

PART III – CSU FACILITIES PLANNING, DESIGN AND CONSTRUCTION STANDARDS

DIVISION 26 – ELECTRICAL

Please also refer to “Part IV – REGULATORY REQUIREMENTS” for additional requirements.

Housing and Dining Facilities (HDS) has adopted amendments for all HDS facilities. Confirm applicable standards with Project Representative on a per Project basis. Refer to HDS amendments here – <https://housing.colostate.edu/about/construction/>.

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26 05 00 – COMMON WORK RESULTS FOR ELECTRICAL

PART 1 GENERAL

A. Codes and Standards:

1. The design and construction of all University Work shall comply with the current Office of the State Architect (OSA) adopted edition of the National Electric Code (NEC), International Energy Conservation Code (IECC), National Fire Protection Association (NFPA), Occupational Safety and Health Administration (OSHA) requirements in 29 CFR 1910, and Underwriters Laboratories (UL), as well as other codes and standards as listed in the introduction.
2. All electrical Work at Colorado State University (CSU) shall be performed by a State of Colorado Licensed Contractor or a Maintenance Electrician under the supervision of a Licensed Electrician.

B. Design:

1. Refer to Chapter 03 – Drawings and Design Requirements by Discipline.

C. Utilities:

1. For Transformers and Underground Distribution, refer to Division 33 – Utilities, 33 70 00 – Electrical Utilities.

D. Project Record Set Documents:

1. Record Drawings provided at completion of the Project must include exact routing details of concealed service and feeder conduits through a given site or building.
2. Provide dimensional ties to all underground or under slab on grade conduits 1” and larger trade size.

26 05 19 – LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 GENERAL

A. Conductor Sizing:

1. Branch circuits whose length from panel to first outlet exceeds 75’-0” for 120-volt circuits shall be next size larger, as recommended by the NEC for limiting voltage drop.
2. Branch circuits whose length from panel to first outlet exceeds 175’-0” for 277-volt circuits shall be next size larger, as recommended by the NEC for limiting voltage drop.
3. Minimum wire size for branch circuit conductors:
 - a. #12 AWG unless allowed otherwise by special permission from Facilities Management

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(FM).

4. Maximum wire size for service and feeder circuit conductors:
 - a. 500 kcmil Copper and 750 kcmil Aluminum, unless allowed otherwise by special permission from FM.

PART 2 PRODUCTS

A. Products Not Permitted:

1. Non–Metallic Cable (type NM or NM–C)
2. Metal–Clad Cable (type AC)
3. Through–the–wall boxes
4. Electrical Nonmetallic Tubing (ENT)

B. Wires and Cables:

1. Building wire and cable electrical power conductors shall be copper, insulated to 600 volts.
2. Metal-Clad Cable
 - a. Metal-Clad cable shall be type MC (not AC) with a full size ground wire.
 - i. Using the metal spiral wrap and/or drain wire as a ground is not permitted.
 - b. Metal-Clad cable may be used in the following applications.
 - i. 6'-0" or shorter for connections to motors and light fixtures.
 - ii. Routed from a junction box above each room, down the wall to an outlet.
 - iii. Branch circuit home-runs back to the panel must be in conduit.
3. Aluminum wire shall be allowed under the following conditions:
 - a. Aluminum wire can be used for service feeders from building service transformer to main distribution panel/center, and for feeders from main distribution panel/center to panel boards.
 - b. The aluminum wire shall be terminated in compression lugs or compression copper pigtail adapters.
 - i. A compression copper pigtail adaptor shall have the barrel designed of high strength aluminum alloy and the pigtail of high conductivity copper.
 - ii. Compression of lugs and pigtail adapters shall be with a Burndy type hydraulic compression tool or equal.
 - c. Aluminum wire shall be no smaller than #1 AWG and no larger than 750 kcmil.
 - i. If aluminum phase conductors are used, copper or aluminum grounding conductors shall be sized per NEC.

PART 3 EXECUTION

- A. Provide dedicated 120 volt hardwire connection and a Category 5 data drop for chilled water meter.
- B. Provide a Category 5 data drop for the steam meter.
- C. Branch Circuits and Color Coding:

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1. Conductor Insulation Color:

Conductor	120/208V 3 Phase	277/480V 3 Phase
Phase A	Black	Brown
Phase B	Red	Orange
Phase C	Blue	Yellow
Neutral	White	Gray
Ground	Green	Green

26 05 33 – RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS

PART 4 NOT USED

PART 5 PRODUCTS

A. Acceptable Products:

1. Wireway System:
 - a. Wiremold
 - b. Monosystems

PART 6 EXECUTION

A. Raceways:

1. Raceways shall be EMT, RMC, PVC for all concealed Work and for exposed Work where allowed.
2. For remodels, surface metal raceways shall be used in finished areas.
 - a. Exposed EMT and RMC are not allowed unless allowed otherwise by special permission from FM.
3. Minimum size of power conduits shall be 3/4" to allow for future installation of additional circuits.
 - a. Minimum size of lighting conduits shall be 1/2".
4. The minimum distance from the top of the ceiling grid to the low point of the pipe and/or conduit shall be 4" to 6" to facilitate replacement and/or removal of ceiling panels.

B. Raceway Supports:

1. Raceways shall not be supported from or attached to ceiling support wires.
2. Raceways or equipment shall not be suspended from steam, water, or other piping, or ductwork. Provide independent and secure support methods.
3. Care shall be taken to avoid placing raceways where they shall be subjected to excessive heat.
 - a. Locate all raceways a minimum of 12" from flues, steam lines, hot water lines, etc.

C. Underground Conduits:

1. Where PVC conduit is used in underground applications or concrete slab, rigid metal conduit (RMC) with PVC jacketing or tar coating or continuous strand epoxy fiberglass shall be used for riser bends and extensions to above grade or through-slab locations.

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- a. Where runs exceed 100'–0" in length between openings, RMC or strand–epoxy fiberglass elbows shall be used for change in direction of 45 degrees or more.
2. Grade mounted junction boxes are not permissible, unless allowed by special permission from FM.

D. Grounding:

1. Provide a separate, insulated equipment–grounding conductor in all lengths of branch circuit and feeder conduits.

26 05 53 – IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 NOT USED

PART 2 NOT USED

PART 3 APPLICATION

A. Equipment Identification:

1. Label all panels, disconnect switches, motor starters, control stations and special devices furnished under Division 26.
 - a. Labels shall be etched lamacoid (black with white core) with minimum 1/8" high letters and shall indicate area served and equipment served.
 - b. Labels shall be attached to equipment with sheet metal screws.
 - c. Labels for emergency equipment shall be the same as above except tags shall be red with white core.
2. Label all junction, splice and terminal boxes and device plates.
 - a. Labeling shall include panel name and circuit number.
 - b. Locate label on inside and outside of all device plates and covers.
 - c. Locate label on outside of junction boxes above ceilings or in unfinished areas.
 - d. Use label maker P–Touch or equal.
3. Cover plates of junction and pull boxes associated with raceways for Emergency Power Systems shall be painted red and labeled emergency.
4. Arc flash and shock hazard appropriated personnel protection PPE requirement warning tags shall be supplied for all equipment from the building service transformer to the branch panels, per Chapter 03 – Drawing and Design Requirements by Discipline.

26 09 23 – LIGHTING CONTROL DEVICES

PART 1 GENERAL

A. Context:

1. The intent of this section is to provide guidelines for lighting control performance, products and application on CSU's Fort Collins campuses.
2. The current market of Lighting Control Systems typically uses proprietary technology where different Manufacturer's products are not compatible with each other.
 - a. In lieu of an emerging lighting control standard, the designer is compelled to use these

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incompatible proprietary Systems.

3. Private offices, open office areas, conference rooms, laboratories, commercial kitchens, restrooms, classrooms, break rooms, custodial closets, storage rooms, electric rooms and mechanical rooms shall be controlled by stand-alone Systems. This shall make these Systems easier to maintain.
 - a. If there is a problem with the System, an electrician knows the problem is local and they shall not have to troubleshoot at the central building lighting control panel. This shall help eliminate bypassing the Control Systems.
4. Lobbies, foyers, corridors, hallways and stairwells shall be controlled by programmable building Control System. This shall simplify modifying operation schedules by programming from one central location.
5. Laboratories and commercial kitchens must have manual Lighting Control Systems because of the personal safety problems if the lights were to automatically shut off.
6. By standardizing on lighting controls, the usage, operation and maintenance of these Systems shall be greatly simplified.

B. Codes and Mandates:

1. All CSU projects shall have a lighting control design conforming to the current OSA adopted edition of the IECC and the guidelines outlined in this section.
2. Where requirements are not equal, the stricter requirement shall be used.
3. Projects pursuing LEED certification shall still conform to the guidelines of this section. If control technologies are being considered that are not referenced in this section, consult with FM Electrical Engineer for approval.

C. Network Compatibility:

1. In general, Lighting Control Systems shall not be networked to the Building Automation System (BAS). However, specified Manufacturers and their products shall be able to communicate using native BACnet for future connectivity.
2. Each panel shall be able to connect to the BAS network and shall allow programming of groups and viewing of status via the BAS software.
 - a. Small site lighting panels shall not be required to be BACnet compatible.

D. Document Requirements:

1. Electrical lighting plans shall include the following:
 - a. Distinct symbology to distinguish between different types of occupancy sensors.
 - i. Technology:
 - a) Infra-red vs ultrasonic vs. dual technology
 - ii. Application:
 - a) Corridor vs. large room vs. small room sensors
 - iii. Wiring:
 - a) Line voltage vs. low voltage vs wireless
 - iv. Location and orientation of each product
 - b. Typical wiring diagrams of lighting control devices in different applications.

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- c. Interconnection diagrams per major Subsystem showing proper wiring.
- d. A lighting control matrix to indicate lighting control performance.
- e. A switch schedule for all low voltage switches identifying what each switch controls.

2. Closeout Documents shall include:

- a. Lighting Controls Manual included in the O&M Manual.
- b. As-Built Record Drawings showing final installed condition.
- c. Any Lighting Control Drawings produced by the Lighting Controls Manufacturer or Vendor.
- d. A record of the schedules/settings programmed into the Lighting Controls System.
- e. The Lighting Controls Manufacturer shall certify in writing that the installed System meets all performance criteria.

E. Quality Assurance:

1. On new construction Projects, a lighting commissioning agent shall be utilized to ensure that the Lighting Control System is fully programmed and operating at its peak performance level.

PART 2 PRODUCTS

A. Performance Specifications:

1. In general, automatic lighting controls shall be vacancy sensor type, “Manual On, Auto Off”.
 - a. Typical auto off time is after 20 minutes of non-activity.
2. Automatic time switch control devices (typically used in common public areas such as lobbies and vestibules) shall include a manual override switching device in a readily accessible location, near the lights being controlled.
3. In general, automatic daylight harvesting controls shall utilize continuous dimming (versus stepped dimming) in normally occupied areas.
 - a. Transient areas such as hallways or stairwells may utilize step-dimming or continuous dimming.
4. Wireless Lighting Control Systems are still considered in their infancy. Wireless Systems may be used in small applications, where deemed appropriate due to building conditions (i.e. historic renovations).
 - a. Verify Wireless System and its operating frequency (Hz) are acceptable to the FM Electrical Engineer and CSU’s Academic Computing and Networking Services (ACNS) department.

B. Terms:

1. Building Control System:
 - a. A central Control System controlling a large number of lighting zones through the inputs such as occupancy sensors, time clock programming, manual wall stations, etc.
 - b. May consist of either one lighting control panel or a group of networked control panels.
2. Manual Control:
 - a. Control method requiring human intervention to regulate electric lighting, typically through a wall switch.
3. Occupancy Sensor:
 - a. A control device that detects the presence or absence of people and causes lighting to be regulated either on or off.

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4. Photo Sensor:
 - a. A control device that detects the presence of visible light and causes lighting to be regulated either on, off or dimmed.
5. Relay Control Panel:
 - a. Central time–based controller program using relays and schedules.
6. Room Controller:
 - a. Room based Control System using a single box to connect control devices to lighting zones, using Category 5 or twisted pair wiring.
7. Stand Alone Devices:
 - a. Wall or ceiling mounted occupancy sensor wired directly to lighting fixtures (through a power pack, as required), with no connectivity to devices outside of this room.

C. Products:

1. Lighting Control Network Cable:
 - a. Cable shall be plenum rated, violet in color with pre–terminated jacks tested by the factory.
2. Occupancy Sensors:
 - a. Occupancy sensors shall be capable of being converted to vacancy sensors. Auto on shall only be allowed per the IECC allowable exceptions.
 - b. Dual technology sensors shall be provided for all offices, conference rooms and other occupied Work spaces.
 - c. Passive infrared sensors may be used in common and storage areas, high–bay and exterior applications.
 - d. Ultrasonic–only sensors may be used in corridors, restrooms and private offices where coverage requirements are met.
 - e. Wall box sensors shall be installed in smaller rooms, so that the majority of the sensor coverage is confined to the room and shall provide 100% coverage of the room with minimal coverage of any adjacent corridor.
 - i. Minimize the number of devices required in a room for ease of maintenance.
 - f. All components shall be UL listed offer a five–year warranty and meet all state and local applicable code requirements.
 - g. Ceiling sensors shall be located a minimum of 4’–0” from mechanical vents.
 - h. Ceiling sensors shall be located a minimum of 2’–0” from walls.
 - i. Sensor timeout shall be set to 20 minutes, typical.
3. Photocells:
 - a. Exterior photocells shall be outdoor–rated and operate within temperature ranges from –20 °F to 90 °F and be sealed against humidity.
 - b. Twist lock photocells on pole lighting shall conform to ANSI C136.41 standards.
4. Room Controllers:
 - a. Acceptable Products:
 - i. Acuity Brands: nLight– Cat 5 wiring
 - ii. Wattstopper Digital Lighting Management– Cat 5 wiring
 - iii. Crestron
5. Wireless Systems:
 - a. In certain unique applications, wireless devices may be an appropriate solution.
 - b. Wireless Systems must be pre–approved by FM Engineering prior to installation.

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- c. Acceptable Products:
 - i. Acuity Brands: nLight Air
 - ii. Crestron
 - iii. Audacy

- 6. Panel-based Time Control Processor (brain of the Relay Panel):
 - a. The clock module shall provide astronomic capabilities, time delays, blink warning, daylight savings and holiday functions and shall include a back-up for the clock function and EEPROM for program retention.
 - b. Lighting control panels shall have remote monitoring and programming capabilities via BacNet IP protocol.
 - c. Provide data outlet at each lighting control panel for connection to CSU Utilities Server.
 - d. The clock shall include the following control scenarios:
 - i. Scheduled ON/OFF
 - ii. Manual ON/Scheduled OFF
 - iii. Manual ON/Auto Sweep OFF
 - iv. Astronomic ON/OFF (or Photo ON/OFF)
 - v. Astronomic and Schedule ON/OFF (or Photocell and Schedule ON/OFF)
 - e. Acceptable Products:
 - i. Acuity Brands: LC&D GR 2400
 - ii. Wattstopper: Digital Lighting Management
 - iii. Crestron

- 7. Small Site Lighting Control Panel (Astronomic Time Clock/ Photocell):
 - a. Acceptable Products:
 - i. Intermatic
 - ii. Tork

- 8. Site Lighting Control Panel with Wireless Dimming:
 - a. Acceptable Products:
 - i. Hubbell WiScape

- 9. Relay Panels:
 - a. Each panel shall be of modular construction and consist of the following components:
 - b. Enclosure/Tub NEMA rating and surface or shall be shown on the plans.
 - i. Cover shall be configured for surface or flush wall mounting of the panel as indicated on the plans.
 - c. Interior assembly shall be supplied as a factory assembled component specifically designed and listed for field installation. The interior construction shall provide isolation of high voltage (class 1) wiring from low voltage (class 2) wiring within the assembled panel.
 - i. The interior assembly shall include intelligence boards, processor, power supply, DIN rails as required by the System, class 2 control devices, and individually replaceable latching type relays.
 - d. The panel interiors shall include the following features:
 - i. Single pole or 2 pole latching relays with modular plug-in design.
 - e. Relay shall be rated as follows:
 - i. 30 amp ballast at 277V
 - ii. 20 amp tungsten at 120V
 - iii. 1.5 HP motor at 120V
 - iv. Match available fault current
 - f. Acceptable Products:
 - i. Acuity Brands: LC&D GR2400 & Blue Box
 - ii. Wattstopper: Digital Lighting Management
 - iii. Crestron

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10. Daylighting Controls:
 - a. Provide daylight controls to control lighting as indicated on plans.
 - b. Daylight zones shall be designed such that lights in the daylight zone are controlled independently of general lighting and are controlled in accordance with the current OSA adopted version of IECC, including but not limited to the following:
 - i. Automatic daylight controls:
 - a) Set points and other controls for calibrating the lighting control shall be “readily accessible” as defined in.
 - b) Daylighting control devices shall be capable of automatically reducing the lighting load in response to daylight contribution.
 - c. Maintain a specified foot candle level based on the contribution of natural and artificial light.
 - d. Daylight zones under skylights shall be controlled separately of daylight zones adjacent to vertical fenestrations.
 - e. Any tools or software required to adjust the System shall be provided as part of the System package.
 - i. This excludes foot–candle meters.
11. Dimming Panels (for use in large classrooms and conference rooms, auditoriums, etc.):
 - a. Dimming panels shall be compatible with the lamp source they are dimming. LEDs are especially sensitive to incompatibilities.
 - i. LED fixtures with integral dimmers shall not be dimmed from a dimming panel.
 - b. All dimmers shall be de–rated to no more than 80% of rated capacity.
 - c. Rooms with indication of preset stations shall be provided with engraved presets, to be approved by the Project Representative, or touch screens with the ability to create and label presets.
 - i. Preset creation shall be limited to select users and password protected.
 - d. Conference rooms and classrooms over 500 square feet shall include the ability to communicate with the Audio Visual System.
 - e. Acceptable Products:
 - i. Acuity Brands: Fresco
 - ii. Crestron
 - iii. Philips Strand

PART 3 EXECUTION

- A. Lighting Control Method by Room Application – In general, the following room types shall be controlled as follows:
 1. Private Office:
 - a. Standalone vacancy sensor (Manual On, Auto Off), typically dual technology
 - b. Exception:
 - i. If the switch is not readily accessible by the entrance, an occupancy sensor is acceptable.
 2. Open Office:
 - a. Manual control by the entrances, grouping the lights into separate zones
 - b. Ceiling vacancy sensors to turn lights off, typically dual technology
 - c. Daylight harvesting control as required
 3. Public Restrooms:
 - a. Standalone occupancy sensor (Auto On, Auto Off), typically ultrasonic
 4. Conference Rooms:
 - a. Manual control by entrance, with control zones for presentation purposes, as necessary

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- b. Ceiling vacancy sensors to turn lights off, typically dual technology
 - c. Daylight harvesting control as required
5. Classrooms:
- a. Manual control by entrance.
 - b. AV pedestal manual control with scene selection, as necessary
 - c. Minimum two lighting control zones – one at the teaching wall, one at the student seating area
 - d. Ceiling vacancy sensors to turn lights off, typically dual technology
 - e. Daylight harvesting control as required
6. Lobbies, Foyers, Corridors, Stairwells:
- a. Occupancy sensor (Auto On, Auto Off)
 - b. Use of light fixtures that dim down to 10% during unoccupied mode and ramp up to 100% upon detection of occupancy.
 - c. Daylight harvesting control shall be provided in areas where sufficient amounts of natural light are available.
 - d. Time schedule operated lighting as required by end user.
7. Breakrooms:
- a. Manual control by the entrance
 - b. Ceiling vacancy sensor to turn lights off, typically dual technology
8. Dining Halls:
- a. Consider scheduled programmable On times with required Manual control to initiate program (this would prevent lights from coming on during a Holiday Break when Dining Hall is not in use.)
 - b. Consider separating Food Prep, Serving, and dining areas for more control.
 - c. Locate manual wall stations at convenient entry points in order to easily initiate the programmed On times, and manually override the Off time if the cleaning crew were to finish early.
9. Commercial Kitchens:
- a. Manual On, Manual Off
10. Laboratories:
- a. Manual On, Manual Off
11. Mechanical/Electrical Rooms:
- a. Manual On, Manual Off
12. Custodial Closets:
- a. Vacancy sensor (Manual On, Auto Off)
13. Storage Rooms:
- a. Vacancy sensor (Manual On, Auto Off)
14. Library Stacks and Warehouse Storage Areas:
- a. Consider use of occupancy sensors integral to the fixture for Auto On, Auto Off.
15. Parking Garages:
- a. Garage lighting shall be reduced to 30% when no activity is detected for 20 minutes. Fixtures with integral occupancy sensors are recommended.
 - b. Daylight transition zone lighting shall be controlled separately by time clock such that these

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- lights are on during the day and off at night.
 - c. Light fixtures adjacent to the perimeter of an open structure garage may be controlled with automatic daylight harvesting controls.
16. Exterior Site Lighting:
- a. Pole Lighting relay control panel–time clock with photocell.
 - b. In general, pole lighting on Main Campus shall remain 100% on after dark.
 - c. South Campus and Foothills may consider dimming after late hours with occupancy sensor override.
 - d. Building Mounted Lighting:
 - i. Time clock with photocell
 - ii. Consider using integral occupancy sensors to decrease light level by 30% when the area is unoccupied.
 - e. Parking Lot Lighting:
 - i. Consider using pole mounted occupancy sensors to decrease light levels by 30%–50% when the area is unoccupied.

PART 4 TESTING AND COMMISSIONING

- A. Projects shall include a Manufacturer Authorized Service Technician to meet the Contractor on–site prior to installation of the System.
 - 1. The Manufacturer authorized technician shall provide a full set of Lighting Control Drawings and review device placement, switch locations, wiring requirements and any other information critical to the installation of the System.
- B. Functional testing is required to verify that the Lighting Control System is operating as designed in accordance with the design intent of the Construction Documents and Manufacturer’s installation instructions.
- C. Functional testing shall be commissioned by the Manufacturer’s factory Authorized Technician or an Independent Consultant authorized by Manufacturer to work on Lighting Control System.
 - 1. Project Representative from Operations and Maintenance shall be present at Contractor functional testing.
- D. Documentation shall be provided to the Project Representative certifying that the installed lighting controls perform in accordance with the design.
- E. Provide documentation for all daylight harvesting zones including desk top readings with lights off, lights at full and lights under daylight harvesting control.
 - 1. Include time, date and general weather conditions (e.g. full sun, cloudy) include information on the testing device, foot–candle meter, etc. used.
 - 2. All testing and verification shall be conducted by Factory Trained Technician.
 - a. Test reports shall be signed by the Technician.
- F. The following shall be verified:
 - 1. Occupancy and daylight sensors are located, installed and adjusted as intended by the factory and the Construction Documents.
 - 2. The sensors and relay panels interact as a complete and operational System to meet the design

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intent.

3. Programmable schedule controls have been programmed to the building representative's satisfaction.
 4. Placement and sensitivity of adjustments for photo sensor controls reduce electric light based on the amount of usable daylight in the space.
 5. The Manufacturer shall provide a factory authorized technician to train Project Representative's personnel with the operation, use, adjustment and problem-solving diagnosis of the occupancy sensing devices and Systems.
- G. Provide an additional follow-up programming session within three months after the initial programming.
- H. Provide accurate As-Built Drawings reflecting the latest programming requirements.

26 22 00 – LOW-VOLTAGE TRANSFORMERS

PART I GENERAL

A. Transformers (dry-type):

1. Transformers of not over 600 volts may be dry-type, indoor when installed in accordance with Article 450 of the NEC.
2. Dry-type transformers shall not be rigidly attached to the building structure, surfaces.
 - a. Flexible conduit shall be used to connect the transformer to the building Wiring System.
3. Transformers larger than 15kVA and transformers designed to be floor-mounted shall be set on resilient vibration-isolating material equal to Korfund "ElastoRib".
 - a. Sufficient quantity of resilient materials shall be used so as not to exceed the Manufacturer's recommended pound per square inch loading factor.
4. Dry-type transformers shall be sized to provide the code calculated demand load.
5. Aluminum windings are acceptable.

B. Grounding:

1. Transformer neutrals for the secondaries of separately derived Systems shall be grounded to the nearest available effectively grounded structural member or the nearest available effectively grounded water pipe, as required by NEC 250.
 - a. Where neither of these grounding electrodes are available, the secondaries shall be grounded by way of a grounding electrode conductor between the secondary neutral and grounding buss at the service entrance equipment.
2. The size of the grounding electrode conductor shall be determined in accordance with NEC.

26 24 13 – SWITCHBOARDS

A. Service and Distribution Switchboards:

1. Provide fully rated main bus in all switchboards.

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- a. Tapered bus assemblies not permitted.
2. Service entrance design shall be based upon fault current figures calculated in accordance with the requirements for Short Circuit Calculations in Chapter 03 – Drawings and Design Requirements by Discipline.

26 24 16 – PANELBOARDS

PART 1 NOT USED

PART 2 PRODUCTS

A. Sole Source Products:

1. Panelboards, switches, relays, circuit breakers:
 - a. Square D Co.

B. Panelboards:

1. Fault current ratings for all new panelboards and enclosed circuit breakers shall be submitted to FM Electrical Engineer for approval prior to the installation of the equipment.
2. Provide ample spare 3/4" or larger conduits out of panels into a wireway or junction boxes.
 - a. Run empty conduits to accessible spaces.
 - b. Provide conduits of sufficient capacity to carry all available spares from panel to above wall or drop ceiling.
3. All lighting and power panels shall be specified to provide minimum of 30% spare breaker space.
4. A/E shall provide panel schedules on Construction Documents.
 - a. Final typed schedules to be provided by the Contractor shall correspond to final CSU room number schedule.
5. Provide fronts with hinged trim, "door in door" construction for one-person access to wiring area.
 - a. All panel covers shall be factory painted with low gloss enamel (not flat wall paint) suitable for metal.
 - b. Field painting shall not be permitted.
6. The switching of lights from lighting panels is acceptable only if specifically approved by FM Planning, Design, Construction and Engineering through the Project Representative and if approved, a separate panel shall be provided for circuits, which are to be controlled.
 - a. No circuits other than lighting shall originate in the panel thus provided.
7. Panelboard circuit directories shall be updated for every project, which involves new circuits, reassignment of circuits or even just renumbering of rooms.

C. Metering:

1. Buildings that require metering for LEED certification shall be provided with a watthour/demand meter and CT's with a minimum accuracy of 1%.
2. Provide for voltmeter, ammeter and other like functions with a switchboard mounted power monitor.
 - a. These units have a selector keypad function for viewing various other parameters.

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26 27 26 – WIRING DEVICES

PART 1 GENERAL

A. Electrical Devices:

1. All electrical devices such as switches and outlets shall be specification grade suitable for high abuse areas.
2. All electrical devices such as disconnects, receptacles, etc. for mechanical equipment shall be attached directly to that equipment.
3. Duplex convenience outlets shall be rated 20 ampere, minimum. Lighting switches shall be rated 20 ampere, 120/277 volt at a minimum.
4. All electrical devices shall have a tape label attached to the inside of the box and on the outside of the cover to identify the branch circuit serving the device.
 - a. The tape label shall be adhesive marking tape with typed black letters on clear background, 3/8" Brother P-Touch or approved equal.
5. Shallow boxes for electrical devices are not permissible, unless allowed by special permission from FM.

B. Locations for Outlets:

1. Provide electrical outlets of 115 volt, 20 amps at the following locations:
 - a. Mechanical and electrical rooms
 - b. Within 25'-0" of rooftop units
 - c. Next to lawn sprinkler controllers
2. Convenience outlets shall be located at approximately 40'-0" intervals in corridors and located at stair landings to accommodate cleaning equipment.
 - a. Outlets shall also be located near office doors where they won't be covered by furniture.
3. Provide GFI protection for all restrooms and custodial closets with mop sinks.
 - a. The circuits in bathrooms, hallways, and custodial closets shall be separate from offices to avoid computer power quality problems.
4. Provide GFI protection for all receptacles within 6'-0" of a water fixture.
5. Provide an accessible NEMA 6-50 outlet located in the mechanical room for a welder.

C. Outlets:

1. Any special purpose electric outlets supplied by the Electrical Contractor shall be provided with matching cord caps.
 - a. If not installed on equipment, these cord caps shall be provided to FM prior to final acceptance of the building.
 - b. Outlets shall conform to NEMA configurations.
2. Use specification grade devices with all-brass Grounding Systems.
3. Outlet boxes shall be minimum 4" nominal square or octagonal, except that cut-in boxes shall be allowed in masonry walls.

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- a. Sectional or handy boxes not permitted.

D. Light Switches:

1. Use specification grade devices suitable for high abuse areas.
2. Refer to Chapter 03 – Drawings and Design Requirements by Discipline for more information.

26 29 00 – LOW-VOLTAGE CONTROLLERS

PART 1 NOT USED

PART 2 PRODUCTS

A. Acceptable Products:

1. Fractional horsepower motor starters:
 - a. Square D Company
 - b. G.E.
 - c. Cutler Hammer
 - d. Siemens
2. Solid state reduced voltage starters:
 - a. Square D Company
 - b. Consider using variable frequency drives instead of reduced voltage starters.
3. Variable frequency drives:
 - a. ABB
 - b. Or approved equal
 - c. Must be capable of network communication using BACnet protocol.

B. Motors, Starters and Protection:

1. All motor disconnects shall be heavy duty rated.
2. All motors 20 horsepower and larger shall be power factor corrected to a minimum of 95% at design load. HVAC Systems may be corrected at the motor control center.
3. For motors 5 horsepower and larger, devices to protect the motor against loss of phase (single phasing protection) shall be provided.
 - a. Devices to meet this requirement shall be of the current sensing type, and may be provided either as an integral part of the thermal overload or as a separate device.
 - b. Units shall have manual reset and adjustable limits.
4. Solid-state reduced voltage starters or variable frequency drives shall be provided for all motors 20 horsepower and larger. The starter shall have current limitation adjustable between 150% and 425% of all load current.
 - a. Smooth, soft start shall be accomplished by adjustable acceleration ramp time between 0.5 and 30 seconds via a potentiometer.
 - b. Solid-state overload with external manual reset shall be provided.
 - c. Starters shall be inhibited when loss of any phase is sensed.
 - d. Diagnostic LED's mounted externally shall indicate phase loss, control power, controller on, overload trip, and shorted SCR's.
 - e. Optional features to be included are hand-off-auto selector switch with red, green, amber

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pilot lights and push-to-reset button and isolation contractor.

5. All motors to be provided with external overload running protection. This is in addition to any 'built-in' protection inherent in the motor.
6. Motors controlled by variable frequency drives shall utilize an SGR– “shaft grounding ring” in order to prevent electrical damage to the motor bearings.
 - a. Consult with FM Electrical Engineer if another form of bearing isolation is being considered.
7. Rooftop unit equipment shall be provided with an integral disconnect.
 - a. Project Team to coordinate with mechanical specification for inclusion of this requirement.
8. Rooftop unit equipment shall be provided with an integral receptacle, not connected to the HVAC equipment’s power circuit.
 - a. The Electrical Contractor shall run another circuit to this receptacle separate from the RTU circuit.
 - b. Project Team to coordinate with mechanical specification for inclusion of this requirement.

C. Variable Frequency Drives (VFD):

1. All motor applications at or above 5 horsepower require the use of a variable frequency drive controlled by an input from the BAS (for energy management purposes).
2. The VFD and options shall be tested to ANSI/UL Standard 508.
 - a. The complete VFD and all options shall be listed by a nationally recognized testing agency such as UL, ETL or CSA.
3. All VFDs shall be installed with the ability to communicate with and respond to signals from the Building Automation System.
4. Drive shall convert constant frequency AC line voltage to a variable frequency, variable voltage AC output suitable for control of standard NEMA design B induction motor over a 6:1 minimum speed range.
5. VFD General Features:
 - a. Controller input:
 - i. Defined by Engineer, but where 208 volt power is utilized, provide a step up isolation transformer to 230 volt.
 - b. Control type:
 - i. programmable carrier frequency from 1 kHz to 12 kHz and required solid state IGBT electronics with Pulse Width Modulated (PWM) output waveform designed to minimize harmonic generated noise in motor.
 - ii. Unit to have advanced electronic controls to ensure that the output current waveform shall be nearly sinusoidal.
 - iii. Unit also to have DC bus reactor for reduced harmonics and improved power factor.
 - c. Full load VFD efficiency shall not be less than 95%. System power factor shall be 95% or better across the operational speed range.
 - d. Enclosure type:
 - i. NEMA 1, or as required
 - ii. Provide cabinet ground lug in VFD enclosure.
 - e. Rated and sized for 5,000’ elevation operating condition.
 - f. Automatic soft start feature to start motor at lowest speed and ramp slowly up to required speed on start-up and for any abrupt changes in required speed.
 - i. Provide a minimum of two acceleration and deceleration ramps adjustable from 0.1

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- seconds to ten minutes.
 - g. VFD bypass device is not required.
6. VFD Protective Features:
- a. Input line fuse or circuit breaker with door interlock disconnect.
 - b. Provide input line filters sized so that total harmonic voltage distortion is less than 5% to ensure compliance with IEEE Standard 519–1992.
 - i. Compliance with this standard shall be a requirement of the VFD System Vendor.
 - ii. The Vendor shall be responsible for the necessary calculations and documentation.
 - iii. Project Representative shall furnish building electrical data.
 - c. Protection against input transients.
 - d. The drive shall have output line reactors to limit the rise over time (dv/dt), reduce motor operating temperature, RFI and EMI.
 - e. Current rating:
 - i. A minimum continuous current rating of the VFD shall be a continuous ampere rating suitable for operation of a premium or standard efficiency motor.
 - ii. Specifically, VFD continuous amps shall not be less than the amps specified in NEC Table 430–250 for the specified horsepower motor.
 - iii. Overcurrent rating shall be 110% for 60 seconds and 220% of rated current for up to one second while starting.
 - f. Provide inverse characteristic time–overcurrent overload protection for the motor sized in accordance with NEC requirements.
 - g. Provide current limiting protection to shut down drive under output line–to–line or line–to–ground short circuit conditions without damage to controller.
 - h. Protection against input phase loss, under voltage, over voltage, short circuit, ground fault and drive and motor over temperature.
 - i. Torque/current limit control which shall slow the motor without tripping when the motor is subjected to an overload, or slow the acceleration ramp when accelerating a high inertia load.
 - j. Automatic restart circuitry to restart motor after a momentary or sustained power failure, phase loss, or non–damaging fault trip.
 - i. No more than five restart attempts shall be allowed before lockout.
 - ii. Auto restart feature shall be switch defeatable.
 - iii. For all applications, the VFD shall be capable of restarting into a forward or reverse rotating motor at any speed.
 - iv. The VFD shall also incorporate a five second control power loss ride through to eliminate nuisance tripping.
7. VFD Interface Features:
- a. Cover mounted alphanumeric display with keypad control panel.
 - i. Display readout shall be in plain English phrases, (without codes), for operating and diagnostic data.
 - ii. Integrated kilowatt–hour and elapsed–time displays are to be included.
 - b. Provide manual speed adjustment, HAND–OFF–AUTO switch and 4–20 milliamp and 0–10 volt speed reference analog inputs, fully isolated and suitable for grounded or ungrounded input signal.
 - c. Provide troubleshooting diagnostic features of diagnostic fault display to show reason for trip.
 - i. Display shall differentiate between: input under voltage, input phase loss or blown fuse, instantaneous overcurrent, sustained motor overload, heat sink over–temperature, overvoltage, etc.
 - ii. Diagnostic test unit may be of the plug–in type, with one test unit provided for several VFDs.
 - iii. If plug–in type unit is provided, one shall be provided for each building.

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- d. Provide LCD indicators, for all normal operation functions, including on–off status of all power devices.
 - e. Provide test mode switch to allow operation and setup of control electronics with power circuitry disabled.
 - f. Provide programmable pre–set default speeds and critical frequency lock–out bands.
 - g. Test switches, LCD readouts or digital readouts shall be located on outside of panel.
8. Quality Features:
- a. To ensure quality and minimize early failures, the complete VFD shall be tested by the Manufacturer.
 - i. The VFD shall operate a dynamometer at full load and speed shall be cycled during the test.
 - ii. All optional features shall be functionally tested at the factory for proper operation.
 - b. Factory trained and authorized start–up and service training for Project Representative's personnel.
 - c. One–year warranty on all parts and labor.
 - i. Extended warranty/service shall be available from the drive supplier.
 - ii. Spare parts are to be available locally.

26 32 13 – ENGINE GENERATORS

Please also refer to “Part IV – REGULATORY REQUIREMENTS” for additional requirements.

PART 1 GENERAL

- A. Generators shall be either natural gas or diesel generator sets.
- 1. Verify with FM Engineering which fuel source is preferred depending upon the location.
 - 2. Generator shall have rated kW/kVA output at 5,000' above sea level.
 - 3. Coordinate requirements with Project Representative.
 - 4. Do not locate generator exhaust in close proximity to HVAC air intakes.
- B. Sound Limitations:
- 1. The noise generated by the installed diesel generator set operating at 100% load shall not exceed the following sound pressure levels in any of the indicated frequencies when measured at a distance of 75'–0" from the end of the exhaust and air intake piping directly along the path of intake and discharge for horizontal piping; or at a radius of 35'–0" from the engine at 45 degrees apart in all directions for vertical piping.
 - 2. Submit data to demonstrate compliance with these sound limitation requirements.

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3. Also, submit certification from the Manufacturer stating that the sound emissions meet the Specifications.

<i>Frequency Band (Hz)</i>	<i>Maximum Acceptable Pressure Level (Decibels)</i>
20–75	81
75–150	71
150–300	64
300–600	58
600–1,200	55
1,200–2,400	54
2,400–4,800	54
4,800–10,000	56

PART 2 PRODUCTS

A. Diesel Generator

1. The main fuel tank shall have capacity to supply fuel to the engine for an uninterrupted 24 hour period at 100% rated load without being refilled.
2. Remote alarm panel: provide a remote alarm panel in accordance with NFPA 110 Level 1.
 - a. The panel shall be supplied with an enclosure.
3. Provide programmable exercise clock timer.

B. BAS Alarms:

1. Provide a dry contact for the following alarms:
 - a. Generator shutdown alarm
 - b. Generator running
 - c. Transfer switch to emergency power

C. Remote Monitoring System:

1. Provide a mobile and web application monitoring with capability to notify designated users of Warnings and Faults via email or text.
2. Cummins Power Command Cloud or equal

D. Local Software Access:

1. Provide a software package in Windows Explorer format that can be used with a personal computer (PC) to be able to access and download alarms, setting, and run times information and equipment history.

PART 3 EXECUTION

- A. Performance test shall be a 100% load test to include resistive and reactive load to nameplate rating at 80% power factor using resistive and reactive load banks.

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- B. Engine generator set shall be operated at 75% of rated load for at least two hours and then 100% rated load for at least four hours.
1. In addition, a full load acceptance test of 100% of rated load shall be applied to the generator with voltage and frequency stabilization occurring per Specifications.

26 33 53 – STATIC UNINTERRUPTIBLE POWER SUPPLY

PART 1 GENERAL

- A. Uninterruptible Power Supply (UPS):
1. UPS shall be a true on–line double conversion UPS, using IGBTs.
 2. UPS shall include an external maintenance bypass cabinet, or some other means of maintaining the UPS without causing the critical load to be shut down.
 3. Provide a dry contact for a general UPS alarm back to FM BAS Shop for monitoring.
- B. Flywheel:
1. Flywheel shall be used in place of chemical batteries for power storage.
 - a. Provide a minimum ten second back–up time based on the full load rating of the UPS.
 2. Provide LCD control touch panel required for MODBUS communications.
 - a. Monitor all Flywheel alarms and warnings.
 - b. Provide communications link back to FM BAS Shop for monitoring.

26 51 00 – INTERIOR LIGHTING

PART 1 GENERAL

- A. CSU is committed to conserving electrical energy by incorporating interior and exterior lighting technologies that are both energy efficient and cost effective.
- B. All light intensity design shall be done in accordance with the recommendations of the Illuminating Engineering Society of North America.
- C. Provide occupancy and vacancy sensors per IECC.
- D. Lighting Design Drawings shall include the following:
1. Lighting Fixture Schedule showing information pertinent to LED sources, including lumen output, wattage, lumens per watt ratio, color temperature, etc.
 2. Power Density schedule showing watts, area and watts–per–square foot density for all major area types.
 3. Lighting control matrix indicating how lighting is controlled in each typical room type (private office, open office, stairwells, corridors, etc.)

PART 2 PRODUCTS

- A. Interior Luminaires:

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1. Standard luminaire for interior office and classroom spaces is the 2'-0" x 4'-0", troffers or flat panels.
2. Other types of acceptable fixtures (where deemed appropriate by the designer) include:
 - a. 2'-0" x 2'-0" troffers
 - b. Recessed "cans"
 - c. Wall washing fixtures
 - d. Wrap-around fixtures
3. Provide a minimum of 10 foot-candles in stairwells.

B. Use of LED Luminaires:

1. LED luminaires are the preferred lighting source at CSU.
2. To ensure that quality luminaires are specified, LED luminaires shall meet the following minimum requirements.
 - a. LED luminaires shall be manufactured by a company that has been in business for five years or longer.
 - b. LED luminaires shall have a minimum of 50,000 hour mean life.
 - c. LED luminaires shall have a minimum five year warranty, including housing, LED source and LED drivers.
 - d. LED fixtures shall be Design Lights Consortium (DLC) listed or adhere to the DLC minimum lumens per watt ratio.
 - e. LED diodes shall be modular – that is, if the LED component fails, the LEDs can be replaced without having to replace the whole fixture.
 - i. LEDs welded or riveted to the fixture housing are unacceptable.
 - f. LED luminaire output shall be a 3500K color temperature and minimum Color Rendering Index (CRI) of 80.
 - i. With prior approval, FM Design and Construction shall allow deviations from this standard.

C. Lamps:

1. Incandescent lamps are prohibited in general.
 - a. For special cases where incandescent lamps are essential, incandescent fixtures may be specified only with approval from FM Engineering.
2. FM prefers that older lamp technologies (metal halide, fluorescent, compact fluorescent), be removed and replaced with a completely new LED fixture.
 - a. However, there are cases where existing installation methods may make this impractical.
 - b. If LED lamps are proposed, coordinate with FM Electrical Engineer to determine if acceptable.
3. LED retrofit lamps shall not be installed in recessed troffer or can light fixtures which do not have integral air circulation in the housing of the fixture.
4. LED retrofit lamps that replace existing T8 fluorescent lamps shall be of the Type "B" that bypasses the fluorescent ballast.
 - a. The fluorescent ballast shall be removed from the fixture.
5. LED lamps shall be manufactured from a company that has been in business for five years or longer.

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6. LED lamps shall have a minimum 50,000 hour mean life.
7. LED lamps shall have a minimum five year warranty, including the driver.

D. Exit Lights:

1. Exit light hardware shall use Light Emitting Diodes (LED) as their source of illumination.
2. Exit signs shall be ENERGY STAR compliant.
3. The use of Self-Luminous exit signs is prohibited.
 - a. Self-Luminous exit signs also known as radioluminescent exit signs or tritium exit signs contain tritium gas which is radioactive and toxic.

E. Emergency Lighting:

1. When emergency light and power is required, consideration shall be given to providing an emergency generator if the load permits.
 - a. Battery powered emergency lighting shall be considered only when loads are too small to justify an emergency generator.
2. Emergency lighting units, or “frog eyes” are preferable for reasons of maintenance and replacement costs.
 - a. EM lighting units shall be used in back of house areas and areas deemed acceptable by the Architect, in lieu of battery back-up ballasts.

26 56 00 – EXTERIOR LIGHTING

PART 1 GENERAL

A. Campus design foot-candle levels are as follows:

1. Parking lots:
 - a. 0.2 fc Minimum
2. Roadways:
 - a. 0.3 fc Minimum
3. Sidewalks:
 - a. 0.5 fc Minimum

B. General sidewalk and bicycle lane illumination shall be achieved using LED luminaires.

1. The color of the luminaires shall be factory light gray.

C. Exterior location luminaires shall not exceed the BUG (Backlight, Uplight and Glare) ratings for the Lighting Zone based on campus location:

1. Main Campus:
 - a. LZ2
2. South Campus:
 - a. LZ2

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3. Foothills Campus:
 - a. LZ1

D. Conductors feeding pole-mounted luminaires shall be THWN stranded copper in minimum 1" PVC underground conduit.

1. Conductors and conduit shall be sized so that the voltage drop from the last over-current device to the luminaire is limited to no more than 3%.

PART 2 PRODUCTS

A. Fixture Heads:

1. Pedestrian Walkways Fixtures:
 - a. Older Areas, Post Top:
 - i. American Electric Lighting, Contempo Series
 - a) 72W, 4000K, Type II, 3792 lumens
 - b) Catalog # 245L-20LEDE10-vtg-4K-R2-GL-PCS
 - ii. Lamp Replacement
 - a) Light Efficient Design: LED-8024 Post Top
 - b) 42W, 4200K, 4979 initial lumens
 - c) SKU # LED-8024M42PT
 - b. New Areas:
 - i. Kim Lighting, Model SAR PicoPrism, Light Grey
 - a) LED-1SA-SAR-x-[P35 or P70]-40L-4K-[vtg]-LG-[HSF or VSF]
2. Streets/Parking Lot Fixtures:
 - a. Kim Lighting Model AR PicoPrism, Light Grey
 - b. LED - 1A-AR-x-[P35 or P70]-80L-4K-[vtg]-LG-HSF

B. Light Poles:

1. Pedestrian Light Poles – 15'-0" above ground, round tapered fiberglass (if using Tenon, make changes as needed):
 - a. Anchor Base:
 - i. Whatley, Model: TR45-15-AB-GRY-SMS-DTC
 - ii. Lithonia, Model: RTF 16 6-1X DM19 FBC DNA
 - b. Anchor Base Tenon:
 - i. Whatley, Model: RT45-15-AB-GRY-SMS-23-50
 - ii. Lithonia, Model: RTF 20 6-6X T20 DNA
2. Street/Parking Lots – 30'-0" (Above Ground) with 8'-0" mast arm:
 - a. Anchor Base:
 - i. Whatley, Model: TR50-30-AB-GRY-SMS-DTC/ (2) WOPAR-8-GRY
 - ii. Lithonia, Model: RTF 30 10-5X DM19 FBC DNA

PART 3 EXECUTION

A. Pedestrian Poles and Luminaires:

1. Pedestrian scale luminaires shall be installed on tenons on top of 15'-0" anchor base, heavy-duty, round tapered fiberglass poles.
2. The pole shall have a smooth finish of light grey color.

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3. The 15'–0" anchor base pole shall be mounted on a 24" diameter caisson.
4. If poles are within 5'–0" of a parking lot curb, the caisson foundation shall be extended 30" above ground level to prevent vehicles from damaging the pole.
5. Refer to CSU Facilities Planning, Design and Construction Standards – Additional Documents for pole and foundation details.
6. Where new sidewalk or bicycle lane illumination is provided near existing 15'–0", concrete octagonal poles, use new, matching, concrete octagonal poles with bolt–down bases, if available.
 - a. Foundations for these poles shall comply with the Manufacturer's recommendations.
7. Bollard Lighting Systems are discouraged due to the abuse they sustain on campus.

B. Roadway and Parking Poles and Luminaires:

1. Roadway and Parking Lot scale luminaire color shall be factory light gray.
2. When installed at least 5'–0" from back of curb line, the luminaries shall be installed on 30'–0" anchor base, heavy–duty round tapered fiberglass poles.
3. The pole finish shall be smooth and color shall be either grey or salmon – splatter color.
 - a. The color choice shall be made by FM depending on the location.
4. The 30'–0" anchor base pole shall be mounted on a 24" or 30" diameter caisson.
5. If poles are within 5'–0" of a parking lot curb or within the parking lot, the caisson foundation shall be extended 30" above ground level to prevent vehicles from damaging the pole.
6. Refer to CSU Facilities Planning, Design and Construction Standards – Additional Documents for pole and foundation details.
7. For parking lot and roadway applications, the luminaires shall be attached to the poles using standard 8'–0", davit–arms.
 - a. FM Electrical Engineer must approve the use of Manufacturer's standard 8' support arms.

C. Exterior Building:

1. Other types of luminaires used for architectural effects on or around buildings shall be subject to review and approval by FM.
 - a. At a minimum, architectural building lighting shall be controlled by photocell and time–clock to limit time of use.
2. Up–lighting is not allowed.
3. Exterior incandescent fixtures and HID are not allowed.
 - a. Use LED light sources for exterior lighting wherever possible.

D. Controls:

1. Control of exterior luminaires shall be by photocell.
 - a. Where practicable, a single photocell shall activate a lighting contactor to control multiple luminaires.
 - b. Where necessary, photocell control of single luminaires shall be allowed.
 - c. No time clocks are allowed, unless overridden by photocell.

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2. When pole installation is complete, numeral stenciling shall be painted or equivalent as directed by FM Utility Services or Electrical staff.
 - a. Contractor shall coordinate with the electric shop for pole number.

END OF DIVISION