements, general information, design criteria, guide specifications and details for electrical and lighting installed at SFO. While this document addresses major areas of concern to SFO, it is not an all-inclusive document.

HOW TO USE THIS DOCUMENT

This document should be used as a resource for the development of project specific design documents including drawings, details and specifications. It is the responsibility of the design, engineering and construction professionals to adhere to all codes and regulations related to the content presented.

SCOPE

This section contains the Standards and Criteria for Lighting. Any questions or concerns regarding the items or equals specified must be submitted to the Standards Committee in writing. All final decisions regarding products shall be made at the Airport's discretion. If the Engineer of Record presents items that are not specified or named equals, they must be brought to the Standards Committee for evaluation of those products.

DRAWING REQUIREMENTS

- A. All design disciplines including the architectural/engineering sub-consultants and the trade bid package subcontractors shall prepare documents using Revit in the current version utilized by the Airport in compliance with the Airport's Building Information Modeling (BIM) Requirements as described in Document 00 73 87: BIM Requirements, unless waived by the Chief Development Officer.
- B. When Revit models may not be applicable, (for example, tasks with underground infrastructure beyond a building footprint), Civil 3D may be used to model utilities and applicable infrastructure if approved by the Chief Development Officer.
- C. Refer to technical specifications for As-Built requirements.
- D. Documents and plans submitted to SFO shall be searchable using PDFs with live text. This includes, but is not limited to, text and symbols. The document shall also provide the capability to turn layers on and off. Any project using legacy documents which may be composed image files shall be converted to live text via Optical Character Recognition (OCR).

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SECTION 26 08 02 – COMMISSIONING OF LIGHTING CONTROL SYSTEMS

PART 1 – GENERAL

1.1 SUMMARY

A. Section Includes:

1. System specific commissioning of day lighting and dimming lighting control systems.

B. Related Sections:

1. General Commissioning Requirements Division 26
2. 26 09 23 – Lighting Control Devices
3. 26 09 43 – Network Lighting Controls

1.2 DESCRIPTION OF WORK – Please refer to relevant sections

1.3 SUBMITTALS – Please refer to relevant sections

PART 2 – PRODUCTS

Not Used

PART 3 – EXECUTION

3.1 COMMISSIONING PROCESS AND PROCEDURES

- A. For a complete description of the commissioning process and procedures, refer to relevant sections.

3.2 SYSTEMS READINESS CHECKLISTS

- A. Review and Complete Systems Readiness Checklists available in Appendix B in accordance with requirements.
- B. Contractor's Commissioning Coordinator shall verify completion of all items, sign and return the checklist to the Commissioning Authority as an indication of final completion with all installation criteria as specified in the Project Contract Documents
- C. To demonstrate the level of rigor required during this process, a sample System Readiness Checklist is provided in Appendix B. Initial checklists will be developed and delivered to the Contractor by the Commissioning Authority after equipment submittals have been accepted. The Contractor shall review the initial Systems Readiness Checklists for completeness and add items as necessary. After approval by the Commissioning Authority, the final Systems Readiness Checklists shall be inserted into the Contractor's Systems Readiness Plan during the Pre-Functional Testing phase.
- D. The Contractor shall submit the System Readiness Plan with blank forms from CxA after equipment submittals have been accepted.

- E. A separate completed checklist shall be submitted for each system and item of equipment within the commissioning scope of work, as specified by general commissioning requirements.
- F. The Systems Readiness Checklists do not represent all the contract documents for the associated equipment. Completion of the items on this checklist does not release the contractor from requirements specified elsewhere.

3.3 SYSTEMS READINESS PLAN

- A. The Contractor shall provide a system readiness plan and manual in accordance with Section general commissioning requirements and 26 08 00. The Contractor shall provide a System Readiness Plan which shall include the following:
 - 1. System Readiness Checklists – provided by the Commissioning Authority (CxA) to be compiled and completed by the Contractor.
 - 2. Start-up and testing procedures and data forms for all equipment and systems within the commissioning scope of work, in accordance with the Contract Documents.
- B. The Contractor shall submit the Systems Readiness Manual, the completed version of the System Readiness Manual, the completed version of the System Readiness Plan, prior to Functional Performance Testing. When it is necessary to begin functional testing on a system (or systems) before the readiness of other systems can be documented, it may be acceptable to provide preliminary submittals of the System for the system (s) that are ready for testing.

3.4 FUNCTIONAL PERFORMANCE TESTING

- A. The Functional Performance Test (FPT) Procedures shall be developed, performed and demonstrated in accordance with general commissioning requirements and 26 08 00.
- B. At a minimum, the contractors and equipment suppliers listed in the FPTs Minimum Participants Table in this section of the specifications are required to participate in developing, performing and demonstrating the indicated FPTs.
- C. A sample FPT is provided at the end of this section. The final FPTs will be drafted by the CxA after equipment submittals have been accepted.
- D. The initial FPT procedures will be developed after review of the submittals. The final FPT procedures may be modifications of the initial FPT procedures, and FPTs may be added; modifications and additions to be made by the Commissioning Authority after equipment submittals have been accepted.
 - 1. The contractor shall provide a finalized draft of the startup and testing plan for CxA review, at least two weeks prior to system testing. The CA shall witness the contractors testing plan and review the results. The contractor shall submit completed testing documentation for inclusion in the final commissioning report.
- E. The Contractor's Commissioning Coordinator, with the Commissioning Authority's input, shall coordinate the subcontractors in developing, performing and demonstrating the successful completion of the FPTs.
- F. Functional testing shall include the testing of all systems mentioned herein, as well as of the components that comprise those systems.

1. Component Testing:
 - a. Component testing applies to all control input and output devices, including those provided by the equipment suppliers and those provided with the Building Management System (BMS). Examples include but are not limited to sensor assemblies, detectors, relays and switches.
 - b. Component testing applies to relevant measuring devices, such as pyranometers.
 - c. Component testing consists of demonstrating field I/O calibration and operation including but not limited to:
 - 1) Accuracy of sensors is within design range as specified.
 - 2) Alarmed points report correctly to operator workstation.
 - 3) Accuracy and settings of binary switches and alarms is as specified, within design temperature range.
 - 4) Fail safe operation of components and controllers is as specified for loss of control signal, electric power, and network communications.
 - 5) All components, values and alarms are correctly mapped to operator interface station.
2. Systems Testing:
 - a. Operational Verification: After functional testing of the system components has been successfully completed, each sequence of operation and control system function shall be functionally tested, including those provided by the equipment suppliers and those provided with the Energy Management and Control System (EMCS). Each control loop shall be tested to verify stable control with the specified and appropriate responses.
 - b. Integrated System Verification: After operational testing has successfully demonstrated that each system functions in accordance with the project documents, functional testing shall occur to verify that the interaction between the systems is as required. Each interactive function shall be functionally tested, including those provided the equipment suppliers and those provide with the Building Management System (BMS).
 - c. Real Time Performance Analysis (trend logging): After operational testing has been successfully completed real time performance testing shall be performed. Data shall be logged for the intervals and periods specified in the FPT procedures. Unless otherwise specified in the FPTs, test periods shall include occupied, unoccupied, weekend, and holiday schedules. Analysis of real-time performance data shall demonstrate that that the systems operate in accordance with the acceptance criteria specified in the FPT procedures. The Contractor shall verify that such data demonstrates acceptable results before submitting for CxA review. If acceptable results are not demonstrated, perform testing and trouble shooting and corrective action to provide resolution. Provisions for retesting, including BACK-CHARGING as specified in general commissioning requirements, shall apply to trend log analysis.

3.5 SEASONAL FUNCTIONAL PERFORMANCE TESTING

- A. Seasonal functional testing does not apply to the commissioned systems within this Division.

3.6 FUNCTIONAL PERFORMANCE TESTING DEMONSTRATION SAMPLING

- A. FPT demonstration sampling does not apply to the commissioned systems within this Division.

3.7 FUNCTIONAL PERFORMANCE TESTING MINIMUM PARTICIPANTS

- A. At a minimum, the parties listed below will participate in the functional testing process and in demonstrating successful functional performance tests to the Commissioning Agent (CxA).
- B. Minimum Participants
 - 1. Commissioning Coordinator
 - 2. Electrical Contractor

END OF SECTION 26 08 02

SECTION 26 09 23 – LIGHTING CONTROL DEVICES

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Time Switches
 - 2. Indoor Occupancy Sensors
 - 3. Outdoor Photoelectric Switches
 - 4. Indoor Photoelectric Switches
 - 5. Switchbox_Mounted Occupancy Sensors
 - 6. Conductors and Cabling
- B. Related Requirements:
 - 1. Division 26 Section “Wiring Devices” for wall-switch occupancy sensors, and manual light switches.
- C. Related Division 26 requirements pertaining to “Wiring Devices” for wall-box dimmers, wall-switch occupancy sensors, and manual light switches.
- D. Control Intent-Control Intent includes, but is not limited to:
 - 1. Defaults and initial calibration settings for such items as time delay, sensitivity, fade rates, etc.
 - 2. Initial sensor and switching zones
 - 3. Initial time switch settings

1.3 DEFINITIONS

- A. LED: Light-emitting diode.
- B. PIR: Passive infrared.

1.4 REFERENCES

- A. Comply with the latest versions of the following standards:
 - 1. National Fire Protection Association (NFPA)
 - 2. Underwriters Laboratories (UL)
 - 3. National Electrical Contractors Association (NECA)

1.5 ACTION SUBMITTALS

- A. Product Data: Catalog sheets, specifications and installation instructions. For each type of product.

B. Shop Drawings:

1. Show installation details for occupancy.
 - a. Interconnection diagrams showing field-installed wiring.
 - b. Include diagrams for power, signal, and control wiring.
 - c. Scale drawing for each area showing exact location of each sensor, room controller, and digital switch.

1.6 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.

1.7 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: Include each type of lighting control device in the emergency, operation, and maintenance manuals.

1.8 QUALITY ASSURANCE

- A. Electrical components, devices, and accessories: listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.9 COORDINATION

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

PART 2 – PRODUCTS

NOTE: Lighting controls shall be over-rideable for fixtures adjacent to commissioned art work.

2.1 TIME SWITCHES

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
1. Cooper Industries, Inc.
 2. Intermatic, Inc.
 3. Invensys Controls
 4. Leviton Mfg. Company Inc.
 5. NSi Industries LLC; TORK Products
 6. Tyco Electronics; ALR Brand
 7. Lightolier
 8. Or approved equal

2.2 INDOOR OCCUPANCY SENSORS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the work shall include, but are not limited to, the following:
1. Cooper Industries, Inc.
 2. Hubbell Building Automation, Inc.

3. Hubbell Lighting
 4. Leviton Mfg. Company, Inc.
 5. Lightolier Controls
 6. Lithonia Lighting; Acuity Lighting Group, Inc.
 7. Lutron Electronics Co., Inc.
 8. Novitas, Inc.
 9. Sensor Switch, Inc.
 10. RAB Lighting, Inc.
 11. Sensor Switch, Inc.
 12. Square D; a brand of Schneider Electric
 13. TORK
 14. Watt Stopper
 15. Or approved equal
- B. General Requirements for Sensors: wall- or ceiling-mounted, solid-state indoor occupancy sensors with a separate power pack.
1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 2. Operation: Unless otherwise indicated, turn lights on when coverage area is occupied, and turn them off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 30 minutes.
 3. Sensor Output: Contacts rated to operate the connected relay, complying with UL 773A. Sensor is powered from the power pack.
 4. Power Pack/Relay Unit: dry contacts rated for 20A ballast load at 120 and 277V AC, for 13A tungsten at 120V AC, and for 1.0 HP at 120V AC. Sensor has 24V DC, 150mA, Class 2 power source, as defined by NFPA 70.
 5. Mounting:
 - a. Sensor: Suitable for mounting in any position on a standard outlet box.
 - b. Relay: Externally mounted through a ½ inch knockout in a standard electrical enclosure.
 - c. Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.
 6. Bypass Switch: Override the "on" function in case of sensor failure.
 7. Automatic Light-Level Sensor:
 - a. Adjustable from 2 to 200 fc; turn lights off when selected lighting level is present.
 8. Digital Room Controllers:
 - a. Self-configuring, digitally addressable one, two or three relays controllers with 0-10 volt control for ballasts (if applicable) and single relay application-specific plug load controllers.
 9. Digital Occupancy Sensors:
 - a. Self-configuring, digitally addressable and calibrated occupancy sensors with LCD display and two-way active infrared (IR) communications.
 10. Digital Switches:
 - a. Self-configuring, digitally addressable pushbutton switches, dimmers, and scene switches with two-way active infrared (IR) communications.
 11. Digital Photo sensors:

- a. Single-zone closed loop and multi-zone open loop daylighting sensors with two-way active infrared (IR) communications can provide switching or dimming control for daylight harvesting.
- 12. Digital Lighting Management (DLM) local network:
 - a. Free topology, plug-in wiring system (Cat 5e) for power and data to room devices.
- 13. Network Bridge:
 - a. BACnet MS/TP-compliant digital networked communication between rooms, panels and the Segment Manager or building automation system (BAS).
- 14. Emergency Lighting Control Unit (ELCU):
 - a. Allows a standard lighting control device to control emergency lighting in conjunction with normal lighting in any area within a building.
- C. Passive Infrared (PIR) Type: Ceiling mounted; detect occupants in coverage area by their heat and movement in area of coverage.
 - 1. Detector Sensitivity: Detect occurrences of 6" minimum movement of any portion of a human body that presents a target of not less than 36 sq. in.
 - 2. Detection Coverage (Room): Detect occupancy anywhere in a circular area of 1000 square feet when mounted on a 96" high ceiling.
 - 3. Detection Coverage (Corridor): Detect occupancy within 90 feet when mounted on a 10 foot-high ceiling.
- D. Ultrasonic Type: Ceiling mounted; detect occupants in coverage area through pattern changes of reflected ultrasonic energy.
 - 1. Detector Sensitivity: Detect a person of average size and weight moving not less than 12" in either a horizontal or a vertical manner at an approximate speed of 12"/s.
 - 2. Detection Coverage (Small Room): Detect occupancy anywhere within a circular area of 600 square feet when mounted on an 8-foot-high ceiling.
 - 3. Detection Coverage (Standard Room): Detect occupancy anywhere within a circular area of 1000 square feet when mounted on an 8-foot-high ceiling.
 - 4. Detection Coverage (Large Room): Detect occupancy anywhere within a circular area of 2000 square feet when mounted on an 8-foot-high ceiling.
 - 5. Detection Coverage (Corridor): Detect occupancy anywhere within ninety feet when mounted on a 10-foot-high ceiling in a corridor not wider than 14 feet.
- E. Dual-Technology Type: Ceiling mounted; detect occupants in coverage area using PIR and ultrasonic detection methods. The particular technology or combination of technologies that control on-off functions is selectable in the field by operating control on unit.
 - 1. Sensitivity Adjustment: Separate for each sensing technology.
 - 2. Detector Sensitivity: Detect occurrences of 6" minimum movement of any portion of a human body that presents a target of not less than 36 square inches, and detect a person of average size and weight moving not less than 12 inches in either a horizontal or a vertical manner at an approximate speed of 12"/s.

3. Detection Coverage (Standard Room): Detect occupancy anywhere within a circular area of 1,000 square feet when mounted on an 8-foot-high ceiling.

2.3 OUTDOOR PHOTOELECTRIC SWITCHES

A. Available Manufacturers:

1. Area Lighting Research, Inc.; Tyco Electronics
2. Grasslin Controls Corporation; a GE Industrial Systems Company
3. Intermatic, Inc.
4. Lithonia Lighting; Acuity Lighting Group, Inc.
5. Novitas, Inc.
6. Paragon Electric Co.; Invensys Climate Controls
7. Square D; Schneider Electric
8. TORK
9. Touch-Plate, Inc.
10. Watt Stopper (The)
11. Or approved equal

B. Description: Solid state, with single-pole, single throw (SPST) dry contacts rated for 1,800VA tungsten or 1,000VA inductive to operate connected relay, contractor coils, or microprocessor input; complying with UL 773A.

1. Light-Level Monitoring Range: 1.5 to 10 fc, with an adjustment for turn-on and turn-off levels within that range.
2. Time Delay: 15-second minimum, to prevent false operation.
3. Surge Protection: Metal-oxide varistor, complying with IEEE C62.41.1, IEEE C62.41.2, and IEEE 62.45 for Category A1 locations.
4. Mounting: Twist lock complying with IEEE C136.10, with base-and-stem mounting or stem-and-swivel mounting accessories as required to direct sensor to the north sky exposure.

2.4 INDOOR PHOTOELECTRIC SWITCHES

A. Available Manufacturers:

1. Allen-Bradley/Rockwell Automation
2. Area Lighting Research, Inc.; Tyco Electronics
3. Eaton Electrical Inc; Cutler-Hammer Products
4. Grasslin Controls Corporation; a GE Industrial Systems Company
5. Intermatic, Inc.
6. Lithonia Lighting; Acuity Lighting Group, Inc.
7. MicroLite Lighting Control Stems
8. Novitas, Inc.
9. Paragon Electric Co.; Invensys Climate Controls
10. Square D; Schneider Electric
11. TORK
12. Touch-Plate, Inc.
13. Watt Stopper
14. Or approved equal

B. System Description: Sensing daylight and electrical lighting levels, the system adjusts the indoor electrical lighting levels. As daylight increases, the lights are dimmed.

1. Lighting control set point is based on two lighting conditions:
 - a. When no daylight is present (target level).
 - b. When significant daylight is present.
 2. System programming is done with two hand-held, remote-control tools.
 - a. Initial setup tool.
 - b. Tool for occupants to adjust the target levels by increasing the set point up to 25 percent, or by minimizing the electric lighting level.
- C. Ceiling-Mounted Photoelectric Switch: Solid-state, light-level sensor unit, with separate relay unit, to detect changes in lighting levels that are perceived by the eye. Cadmium sulfide photo resistors are not acceptable.
1. Sensor Output: Contacts rated to operate the associated relay, complying with UL 773A. Sensor shall be powered from the relay unit.
 2. Relay Unit: Dry contacts rated for 20A ballast load at 120 and 277V AC, for 13A tungsten at 120V AC, and for 1 HP at 120V AC. Power supply to sensor shall be 24V DC, 150-mA, Class 2 power source as defined by NFPA 70.
 3. Light-Level Monitoring Range: 10 to 200 fc, with an adjustment for turn-on and turn-off levels within that range.
 4. Time-Delay: Adjustable from 5 to 300 seconds to prevent cycling, with dead band adjustment.
 5. Indicator: Two LEDs to indicate the beginning of on-off cycles.
- D. Skylight Photoelectric Sensors: Solid-state, light-level sensor; housed in a threaded, plastic fitting for mounting under skylight, facing up at skylight; with separate relay unit, to detect changes in lighting levels perceived by the eye. Cadmium sulfide photo resistors are not acceptable.
1. Sensor Output: Contacts rated to operate the associated relay, complying with UL 773A. Sensor shall be powered from the relay unit.
 2. Relay Unit: Dry contacts rated for 20A ballast load at 120 and 277V ac, for 13-A tungsten at 120-V ac, and for 1 HP at 120-V AC. Power supply to sensor shall be 24V DC, 150-mA, Class 2 power source as defined by NFPA 70.
 3. Light-Level Monitoring Range: 1,000 to 10,000 FC, with an adjustment for turn-on and turn-off levels within that range.
 4. Time Delay: Adjustable from 5 to 300 seconds to prevent cycling, with dead band adjustment.
 5. Indicator: Two LEDs to indicate the beginning of on-off cycles.

2.5 SWITCHBOX-MOUNTED OCCUPANCY SENSORS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the work include, but are not limited to, the following:
1. Bryant Electric; a Hubbell Company
 2. Cooper Industries, Inc.
 3. Hubbell Building Automation, Inc.
 4. Leviton Mfg. Company, Inc.
 5. Lightolier Controls

6. Lithonia Lighting; Acuity Lighting Group, Inc.
 7. Lutron Electronics Co., Inc.
 8. Sensor Switch, Inc.
 9. Square D; a brand of Schneider Electric
 10. Watt Stopper
 11. Or approved equal
- B. General Requirements for Sensors: Automatic-wall-switch occupancy sensor, suitable for mounting in a single gang switchbox.
1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application, and shall comply with California Title 24.
 2. Operating Ambient Conditions: Dry interior conditions, 32 to 120 °F.
 3. Switch Rating: Not less than 800-VA fluorescent at 120 V, 1200-VA fluorescent at 277 V, and 800-W incandescent.

2.6 CONDUCTORS AND CABLES

- A. Power Wiring to Supply Side of Remote-Control Power Sources: Not smaller than No. 12 AWG. Comply with requirements in Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."
- B. Classes 2 and 3 Control Cable: multi-conductor cable with stranded-copper conductors not smaller than No. 18 AWG. Comply with requirements in Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."
- C. Class 1 Control Cable: Multi-conductor cable with stranded-copper conductors not smaller than No. 14 AWG. Comply with requirements in Division 26 sections pertaining to "Low-Voltage Electrical Power Conductors and Cables."

PART 3 – EXECUTION

3.1 SENSOR INSTALLATION

- A. Coordinate layout and installation of ceiling-mounted devices with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, smoke detectors, fire-suppression systems, and partition assemblies.
- B. Install and aim sensors in locations to achieve not less than 90 percent coverage of areas indicated. Do not exceed coverage limits specified in manufacturer's written instructions.

3.2 WIRING INSTALLATION

- A. Wiring Method: Comply with Division 26 section "Low-Voltage Electrical Power Conductors and Cables." Minimum conduit size is 1/2 inch.
- B. Wiring within Enclosures: Comply with NECA 1. Separate power-limited and non-power-limited conductors according to conductor manufacturer's written instructions.
- C. Size conductors according to lighting control device manufacturer's written instructions unless otherwise indicated.

- D. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

3.3 IDENTIFICATION

- A. Identify components and power and control wiring according to Division 26 Section "Identification for Electrical Systems."
 - 1. Identify controlled circuits in lighting contactors and at the sensor junction boxes.
- B. Label time switches and contactors with a unique designation.

3.4 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
 - 1. Operational Test: After installing time switches and sensors, and after electrical circuitry has been energized, start units to confirm proper unit operation.
 - 2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- B. Lighting control devices will be considered defective if they do not pass tests and inspections.
- C. Prepare test and inspection reports.

3.5 ADJUSTING

- A. Occupancy Adjustments: When requested within a 12-month period from date of Substantial Completion, provide on-site assistance in adjusting sensors to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.
 - 1. For occupancy and motion sensors, verify operation at outer limits of detector range. Set time delay to suit Owner's operations.

3.6 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain lighting control devices.
- B. Coordinate demonstration of products specified in this Section with demonstration requirements for low-voltage, programmable lighting control system specified in Division 26 Section "Network Lighting Controls."
- C. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain lighting control devices. Refer to "Demonstration and Training requirements.

END OF SECTION 26 09 23

SECTION 26 09 43 – NETWORK LIGHTING CONTROLS

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, apply to this Section.

1.2 SUMMARY

- A. Section Includes: Lighting control panels using mechanically held relays for switching.
- B. Section Includes: Networked lighting control panels using control-voltage relays for switching and that are interoperable with BAS.

1.3 DEFINITIONS

- A. BAS: Building Automation System.
- B. IP: Internet Protocol.
- C. Monitoring: Acquisition, processing, communication, and display of equipment status data, metered electrical parameter values, power quality evaluation data, event and alarm signals, tabulated reports, and event logs.
- D. PC: Personal Computer; sometimes plural as “PCs.”
- E. RS-485: A serial network protocol, similar to RS-232, complying with TIA-485-A.

1.4 REFERENCES

- A. Comply with the latest versions of the following standards:
 1. Code of Federal Regulations (CFR)
 2. National Fire Protection Association (NFPA)
 3. Nationally Recognized Testing Laboratories (NRTL)
 4. National Electrical Manufacturers Association (NEMA)
 5. Underwriters Laboratories (UL)
 6. National Electrical Testing Association (NETA)
 7. American Society of Heating, Refrigerating and Air-Conditioning Engineers Standards (ASHRAE)
 8. National Electrical Contractors Association (NECA)

1.5 SUBMITTALS

- A. Product Data: For each type of product.
 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for control modules, power distribution components, relays, manual switches and plates, and conductors and cables.
 2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

- B. Shop Drawings: For each relay panel and related equipment.
 - 1. Include dimensioned plans, elevations, sections, and details. Show tabulations of installed devices, equipment features, and ratings.
 - 2. Detail enclosure types and details for types other than NEMA 250, Type 1.
 - 3. Detail wiring partition configuration, current, and voltage ratings.
 - 4. Short-circuit current rating of relays.
 - 5. Include diagrams for power, signal, and control wiring.
 - 6. Block Diagram: Show interconnections between components specified in this Section and devices furnished with power distribution system components. Indicate data communication paths and identify networks, data buses, data gateways, concentrators, and other devices to be used. Describe characteristics of network and other data communication lines.
- C. Coordination Drawings: Submit evidence that lighting controls are compatible with connected monitoring and control devices and systems specified in other Sections.
 - 1. Show interconnecting signal and control wiring, and interface devices that prove compatibility of inputs and outputs.
 - 2. For networked controls, list network protocols and provide statements from manufacturers that input and output devices comply with interoperability requirements of the network protocol.
- D. Qualification Data: For testing agency.
- E. Field quality-control reports.
- F. Software licenses and upgrades required by and installed for operation and programming of digital and analog devices.
- G. Sample Warranty: For manufacturer's special warranty.
- H. Operation and Maintenance Data: For lighting controls to include in emergency, operation, and maintenance manuals.
- I. Software and Firmware Operational Documentation:
 - 1. Software operating and upgrade manuals.
 - 2. Program Software Backup: On magnetic media or compact disk, complete with data files.
 - 3. Device address list.
 - 4. Printout of software application and graphic screens.

1.6 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Member Company of NETA or an NRTL.
 - 1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

PART 2 – PRODUCTS

2.1 SYSTEM DESCRIPTION

- A. Input signal from field-mounted manual switches, or digital signal sources, shall open or close one or more lighting control relays in the lighting control panels. Any combination of inputs shall be programmable to any number of control relays.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. Comply with 47 CFR, Subparts A and B, for Class A digital devices.
- D. Comply with UL 916.

2.2 PERFORMANCE REQUIREMENTS

- A. BAS Interface: Provide hardware and software to enable the BAS to monitor, control, display, and record data for use in processing reports.
 - 1. Hardwired Points:
 - a. Monitoring: On-off status.
 - b. Control: On-off operation.
 - 2. Communication Interface: Comply with ASHRAE 135. The communication interface shall enable the BAS operator to remotely control and monitor lighting from a BAS operator workstation. Control features and monitoring points displayed locally at lighting panel shall be available through the BAS.

2.3 LIGHTING CONTROL RELAY PANELS

- A. Manufacturer: Subject to compliance with requirements, provide or comparable product by one of the following:
 - 1. Lutron Electronics Co., Inc.
 - 2. Acuity Brands, Inc.; Lighting Control & Design, Inc.
 - 3. General Electric Company; GE Consumer & Industrial - Electrical Distribution
 - 4. Leviton Mfg. Company Inc.
 - 5. Lightolier Controls; a Philips Group brand
 - 6. Siemens Energy & Automation, Inc.
 - 7. Touch-Plate Technologies
 - 8. Watt Stopper; a Legrand Group brand
 - 9. Or approved equal.
- B. Description: Standalone lighting control panel using mechanically latched relays to control lighting and appliances.
- C. Lighting Control Panel:
 - 1. A single enclosure with incoming lighting branch circuits, control circuits, switching relays, and on-board timing and control unit.
 - 2. A vertical barrier separating branch circuits from control wiring.
- D. Control Unit: Contain the power supply and electronic control for operating and monitoring individual relays.
 - 1. Timing Unit:

- a. 365-day calendar, astronomical clock, and automatic adjustments for daylight savings and leap year.
 - b. Clock configurable for 12-hour (am/pm) or 24-hour format.
 - c. Four independent schedules, each having 24 time periods.
 - d. Schedule periods settable to the minute.
 - e. Day-of-week, day-of-month, day-of-year with one-time or repeating capability.
 - f. 10 special date periods.
- E. Relays: Electrically operated, mechanically held single-pole switch, rated at 20 A at 120V tungsten, 30A at 277V ballast, 1.5 HP at 120V, and 3 HP at 277V. Short-circuit current rating shall be not less than 14 kA. Control shall be three-wire, 24-V ac.
- F. Power Supply: NFPA 70, Class 2, sized for connected equipment, plus 20 percent spare capacity. Powered from a dedicated branch circuit of the panel board that supplies power to the line side of the relays, sized to provide control power for the local panel-mounted relays, bus system, low-voltage inputs, field-installed occupancy sensors, and photo sensors.

2.4 MANUAL SWITCHES AND PLATES

- A. Push-Button Switches: Modular, momentary contact, three wire, for operating one or more relays and to override automatic controls.
- 1. Match color and style specified in Division 26 sections pertaining to "Wiring Devices."
 - 2. Integral LED pilot light to indicate when circuit is on.
 - 3. Internal LED locator light to illuminate when circuit is off.
- B. Wall Plates: Single and multi-gang plates as specified in Division 26 sections pertaining to "Wiring Devices."
- C. Legend: Engraved or permanently silk-screened on wall plate where indicated. Use designations indicated on Drawings.

2.5 FIELD-MOUNTED SIGNAL SOURCES

- A. Daylight Harvesting Switching Controls: Comply with Division 26 sections pertaining to "Lighting Control Devices." Control power may be taken from the lighting control panel, and signal shall be compatible with the relays.
- B. Indoor Occupancy Sensors and Extreme-Temperature Occupancy Sensors: Comply with Section 26 09 23 "Lighting Control Devices." Control power may be taken from the lighting control panel, and signal shall be compatible with the relays.

2.6 CONDUCTORS AND CABLES

- A. Power Wiring to Supply Side of Class 2 Power Source: Not smaller than No. 12 AWG, complying with Division 26 sections pertaining to "Low-Voltage Electrical Power Conductors and Cables."
- B. Classes 2 and 3 Control Cables: Multi-conductor cable with copper conductors not smaller than No. 18 AWG, complying with Division 26 sections pertaining to "Low-Voltage Electrical Power Conductors and Cables."

- C. Class 1 Control Cables: Multi-conductor cable with copper conductors not smaller than No. 14 AWG, complying with Division 26 sections pertaining to "Low-Voltage Electrical Power Conductors and Cables."
- D. Digital and Multiplexed Signal Cables: Unshielded, twisted-pair cable with copper conductors, complying with TIA/EIA-568-B.2, Category 6 for horizontal copper cable and with Division 27 sections pertaining to "Communications Horizontal Cabling."

PART 3 – EXECUTION

3.1 EXAMINATION

- A. Receive, inspect, handle, and store panels according to NECA 407.
- B. Examine panels before installation. Reject panels that are damaged or rusted or have been subjected to water saturation.
- C. Examine elements and surfaces to receive panels for compliance with installation tolerances and other conditions affecting performance of the Work.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 WIRING INSTALLATION

- A. Comply with NECA 1.
- B. Wiring Method: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters and except in accessible ceiling spaces and in gypsum board partitions where unenclosed wiring method may be used. Conceal raceway and cables except in unfinished spaces.
 - 1. Install plenum cable in environmental air spaces, including plenum ceilings.
 - 2. Comply with requirements for cable trays specified in Division 26 sections pertaining to "Cable Trays for Electrical Systems."
 - 3. Comply with requirements for raceways and boxes specified in Division 26 sections pertaining to "Raceways and Boxes for Electrical Systems."
- C. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.
- D. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

3.3 PANEL INSTALLATION

- A. Comply with NECA 1.
- B. Install panels and accessories according to NECA 407.
- C. Comply with mounting and anchoring requirements specified in Division 26 sections pertaining to "Vibration and Seismic Controls for Electrical Systems."

- D. Mount top of trim 90 inches above finished floor unless otherwise indicated.
- E. Mount panel cabinet plumb and rigid without distortion of box.
- F. Install filler plates in unused spaces.

3.4 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Division 26 sections pertaining to "Identification for Electrical Systems."
- B. Create a directory to indicate loads served by each relay; incorporate Owner's final room designations. Obtain approval before installing. Use a PC or typewriter to create directory; handwritten directories are unacceptable.
- C. Lighting Control Panel Nameplates: Label each panel with a nameplate complying with requirements for identification specified in Division 26 sections pertaining to "Identification for Electrical Systems."

3.5 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
 - 1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
 - 2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
- D. Acceptance Testing Preparation:
 - 1. Test continuity of each circuit.
- E. Lighting control panel will be considered defective if it does not pass tests and inspections.
- F. Prepare test and inspection reports, including a certified report that identifies lighting control panels and describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations made after remedial action.

3.6 STARTUP SERVICE

- A. Perform startup service.
 - 1. Complete installation and startup checks according to manufacturer's written instructions.
 - 2. Confirm correct communications wiring, initiate communications between panels, and program the lighting control system according to approved configuration schedules, time- of-day schedules, and input override assignments.

3.7 ADJUSTING

- A. Occupancy Adjustments: When requested allow one extra operational setting of sensors within a 12-month period from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.8 SOFTWARE SERVICE AGREEMENT

- A. Technical Support: Beginning at Substantial Completion, service agreement shall include software support for 2 years.
- B. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system and new or revised licenses for using software.
 - 1. Upgrade Notice: At least 30 days to allow Owner to schedule and access the system and to upgrade computer equipment if necessary.

3.9 TRAINING

- A. Train Owner's maintenance personnel to adjust, operate, and maintain the control unit and operator interface.
- B. Provide actual software-based and hands-on training to a minimum of three (3) Airport personnel in the programming, operation and maintenance of Network Lighting Control System.

END OF SECTION 26 09 43

SECTION 26 50 00 – LIGHTING

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, apply to this Section.

1.2 SUMMARY

- A. The following standards and guidelines are based on the premise that the lighting design and engineering efforts support the client’s overall project vision in coordination with the architect and interior designer.
- B. Should an element of lighting design practice not be specifically identified within this guideline report, it shall be the consultant’s responsibility to engage the client and design team in detailed design and technical discussions in the interest of ongoing evolution of these criteria as new practices and technology evolve.
- C. The lighting designer’s and engineer’s documents shall work in concert and in balance with the San Francisco International Airport’s expectations of realizing a Net Zero energy facility and implementing comprehensive REACH strategy programs.
- D. All lighting and engineering design and specifications must be in accordance with all applicable California Title 24 Building Energy Efficiency Standards, National Building Code, American National Standards Institute (ANSI) and California Energy Commission (CEC). TSA Requirements, as well as prevailing Health Code and Life Safety requirements.

1.3 DEFINITIONS

Color Rendering Index (CRI):	A rating index typically from 0 → 100 used to represent how well a light source renders the colors of objects that it illuminates to its true hue.
Foot-candle (FC):	A unit of illuminance produced by a source of one candle at a distance of one foot per square foot.
Kelvin Temperature (K):	A measurement that indicates the hue of a specific type of light source
LED:	Light Emitting Diode
Lamp Lumen Depreciation (LLD):	A multiplying factor used typically in lighting calculation studies to predict the depreciation in light output for a specific light source over a defined period of time.
Light Loss Factor (LFF):	A multiplying factor which light output can be adjusted by due to environmental impacts and/or product degradation for lighting calculation studies.
Lumens:	Raw light output.
MacAdam Ellipse:	A metric for expressing the extent of color difference within a batch of LEDs.

- A. Provide a complete lighting system including fixtures, lamps, bases, hangers, reflectors, glassware, lens, ballasts, driver, conduit, connectors, supports and all other auxiliary Provisions: Applicable provisions of Section 26 05 00: General Electrical Requirement become a part of this Section as if repeated herein.
- B. Work included equipment.
- C. Fixtures should be wired, assembled and ready for operation.
- D. Underwriters Laboratories (UL) listed for application intended.
- E. Provide lighting equipment as specified in the fixture schedule or approved equal. Coordinate fixture with ceiling type prior to ordering.

1.4 SPECIAL REQUIREMENTS AND REFERENCES

- A. Illuminating Engineering Society of North America (IESNA) Tenth Edition
 - 1. Section 13.8 under *"Life and Lumen Maintenance"*
 - 2. Section 22.2 *"Common Application Illuminance Recommendations"*
 - 3. Section 36 *"Lighting for Transport"*
 - 4. Section 36.4 through 36.11, Table 36.2 *"Transport Illuminance Recommendations"*
- B. Illuminating Engineering Society of North America (IESNA) IES RP-20-14 *"Lighting for Parking Facilities"*
- C. TSA 2016 Checkpoint Design Guide CDG Rev 6.1
 - 1. Section 3-3.8 *"Lighting Requirements"*
- D. Exit Signs. The installation and design of exit sign and emergency lighting fixtures shall meet the requirements of Federal, State and local codes.

1.5 SUBMITTALS

- A. Provide submittals for the following:
 - 1. Fixtures
 - 2. Exit signs/ Emergency lighting units
 - 3. Ballasts, Drivers – dimming percentage and type
 - 4. Lamps
 - 5. Luminaire mounting
 - 6. Luminaire accessories
 - 7. Lighting Calculations per Category / Area
 - a. Levels
 - b. Ratios (Average to Minimum)
 - c. Lamp Lumen Depreciation (LLD)
 - 8. Luminaire Specification Evaluation
 - a. Kelvin Temperature
 - b. Color Rendering Index (CRI)
 - c. MacAdam Ellipse

- d. LED chip manufacture
 - e. Color test confirmation
9. Zoning and Lighting Control Matrix Evaluation
 10. Sequence of Operations
 11. Energy Saving Evaluation – Daylight and Occupancy Sensors

1.6 ILLUMINANCE CRITERIA

A. Photometric Layout:

1. Photometric studies shall be prepared for each major project area and calculated independently. Each area of photometric study shall include a statistical report summary. General area lighting and lighting intended for task work shall be summarized separately. Photometric studies shall be circulated to permit the client and the design team to discuss, in detail, the light level averages and minimums for individual areas relative to the hierarchy of light levels in the overall design.
2. Photometric calculations shall be based on full radiosity analysis with finished surface reflectance set as close as possible to percentages specified by the architect and interior designer. The calculation model used in project Photometric calculations shall include the major architectural, structural, and interior massing elements located within each project area. Photometric calculation studies shall confirm that the amount of illumination intended for finished surfaces is not obstructed by major massing elements.
3. Photometric calculations are to be measured at the relevant working plane (WP) elevation (typically 30" - 36") above the finish floor (unless noted). Exceptions are at egress paths of travel, stairs, ramps, escalators, and entrances and exiting of moving sidewalks, where calculations are to be measured at finish floor level (unless noted).
4. All averages to be based from average to minimum foot-candle ratios in accordance with Illuminating Engineering Society of North America (IESNA) guidelines. Reference Section 36, Table 36.2 of the IESNA Handbook 10th Edition.
5. All security areas' lighting levels are to be in accordance with the TSA requirements. Reference TSA 2016 Checkpoint Design Guide CDG Rev 6.1 Section 3-3.8 "*Lighting Requirements.*"
6. Photometric studies of food service kitchen, preparation areas, and bars shall confirm light levels meet state and local health code mandated light levels and ratios.
7. For Exterior Lighting, Back-light, Up-light, and Glare, (BUG) Rating System shall be utilized in compliance with the local code requirements.

B. Recommended Illumination Level per Category:

1. General Terminal Circulation: 10 foot-candles (FC) average (3.1 ratio of Average to Minimum, unless otherwise noted)
 - a. Check-in
 - b. Concourse
 - c. Arrivals to Baggage Claim
 - d. Transitions
 - e. Restroom (2.1 ratio of Average to Minimum)

- f. Jet Way/Jet Bridge/Fixed Link
- 2. Vertical Circulation: 10 FC average (2.1 ratio of Average to Minimum)
 - a. Stairs
 - b. Escalator
- 3. Portals: 15 FC average (3.1 ratio of Average to Minimum, unless otherwise noted)
 - a. Major interior / exterior entrances
 - b. Club Entrances
 - c. Gate entries / exits to and from airplane bridges / exterior loading
 - d. Restroom entrances
 - e. Restroom stalls and urinals
 - f. Secure enclosed waiting area entrances
- 4. Security Areas: 30 FC minimum per TSA requirements.
 - a. Baggage scanning and search
 - b. Scanning and screening areas
 - c. Gate ticket scanners
 - d. Any areas requiring identification review and confirmation
- 5. TSA Areas:
 - a. Security Checkpoints: in location where, critical decisions are made based on visual evaluation (e.g. at bag inspection tables or the TDC podium), a light level of 30 FC minimum is required. A light level of 50 FC average is recommended at task surfaces (2.1 ratio of Average to Minimum)
- 6. Task Areas: 10 FC average (3.1 ratio of Average to Minimum, unless otherwise noted)
 - a. Check-in Desk
 - b. Information Desk
 - c. Gate Check-in Counter
 - d. Restroom Vanity (2.1 ratio of Average to Minimum)
 - e. Baggage Claim Carousel
- 7. Collection Areas: 15 FC average (3.1 ratio of Average to Minimum)
 - a. Holding Areas (Gate Lounges)
 - b. Major nodes within circulation
 - c. Recompose

8. Concessions (Food and Beverage / Retail)

Concessions entrances:	30 FC average – (3.1 ratio of Average to Minimum)
Food Courts:	25 FC average – (3.1 ratio of Average to Minimum)

9. Back of House:

General Circulation:	5 FC average – (2.1 ratio of Average to Minimum)
Employee Lounge:	15 FC average – (2.1 ratio of Average to Minimum)
Restrooms General:	5 FC average – (2.1 ratio of Average to Minimum)
Restrooms Vanities and Stalls/Urinals:	15 FC average – (2.1 ratio of Average to Minimum)
Baggage Claim (manual handling) areas:	30 FC average – (2.1 ratio of Average to Minimum)

10. Terminal Landside (Curbside):

Arrivals and Departures:	10 FC average – (2.1 ratio of Average to Minimum)
Curbs:	4 FC average – (2.1 ratio of Average to Minimum)
Internal Roadways:	1.5 FC average – (3.1 ratio of Average to Minimum)
Crosswalks (Pedestrian pathways to Building entries):	3 FC average – (3.1 ratio of Average to Minimum)

11. Parking Lots (Security Conditions):

Drive Aisles and Parking Areas:	3 FC average (4:1 ratio of Average to Minimum)
Transaction Areas (Pedestrian & Vehicle):	6 FC average (4:1 ratio of Average to Minimum)
Sidewalks around Parking lot:	6 FC average (4:1 ratio of Average to Minimum)
Entrances and Exits:	6 FC average (4:1 ratio of Average to Minimum)
All Vertical illumination to be ½ FC measured at 5 feet AFG (Above Finished Grade).	

12. Parking Structures Security Conditions):

Entrances and Exits:	50 FC average during the day 10 FC average at night (4:1 ratio of Average to Minimum)
Gathering Areas (Elevators and Stairs):	10 FC average at a 30' radius from the center of the gathering point (4:1 ratio of Average to Minimum)
Parking Stalls and Drive Aisles:	6 FC average – (4:1 ratio of Average to Minimum)
Ramps:	12 FC average – (4:1 ratio of Average to Minimum)
All Vertical illumination to be ½ FC average of the above Horizontal FC levels measured at 5 feet AFG (Above Finished Grade).	

C. Lamp Lumen Depreciation (LLD)

1. Standards for application of LLD shall follow IESNA guidelines as a basis for Indoor Lighting Design: "All light sources lose some ability to produce (light output) over their operating lives. "Most common for LED's is to employ a time at which they are estimated to produce 70% of initial lumens, a time known as L70." "A LLD of not greater than 0.70 should be employed for SSL (Solid State Lighting) products in applications where the quantity of light is a key design criterion." Reference Section 13.3 "Life and Lumen Maintenance" of the IESNA Handbook 10th Edition.
2. The recommended minimum standard for LLD per anticipated life over hours for all fixtures in Passenger areas shall be:
 - a. L70 at 50,000 (or more) hours. The corresponding LDD for the fixtures shall be set to 0.7 in lighting photometric studies prepared for the project.
3. In instances where specified fixtures are rated at L90 at 90,000 (or more) hours, the corresponding LDD for the fixtures shall be set to 0.9 in lighting photometric studies.

D. Additional Criteria:

1. When a specified luminaire is directed upward an additional 0.1LLF (Light Loss Factor) shall be added to account for dust and debris at the fixture.
2. The recommended LLD for Back of House fixtures is L90 at 90,000 (or more) hours.
3. Back of House fixture samples shall be provided for team review. Review of Back of House fixtures shall confirm the fixtures do not produce objectionable glare from direct view of the LEDs.
4. Photometric studies shall confirm recommended light levels in major project areas are achievable with an LLD rating of 0.7 applied to light fixtures. A LLD rating of 0.9 shall only be used in photometric studies of L90 at 90,000 hour rated fixtures.
5. It is not recommended to achieve recommended foot-candle levels through on-site dimming of light fixtures to levels at or below 50% brightness.

1.7 LIGHT SOURCE CRITERIA

A. Kelvin Temperature (K) and Color Rendering Index (CRI)

1. The Kelvin Temperature and CRI of light sources shall be consistent with the Kelvin and CRI of light sources utilized by the project design team in selecting the material and painted finishes for the interiors and exteriors of the project. Selection of lighting Kelvin Temperature and CRI shall support the project team's design objectives for the overall passenger experience.
 - a. Public Areas: 3500K at 90+CRI
 - b. Public Portals/Vestibules: 3500K at 90+CRI
 - c. Public Restroom Hospitality Areas (Vanity and Parlors): 3000K at 85+CRI
 - d. Concession (Food and Beverage): 3000K 85+CRI
 - e. Back of House Areas excluding Office Spaces and Breakrooms: 3500K at 80+ CRI
 - f. Back of House Office Spaces and Breakrooms: 3500K at 85+ CRI
 - g. Tenant Retail Areas: 3000K at 85+CRI, 3500K at 90+CRI, or 4000K at 90+CRI

B. MacAdam Ellipse:

1. Down lights: 1-Step → 3-Step
2. Wall Wash lighting: 1-Step or 2-Step
3. Accent Lighting: 1-Step → 3-Step
4. Track Head Fixtures: 1-Step → 3-Step
5. Linear slots with frosted lens: 1-Step → 3-Step
6. Cove lighting: 1-Step or 2-Step

C. LED Manufacturers

1. During the specification selection process, the specifier must clearly identify the LED chip manufacturers within the selected luminaires. This information will be critical in the color testing process with the design team and ownership.

D. Color Testing

1. The specifier shall coordinate samples of the specified luminaires for color testing efforts in correlation with approved material samples provided by the design team.
2. This effort shall confirm the Kelvin Temperature, CRI, MacAdam Ellipse, LED Chips and the selected finishes/materials for the design team and ownership concurrence.

1.8 LIGHTING CONTROL CRITERIA:

A. Lighting Control Zones

1. The Lighting Designer and Electrical Engineer shall provide lighting control zoning of all specified luminaires. Control zones shall be planned to allow flexibility in adjusting light levels in each space, during different times of day, and during occupied and unoccupied periods.
2. Where different types of project areas overlap (e.g. Circulation, and Guest Lounges) the lighting for each type of area shall be zoned separately. Additional separate control zones shall be provided for the different types of lighting (e.g. direct downlighting, indirect downlighting, cove lighting, task surface lighting, artwork or featured accent lighting,) located within each project area. Separate control zones should be provided for lighting located at the perimeter areas of project spaces.
3. Lighting control zoning shall be planned to meet the daylighting and skylighting requirements of Title 24 and the objectives of San Francisco International Airport's Shareholders and Operations team.
4. When planning lighting control zones, consideration should be given to using dimming drivers paired with control components in a system designed to provide dimming control of individual light fixtures.

B. Lighting Control Matrix

1. The Lighting Designer and Electrical Engineer shall provide a Lighting Control Matrix document providing preliminary intended light levels for each space. The Lighting Control Matrix document shall be coordinated with the effort of the lighting control system manufacturer in preparing Lighting Sequence of Operations documentation.
2. The Lighting Control Matrix shall organize Light levels into major lighting presets for each space:
 - a. Morning
 - b. Day
 - c. Evening
 - d. Night
 - e. Unoccupied
 - f. Daylight harvesting
 - g. Clean-up
 - h. Emergency

C. Sequence of Operations

1. In coordination with San Francisco International Airport's Shareholders and Operations Team, the Lighting Designer and Electrical Engineer shall collaborate with the lighting control system manufacturer in creating a project-wide Sequence of Operations overview document charting the expected programming and daily operation of the lighting control system.

D. Luminaire Drivers/Power Supplies

1. Dimming percentage (e.g. 10%, 1%, <1%) shall be included and clearly identified in luminaire specifications for driver or power supply components.
2. Dimming type and wire count (e.g. 0-10v 4-wire, 3-wire control, Phase Dimming 2-wire) shall be included and clearly identified in luminaire specifications for driver or power supply components.

3. Luminaire dimming driver and power supply components are to be fully compatible with the project Lighting Control System. Luminaire drivers and power supplies shall operate free of flicker and strobing at all dimming percentages (e.g. 10%, 1%, <1%).
 4. Consideration should be given to using dimming drivers paired with control components in a system designed to provide dimming control of individual light fixtures.
- E. Lighting Control System Programming
1. The Lighting Control System Manufacturer and the Contractor are to allocate sufficient time and personnel resources to support careful initial lighting programming sessions, follow up team review sessions, and subsequent adjustment sessions. These sessions will be scheduled to program, review, and adjust preset light levels in each project area.
 2. The Lighting Control System Manufacturer and the Contractor shall provide sufficient labor and resources to fully support the requirements of the Airport's enhanced system commissioning schedule.
 3. Lighting Control System training, review, and adjustment sessions shall be provided by the Manufacturer and the Contractor to fully support the needs of the Airport's Operations team schedule.
 4. Initial light level setting shall rely on the Light Level recommendations given above for each type of area or task in the project which follow a consistent design hierarchy of illumination.
 5. Light level programming and adjustment sessions shall be tasked with balancing the light levels within each space to achieve visual harmony between differing types of light sources (e.g. direct general lighting, indirect general lighting, cove lighting, task lighting, artwork and featured accent lighting). Light level programming sessions shall be tasked with setting light levels to create and/or enhance elements of visual interest in the design of each space.
 6. Light level programming shall include efforts to review and set adequate illumination at the perimeter of large spaces, and at exits, entrances, and transition spaces.
 7. Adjustments to initial light level settings shall be made based on review team comments.
 8. Occupancy sensors shall be added throughout the public areas. Occupancy sensor programming shall result in a 20% minimum reduction in lighting energy consumption in all areas during unoccupied periods.

PART 2 – PRODUCTS

2.1 GENERAL

- A. Provide lighting fixtures, lamps, ballasts, drivers, and accessories complete and ready for operation. Furnish the fixtures as indicated on the drawings and as listed on the lighting fixture schedule. Material and equipment shall be in accordance with NEC, UL, ANSI, and as shown on the drawings and specified.
- B. Provide the Underwriters Laboratories or TTL labels on all lighting fixtures.
- C. Provide lighting fixtures in the finishes and colors as noted on the Drawings. Where fixtures finishes are noted to be "By Architect", include the available finishes when making fixture submittals, and obtain the architect's written selection of fixture finishes prior to ordering lighting fixtures.
- D. Verify in all cases, the lengths and quantity of fixtures necessary to achieve the indicated results.

- E. All lighting fixtures shall have published photometric tests conducted by Electrical Testing Laboratories. Make available the test results upon request. Testing shall include candlepower distribution curves, total fixture efficiency, brightness and shielding angles in longitudinal and transverse directions.

2.2 LED LUMINAIRES

- A. The illumination levels and uniformity shall match as noted above in Section 1.0 or otherwise noted.
- B. All interior luminaires shall be LED. Any other illumination source will require approval from Airport.
- C. Luminaires shall be certified by a National Recognized Testing Laboratory.
- D. LED driver voltage shall be universal 120-277V and power factor > 0.9.
- E. Luminaire shall be tested according to IES LM-79 and LM-80.

2.3 WARRANTY

- A. All interior LED lighting fixtures shall provide a minimum warranty of 5 year including LED drive and all LED components.

PART 3 – EXECUTION

3.1 INSTALLATION

A. GENERAL

1. Install fixtures in straight, true lines and without visible gaps between fixtures and building surfaces and between fixtures in continuous rows. For linear wall mounted fixtures, ensure that the wall surface is finished flat, straight, and free of imperfections prior to mounting the fixtures. Replace or repair lighting fixture installations that are out of plumb or that have obvious gaps or misalignment.
2. Provide fixtures with the appropriate trim frames, flanges, canopies, and finish accessories to accommodate the ceiling conditions. Prior to ordering fixtures, and throughout the Project, verify the exact ceiling types, finishes, and thicknesses and coordinate the fixture installation therewith.
3. Refer to the Drawings, particularly the architectural elevations and reflected ceiling plans, in determining the exact mounting location and height of lighting fixtures. For wall mounted or suspended fixtures that do not have the mounting heights clearly indicated, contact the Architect for clarification prior to ordering pendants and installing the fixtures.
4. Align, mount, and level the luminaires uniformly.

B. AUDIBILITY

1. Fixtures shall be free from any undesirable hum, vibration, or noise. Provide lighting equipment suitable for the intended ambient sound levels. Where necessary to meet these criteria, provide additional means of sound deadening, whether or not specifically indicated. Fixtures that are found to be unsatisfactory in the opinion of the Airport shall be removed and replaced.

C. SUPPORTS AND BLOCKING

1. Provide hangers, suspension cables, and blocking for lighting fixtures that will provide support independent of suspended ceilings, ceiling or wall surfaces, and electrical outlet boxes. Exception: Fixtures less than 12" in all dimensions and weighing less than six pounds may be permitted to be supported from the electrical outlet box if the box itself is independently supported by blocking or hangars.
2. Install luminaires in accordance with manufacturer's instructions complete with lamps ready for operations as indicated.

D. OBSTRUCTIONS

1. Verify throughout the Project that mounting locations and suspension systems remain free of obstructions. Suspended or pendant mounted fixtures must be free to swing 45 degrees in all directions without hitting obstructions or other fixtures. Provide seismic rated swivel ball hangars for pendant mounted lighting fixtures to achieve the proper swing.
2. Avoid interference with and provide sufficient clearance for equipment. Where an indicated position conflicts with other equipment, change the location of the luminaires by the minimum distance necessary.

E. CLEANING AND ADJUSTING

1. Clean fixtures internally and externally after installation. Use methods and materials recommended by manufacturer.
2. Adjust amiable fixtures to provide required light intensities.
3. Clean and remove dirt and debris from enclosure.
4. Clean photometric control surfaces as recommends by manufacturer.
5. Clean finished and touch up damage. Provide final touchup painting to repair fixture finishes which are nicked or marred during installation. Obtain the paint from the fixture manufacturer. All fixtures shall be clean, and lamps shall be operable at time of acceptance.

F. GROUNDING

1. All conduits and utilizations equipment shall be permanently and effectively grounded in accordance with the latest rules of the National Electrical Code, the California State Safety Orders, and the Airport rules and regulations.

G. FINAL TEST

1. The Electrical contractor shall test in the presence of a representative of the Airport contract manager all work done on this project function as intended. This includes, but not limited to, a complete on-site testing of lighting control system's functionality. All defects or omissions in the work must be satisfactorily corrected before acceptance of the work.

H. PROTECTION OF FINISHED WORK

1. Replace and re-lamp luminaires which have failed at substantial completion at no additional cost to the Airport.

END OF SECTION 26 50 00

SECTION 26 56 00 – EXTERIOR LIGHTING

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, apply to this Section.

1.2 DESCRIPTION

- A. Provisions: Applicable provisions of Division 26 sections pertaining to General Electrical Requirements become a part of this Section as if repeated herein.
- B. Work Included: Furnish and install luminaire with concrete foundation, area lights, floodlights, and associated wiring, pull boxes and all other auxiliary equipment as shown on drawings. Furnish and install light fixtures at location shown on the drawings.

1.3 SPECIAL REQUIREMENTS

- A. All lighting systems and equipment shall be installed and tested in full accordance with the provisions of the California Energy Commission Title 24, NEC, and IESNA.
- B. Photometric plan shall be submitted and approved by Airport. Photometric plan shall include the followings:
 - 1. Floor plan or site plan shows location, type, model, and mounting height of all luminaires and photometric in foot-candle output of all proposed luminaires.
 - 2. Table shows the average, minimum and maximum foot-candles, average to minimum ratio, and maximum to minimum ratio.
 - 3. Photometric plan shall be stamped and signed by a licensed professional electrical engineer.

1.4 SUBMITTALS

- A. As per Division 1 sections pertaining to Submittals.
- B. Provide submittals for the following:
 - 1. Luminaire
 - 2. Pole
 - 3. Lamps

1.5 RECOMMENDED ILLUMINATION LEVELS

- A. Exterior:
 - 1. Arrival (Exterior) = 5-10FC
 - 2. Parking Lot = per IESNA recommendation

1.6 QUALITY ASSURANCE

- A. As per Division 1 sections pertaining to Quality Control.

PART 2 – PRODUCTS

- A. POLE/LUMINAIRES
- B. Pole foundation shall be as shown on drawings. All material shall be in accordance with NEC, UL, ANSI and as shown on the drawings and specified.
- C. Pole shall be anchor base type with a mounting height as shown on drawings. The shaft shall be tapered steel fabricated from #11 Manufacturer's Standard Gauge steel. Pole shall be provided with a 3" x 5" opening hand-hole complete with reinforced frame and cover. Pole manufacturer shall be the same as the luminaire, unless otherwise noted.
- D. Luminaire shall be light emitting diodes unit containing all its electrical components within its housing and shall be complete with lamp and external shield.
- E. In-line fuse and fuse holder shall be located within the pole and accessible thru the hand-hole. Fuse holder shall be waterproof with an "L" or "Y" type receptacle. Fuse shall be 15A rated.
- F. All exterior lighting fixtures shall be controlled by photo sensor, unless otherwise noted.
- G. All exterior lighting fixtures mounted under 24 feet shall be controlled by a photo sensor and motion sensor, unless otherwise noted.

2.2 LED LUMINAIRES

- A. The illumination levels and uniformity shall meet the recommendations of the latest edition of the IESNA Lighting Handbook.
- B. All exterior luminaires shall be LED. Any other illumination source will require approval from Airport.
- C. Luminaires shall be certified by a National Recognized Testing Laboratory.
- D. Correlated Color Temperature (CCT) shall be 3,000K and greater and approved by Airport.
- E. The color rendering index (CRI) shall be 90 or better per IES LM-79-08.
- F. Minimum 50,000 hours rated life for LED modules, and minimum 50,000 hours rated for LED driver.
- G. Luminaire shall maintain 70% lumen output for a minimum of 50,000 hours.
- H. LED driver voltage shall be universal 120-277V, and power factor > 0.9.
- I. Luminaire shall be tested according to IES LM-79 and LM-80.
- J. All exterior luminaries shall have full cut-off per IESNA standard, and the maximum lighting level 10 ft. past the edge of the project area shall be less than 0.1 foot-candle.

2.3 WARRANTY

- A. All exterior LED lighting fixtures shall provide a minimum warranty of 5 year including LED drive and all LED components.

2.4 RECOMMENDED MANUFACTURERS

- A. Cree
- B. approved equal.

PART 3 – EXECUTION

3.1 INSTALLATION

- A. All fixtures shall be clean and lamps shall be operable at time of acceptance.
- B. Install luminaries in accordance with the NEC, as shown on the drawings and in accordance with manufacturer's instructions complete with lamps ready for operation as indicated.
- C. Align, mount, and level the luminaries uniformly.
- D. Avoid interference with and provide sufficient clearance for equipment. Where an indicated position conflicts with other equipment, change the location of the luminaries by the minimum distance necessary.

3.2 FIELD QUALITY CONTROL

- A. As per Division 1 sections pertaining to Quality Control and Division 1 sections pertaining to Contract Closeout.

END OF SECTION 26 56 00

APPENDIX A – MASTER LIST OF MANUFACTURERS

This section provides the Master List of Manufacturers approved for Lighting approved by SFO, organized by section and subsection. Contractors are responsible for any extra cost incurred when evaluating products by manufacturers that are not listed are approved equals.

26 09 23 – LIGHTING CONTROL DEVICES

TIME SWITCHES

1. Cooper Industries, Inc.
2. Intermatic, Inc.
3. Invensys Controls
4. Leviton Mfg. Company Inc.
5. NSi Industries LLC; TORK Products.
6. Tyco Electronics; ALR Brand
7. Lightolier
8. Or approved equal

INDOOR OCCUPANCY SENSORS

1. Cooper Industries, Inc.
2. Hubbell Building Automation, Inc.
3. Hubbell Lighting
4. Leviton Mfg. Company Inc.
5. Lightolier Controls
6. Lithonia Lighting; Acuity Lighting Group, Inc.
7. Lutron Electronics Co., Inc.
8. Novitas, Inc.
9. Sensor Switch, Inc.
10. RAB Lighting, Inc.
11. Sensor Switch, Inc.
12. Square D; a brand of Schneider Electric
13. TORK
14. Watt Stopper; a Legrand Group brand
15. Or approved equal

INDOOR PHOTOELECTRIC SWITCHES

1. Allen-Bradley/Rockwell Automation
2. Area Lighting Research, Inc.; Tyco Electronics
3. Eaton Electrical Inc; Cutler-Hammer Products
4. Grasslin Controls Corporation; a GE Industrial Systems Company
5. Intermatic, Inc.
6. Lithonia Lighting; Acuity Lighting Group, Inc.
7. MicroLite Lighting Control Stems
8. Novitas, Inc.
9. Paragon Electric Co.; Invensys Climate Controls
10. Square D; Schneider Electric
11. TORK
12. Touch-Plate, Inc.
13. Watt Stopper; a Legrand Group brand

14. Or approved equal

OUTDOOR PHOTOELECTRIC SWITCHES

1. Area Lighting Research, Inc.; Tyco Electronics
2. Grasslin Controls Corporation; a GE Industrial Systems Company
3. Intermatic, Inc.
4. Lithonia Lighting; Acuity Lighting Group, Inc.
5. Novitas, Inc.
6. Paragon Electric Co.; Invensys Climate Controls
7. Square D; Schneider Electric
8. TORK
9. Touch-Plate, Inc.
10. Watt Stopper; a Legrand Group brand
11. Or approved equal

SWITCHBOX-MOUNTED OCCUPANCY SENSORS

1. Bryant Electric; a Hubbell company
2. Cooper Industries, Inc.
3. Hubbell Building Automation, Inc.
4. Leviton Mfg. Company Inc.
5. Lightolier Controls
6. Lithonia Lighting; Acuity Lighting Group, Inc.
7. Lutron Electronics Co., Inc.
8. Sensor Switch, Inc.
9. Square D; a brand of Schneider Electric
10. Watt Stopper; a Legrand Group brand
11. Or approved equal

26 09 43 - NETWORK LIGHTING CONTROL

LIGHTING CONTROL RELAY PANELS

1. Acuity Brands, Inc.; Lighting Control & Design, Inc.
2. General Electric Company; GE Consumer & Industrial – Electrical Distribution
3. Leviton Mfg. Company Inc.
4. Lightolier Controls; a Philips Group brand
5. Siemens Energy & Automation, Inc.
6. Touch-Plate Technologies
7. WattStopper; a Legrand Group brand
8. Or approved equal

26 50 00 - LIGHTING

1. AFX
2. Aion
3. Bega
4. BK Lighting
5. Boca Flasher
6. Cooper Lighting
7. Elliptipar
8. Emergilite

9. Finelite
10. Fluxwerx
11. Green Creative
12. Kenall, Leotek
13. Lucifer
14. Meteor
15. Noribachi
16. Philips (Gardco, Lightolier, Stonco)
17. Phoenix
18. Q-Tran
19. RAB
20. TMS
21. Visionaire Lighting
22. Wila
23. Williams
24. Zumtobel
25. Lithonia
26. ILP
27. Metalux
28. Spectrum Lighting
29. Holophane
30. Or approved equal

26 56 00 - EXTERIOR LIGHTING

1. Cree
2. Or approved equal

APPENDIX B – SAMPLE SYSTEMS READINESS CHECKLISTS FOR COMMISSIONING OF LIGHTING SYSTEMS

CONTRACTOR’S SYSTEM READINESS CHECKLIST

System: Lighting Controls
Applicable Equipment: All New Lighting Control Panels
Instructions: Contractor shall submit a completed and signed copy of this checklist as an indication of compliance with all installation criteria specified in the Construction Documents.

Installation:

- Light fixtures and lighting controls have been fully installed.
- Proper sized breakers have been installed on each lighting circuit.
- Final wiring connections are complete.
- Wiring has been tagged with permanent labels per Construction Documents.
- Lighting fixtures, sensors and controls have been tagged with permanent labels per Construction Documents.
- There are no metal shavings inside panel enclosures.
- Junction boxes for control wiring are installed such that Class 2 wiring is not run in common with Class 1 wiring.
- Lighting levels have been measured and verified as appropriate for all zones. Daylight sensor control has been adjusted and tested for every zone.
- Occupancy sensor control has been adjusted and tested for every zone.
- Occupancy sensors have been located to minimize false signals or interference by obstructions.
- Ultrasonic occupancy sensors do not emit sound audible to occupants, if applicable.

Signed: _____ Date: _____ Company: _____

Control System Integration:

- Sensors and controls have been installed and verified operational.
- Lighting control timers are programmed for weekday, weekend, and holiday schedules and programming is documented for the owner if applicable.
- Occupant override time limit is set to no more than 2 hours.

Signed: _____ Date: _____ Company: _____

Functional Performance Test (FPT) Readiness:

- All contractor-submitted start-up and testing documentation has been completed and provided to the Commissioning Authority.
- Commissioning Authority notified of and witnessed testing per contract documents. Damaged factory finishes have been replaced, repaired or touched up.
- All known issues have been corrected or reported to the Commissioning Agent (CxA) and the systems are ready for the functional performance test phase of commissioning.
- EQUIPMENT READY FOR FUNCTIONAL TESTING – Contractor's pre-functional testing is complete; contractor has verified that functional performance testing (FPT) of the equipment and associated system demonstrates acceptable results as specified in FPT procedures.

Signed: _____ Date: _____ Company: _____

This checklist is not intended to represent all the requirements of the Construction Documents within this section. Completion of the items on this checklist does not release the Contractor from their contractual obligation to complete all the work as detailed within the entire specification section.

Signed: _____ Date: _____
Contractor's Commissioning Coordinator

Signed: _____ Date: _____
Commissioning Authority

Outstanding Issues: _____



San Francisco
International
Airport

Standards Adoption

The "Electrical – Lighting" Version 4.0, January 2019 standards were adopted by the Standards Committee on January 7, 2019, and are effective immediately.

Confirmed:

A handwritten signature in blue ink, appearing to be "G. Neumayr", is written over a horizontal line.

Geoffrey W. Neumayr, Standards Committee Chair