

**CSU HOUSING & DINING SERVICES TECHNICAL STANDARDS
DIVISION 26 – ELECTRICAL**

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26 00 00 - GENERAL INFORMATION

A. Codes and Standards:

1. The design and construction of all University work shall comply with the current edition of the National Electric Code (NEC), International Energy Conservation Code (IECC), National Fire Protection Association (NFPA), Occupational Safety & Health Administration (OSHA) requirements in 129 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 shall be performed by a State of Colorado licensed contractor or a maintenance electrician under the supervision of a licensed electrician.

B. Design: See Chapter 22 – Electrical Drawings and Design in Part II - CSU Design Standards.

C. Utilities: for Transformers and Underground Distribution, see Section 33 70 00 – Electrical Utilities

D. Project Record Set Documents

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

26 05 19 – LOW VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

A. Products Not Permitted:

1. Non-Metallic Cable (type NM or NM-C). Except for wiring with residential dwelling units
2. Metal-Clad Cable (type AC or MC) unless 6 feet or shorter for connection to motors and light fixtures.
3. Through-the-wall boxes.
4. Electrical Nonmetallic Tubing (ENT) except in residential buildings.

B. Wires and Cables:

1. Building wire and cable electrical power conductors shall be copper, insulated to 600 volts.
2. Aluminum wire will 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. A compression copper pigtail adaptor shall have the barrel designed of high strength aluminum alloy and the pigtail of high conductivity copper. 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. If Aluminum

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phase conductors are used, copper or aluminum grounding conductors shall be sized per NEC.

3. Branch circuits whose length from panel to first outlet exceeds 75 feet for 120-volt circuits shall be next size larger, as recommended by the NEC for limiting voltage drop.
4. Branch circuits whose length from panel to first outlet exceeds 175 feet for 277-volt circuits shall be next size larger, as recommended by the NEC for limiting voltage drop.
5. Minimum wire size for branch circuit conductors: #12 AWG unless allowed otherwise by special permission from Facilities Management
6. Maximum wire size for service and feeder circuit conductors: 500 kcmil Copper and 750 kcmil Aluminum, unless allowed otherwise by special permission from Facilities Management.

C. Branch Circuits and Color Coding:

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 – RACEWAYS, BOXES AND DEVICES FOR ELECTRICAL SYSTEMS

A. Acceptable Product:

1. Wireway System - Wiremold, Monosystems.

B. 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. Exposed EMT and RMC are not allowed unless allowed otherwise by special permission from Facilities Management.
3. Minimum size of power conduits shall be ¾ inch to allow for future installation of additional circuits. Minimum size of lighting conduits shall be ½ inch.
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 inches to facilitate replacement and/or removal of ceiling panels.

C. 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 will be subjected to excessive heat.

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Locate all raceways a minimum of 12 inches from flues, hot water lines, etc.

D. 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. Where runs exceed 100 feet in length between openings, RMC or strand-epoxy fiberglass elbows shall be used for change in direction of 45 degrees or more.

E. 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. The tape label shall be adhesive marking tape with typed black letters on clear background, 3/8 inch Brother P-Touch or approved equal.

F. Locations for Outlets:

1. Provide electrical outlets of 115 volt, 20 amps at the following locations:
 - a. Mechanical and electrical rooms
 - b. Within 25 feet of rooftop units
 - c. Next to lawn sprinkler controllers.
 - d. Exterior refrigeration compressors
2. Convenience outlets should be located at approximately 25-foot intervals in corridors and located at stair landings to accommodate cleaning equipment. Outlets should also be located near office doors where they won't be covered by furniture.
3. Provide GFI protection for all restrooms, Vending machines and refrigerated water coolers as per NEC. The circuits in bathrooms, hallways, and janitor's closets should be separate from offices to avoid computer power quality problems.

G. Outlets:

1. Any special purpose electric outlets supplied by the electrical contractor shall be provided with matching cord caps. If not installed on equipment, these cord caps shall be provided to Facilities Management prior to final acceptance of the building. Outlets shall conform to NEMA configurations.
2. Use specification grade devices with all-brass grounding systems.
3. Outlet boxes shall be minimum 4-inch nominal square or octagonal, except that cut-in boxes

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will be allowed in masonry walls. Sectional or handy boxes not permitted.

H. Light Switches:

1. Use specification grade devices suitable for high abuse areas.
2. See Section 26 09 00 Lighting Controls for more information.

I. Grounding

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

26 09 00 – LIGHTING CONTROLS

PART 1 GENERAL

A. Context

1. The intent of this section is to provide guidelines for lighting control performance, products and application on Colorado State University campuses.
2. The current market of lighting control systems typically uses proprietary technology where different manufacturer's products are not compatible with each other. In lieu of an emerging lighting control standard, the designer is compelled to use these incompatible proprietary systems.
3. Private offices, open office areas, conference rooms, laboratories, commercial kitchens, restrooms, classrooms, break rooms, janitor closets, storage rooms, electric rooms and mechanical rooms will be controlled by stand-alone systems. This will make these systems easier to maintain. If there is a problem with the system, an electrician knows the problem is local and they will not have to troubleshoot at the central building lighting control panel. This should help eliminate bypassing the control systems.
4. Lobbies, foyers, corridors, hallways and stairwells will be controlled by programmable building control system. This will 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 should be greatly simplified.

B. Codes and Mandates

1. All CSU projects shall have a lighting control design conforming to the latest Colorado State adopted International Energy Conservation Code and the guidelines outlined in this section. These guidelines are written to conform to the latest adopted Energy Code. Where requirements are not equal, the stricter requirement shall be used.
2. Projects pursuing LEED certification should still conform to the guidelines of this section. If control technologies are being considered that are not referenced in this section, consult with CSU Facilities Management Electrical Engineer for approval.

C. Network Compatibility

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1. In general, lighting control systems will not be networked to the Building Automation system. However, specified manufacturers and their products shall be able to communicate using native BACnet for future connectivity. Each panel shall be able to connect to the Building Automation System network and shall allow programming of groups and viewing of status via the BAS software. Small site lighting panels will 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
 1. Technology: infra-red vs ultrasonic vs. dual technology
 2. Application: Corridor vs. large room vs. small room sensors
 3. Wiring: Line voltage vs. low voltage vs wireless
 4. Location and orientation of each product
 - b. Typical wiring diagrams of lighting control devices in different applications.
 - 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. Close Out 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 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 PRODUCT REQUIREMENTS

A. Performance Specifications

1. In general, automatic lighting controls will be Vacancy Sensor type, “Manual On, Auto Off”. 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. 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). Verify wireless system and its operating frequency (Hz) are acceptable to the CSU Housing and Dining Services Facilities, Facilities Management Electrical Engineer and CSU’s Academic Computing and Networking Services (ACNS) department.

B. Terms

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1. Building Control System – 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. May consist of either one lighting control panel or a group of networked control panels.
2. Manual Control- control method requiring human intervention to regulate electric lighting-typically through a wall switch.
3. Occupancy Sensor- a control device that detects the presence or absence of people and causes lighting to be regulated either on or off.
4. Photo sensor- 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 – Central time-based controller program using relays and schedules
6. Room Controller – 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- 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 will only be allowed under the exceptions sections of IECC Section 405.2.2.2.
 - b. Dual technology sensors will 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 will be installed so that the majority of the sensor coverage is confined to the room and will provide 100% coverage of the room with minimal coverage of any adjacent corridor.
 - 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 feet from mechanical vents.
 - h. Ceiling sensors shall be located a minimum of 2 feet 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 degrees to 90 degrees Fahrenheit and be sealed against humidity.
 - b. Twistlock photocells on pole lighting shall conform to ANSI C136.41 standards.
4. Room Controllers
 - a. Acceptable Products
 1. Acuity Brands: nLight
 2. Wattstopper Digital Lighting Management
 3. Douglas: Dialog

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5. 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 will include a back-up for the clock function and EEPROM for program retention.
 - b. The clock shall include the following control scenarios:
 1. Scheduled ON/OFF
 2. Manual ON/Scheduled OFF
 3. Manual ON/Auto Sweep OFF
 4. Astronomic ON/OFF (or Photo ON/OFF)
 5. Astronomic and Schedule ON/OFF (or Photocell and Schedule ON/OFF)
 - c. Acceptable Products
 1. Acuity Brands: LC&D GR 2400
 2. Douglas: Dialog
 3. Wattstopper: Digital Lighting Management
6. Small Site Lighting Control Panel (Astronomic Timeclock/ Photocell)
 - a. Acceptable Products
 1. Intermatic
 2. Tork
7. Relay Panels
 - a. Each panel shall be of modular construction and consist of the following components:
 1. Enclosure/Tub NEMA rating and surface or shall be shown on the plans. Cover shall be configured for surface or flush wall mounting of the panel as indicated on the plans.
 2. 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. 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.
 3. The panel interiors shall include the following features:
 - a. Single pole or 2 pole latching relays with modular plug-in design. 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. 14,000 amp short circuit current rating.
 - b. Acceptable Products
 1. Acuity Brands: LC&D GR2400 & Blue Box
 2. Douglas: Dialog
 3. Wattstopper: Digital Lighting Management
8. Daylighting Controls
 - a. Provide daylight controls to control lighting as indicated on plans. 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 2012 IECC Section C405.2.2.3.1 or Section C4015.2.2.3.2 including but not limited to the following:
 1. Automatic daylight controls – Set points and other controls for calibrating the lighting control shall be “readily accessible” as defined in IECC section C405.2.2.3.2
 2. Daylighting control devices shall be capable of automatically reducing the lighting load in response to daylight contribution.

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3. Maintain a specified foot candle level based on the contribution of natural and artificial light.
 - b. Daylight zones under skylights shall be controlled separately of daylight zones adjacent to vertical fenestrations.
 - c. Any tools or software required to adjust the system will be provided as part of the system package. This excludes foot-candle meters.
9. 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. LED fixtures with integral dimmers shall not be dimmed from a dimming panel.
 - b. All dimmers will 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 owner, or touch screens with the ability to create and label presets. Preset creation will be limited to select users and password protected.
 - d. Conference rooms and classrooms over 500 square feet shall include the ability to communicate with an Audio Visual system via RS 232.
 - e. Acceptable Products
 1. Acuity Brands: Fresco
 2. Crestron
 3. Philips Strand

D. 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: 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. Stand Alone Occupancy Sensor (Auto On, Auto Off), typically ultrasonic. Or combination PIR/Ultrasonic
4. Conference Rooms
 - a. Manual control by entrance, with control zones for presentation purposes, as necessary
 - 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)

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- 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.

7. Break Rooms

- 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.) Use of occupancy sensors vs. timed programs is preferred.
- 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.
- d. Provide locking covers for all switches in public spaces.

9. Commercial Kitchens

- a. Manual On, Manual Off

10. Mechanical / Electrical Rooms

- a. Manual On, Manual Off

11. Janitor closets

- a. Vacancy Sensor (Manual On, Auto Off)

12. Storage Rooms

- a. Vacancy Sensor (Manual On, Auto Off)

13. Warehouse Storage areas

- a. Consider use of occupancy sensors integral to the fixture for Auto On, Auto Off.

14. Exterior Site Lighting

- a. Pole Lighting: Relay control panel- time clock with photocell
- b. Building Mounted lighting: time clock with photocell. Consider using integral occupancy sensors to decrease light level by 30% when the area is unoccupied.
- c. Parking Lot Lighting: Consider using pole mounted occupancy sensors to decrease light levels by 30% when the area is unoccupied.

PART 3 COMMISSIONING

- A. Projects shall include a manufacturer authorized service technician to meet the Contractor on-site prior to installation of the system. The manufacturer authorized technician will 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. Per IECC 2015, 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.
- D. Documentation shall be provided to the Owner's representative certifying that the installed lighting

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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. Include time, date and general weather conditions (e.g. full sun, cloudy) include information on the testing device, foot-candle meter, etc. used. All testing and verification will be conducted by factory trained technician. Test reports will 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 contract documents.
 - 2. The sensors and relay panels interact as a complete and operational system to meet the design intent.
 - 3. Programmable schedule controls have been programmed to the Building Representative's satisfaction.
 - 4. Placement and sensitivity of adjustments for photosensor controls reduce electric light based on the amount of usable daylight in the space.
- G. The manufacturer shall provide a factory authorized technician to train Owner's personnel with the operation, use, adjustment and problem solving diagnosis of the occupancy sensing devices and systems.

26 05 53 – IDENTIFICATION FOR ELECTRICAL SYSTEMS

A. Equipment Identification:

- 1. Label all panels, disconnect switches, motor starters, control stations and special devices furnished under Division 26. Labels shall be etched lamacoid (black with white core) with minimum 1/8-inch high letters and shall indicate area served and equipment served. Labels shall be attached to equipment with sheet metal screws. 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. Labeling shall include panel name and circuit number. Locate label on inside and outside of all device plates and covers. Locate label on outside of junction boxes above ceilings or in unfinished areas. 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.

26 22 00 – LOW-VOLTAGE TRANSFORMERS

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. Flexible conduit shall be used to connect the transformer to the building wiring system.

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3. Transformers larger than 15kVA and transformers designed to be floor-mounted shall be set on resilient vibration-isolating material equal to Korfund "ElastoRib". 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 secondary's of separately derived systems will be grounded to the nearest available effectively grounded structural member or the nearest available effectively grounded water pipe, as required by NEC 250. Where neither of these grounding electrodes are available, the secondary's will be grounded by way of a grounding electrode conductor between the secondary neutral and grounding buss at the service entrance equipment. The size of the grounding electrode conductor shall be determined in accordance with NEC.

26 24 16 – SWITCHBOARDS AND PANELBOARDS

- A. Sole Source Products:
1. Panel boards, Switches, Relays, Circuit Breakers - Square D Co.
- B. Panel boards:
1. Fault current ratings for all new panel boards and enclosed circuit breakers shall be submitted to Facilities Management- Electrical Engineer for approval prior to the installation of the equipment.
 2. Provide ample spare $\frac{3}{4}$ inch or larger conduits out of panels into a wireway or junction boxes. Run empty conduits to accessible spaces. Provide conduits of sufficient capacity to carry all available spares from panel to above wall or drop ceiling.
 3. All lighting and power panels will be specified to provide minimum of 30 percent spare breaker space. Residential dwelling units shall have 10 percent spare breakers, but no less than 2 breakers.
 4. A/E will provide panel schedules on contract drawings. Final typed schedules to be provided by the Contractor will correspond to final Colorado State University room number schedule.
 5. Provide fronts with hinged trim, "door in door" construction for one person access to wiring area. All panel covers will be factory painted with low gloss enamel (not flat wall paint) suitable for metal. Field painting will not be permitted.
 6. The switching of lights from lighting panels is not acceptable.
 7. Panel board circuit directories should be updated for every project, which involves new circuits, reassignment of circuits or even just renumbering of rooms.
- C. Metering:
1. All buildings are to be provided with an Elster AMI (wireless mesh) master watt-hour meter, 15-minute demand register. By-pass switches to be provided in meter housing for meter removal and test of meter. Do not specify primary rated meter. This meter is normally sized and

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furnished by Owner. If Owner is not allowed to provide, coordinate meter specifications with Owner.

2. Provide for voltmeter, ammeter and other like functions with a switchboard mounted power monitor. These units have a selector keypad function for viewing various other parameters.

D. Service and Distribution Switchboards

1. Provide fully rated main bus in all switchboards. 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 Section 2213.4 Short Circuit Calculations.

26 29 00 – LOW VOLTAGE CONTROLLERS

A. Acceptable Product:

1. Fractional horsepower motor starters - Square D Company, G.E.
2. Solid state reduced voltage starters - Square D Company. Consider using Variable Frequency Drives instead of reduced voltage starters.
3. Variable Frequency Drives – ABB or approved equal. Must be capable of network communication using Bacnet protocol.

B. Motors, Starters and Protection:

1. Electrical contractor (rather than mechanical contractor) will supply and install all motor controllers and disconnect switches.
2. All motor disconnects shall be heavy duty rated.
3. All motors 20 hp and larger will be power factor corrected to a minimum of 95 percent at design load. HVAC systems may be corrected at the motor control center.
4. For motors 5 horsepower and larger, devices to protect the motor against loss of phase (single phasing protection) shall be provided. 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. Units shall have manual reset and adjustable limits.
5. 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 percent and 425 percent of all load current. Smooth, soft start shall be accomplished by adjustable acceleration ramp time between 0.5 and 30 seconds via a potentiometer. Solid-state overload with external manual reset shall be provided. Starters shall be inhibited when loss of any phase is sensed. Diagnostic LED's mounted externally shall indicate phase loss, control power, controller on, overload trip, and shorted SCR's. Optional features to be included are Hand-Off-Auto selector switch with red, green, amber pilot lights and push-to-reset button and isolation contractor.
6. All motors to be provided with external overload running protection. This is in addition to any 'built-in' protection inherent in the motor.
7. Motors controlled by VFD's shall utilize an SGR- "shaft grounding ring" in order to prevent electrical damage to the motor bearings. Consult with campus Electrical Engineer if another form of bearing isolation is being considered.

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8. Rooftop unit equipment shall be provided with an integral disconnect. Consultant to coordinate with mechanical specification for inclusion of this requirement.
9. Rooftop unit equipment shall be provided with an integral receptacle, not connected to the HVAC equipment's power circuit. The Electrical contractor shall run another circuit to this receptacle separate from the RTU circuit. Consultant to coordinate with mechanical specification for inclusion of this requirement.

C. Variable Frequency Drives (VFD):

1. All motor applications at or above 5 HP require the use of a Variable Frequency Drive controlled by an input from the building automation system (for energy management purposes).
2. The VFD and options shall be tested to ANSI/UL Standard 508. The complete VFD and all options shall be listed by a nationally recognized testing agency such as UL, CUL, 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 - defined by engineer, but where 208 volt power is utilized, provide a step up isolation transformer to 230 volt.
- b. Control type - 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. Unit to have advanced electronic controls to ensure that the output current waveform will be nearly sinusoidal. 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 - NEMA 1, or as required.
- e. Provide cabinet ground lug in VFD enclosure.
- f. Rated and sized for 5000 feet elevation operating condition.
- g. 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. Provide a minimum of two acceleration and deceleration ramps adjustable from 0.1 seconds to 10 minutes.
- h. VFD Bypass device is not required.

5. 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. Compliance with this standard shall be a

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requirement of the VFD system vendor. The vendor shall be responsible for the necessary calculations and documentation. Owner will 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 - A minimum continuous current rating of the VFD shall be a continuous ampere rating suitable for operation of a premium or standard efficiency motor. Specifically, VFD continuous amps shall not be less than the amps specified in NEC Table 430-250 for the specified horsepower motor. Overcurrent rating shall be 110% for 60 seconds and 220% of rated current for up to 1 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 will 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. No more than 5 restart attempts should be allowed before lockout. Auto restart feature shall be switch defeatable. For all applications, the VFD shall be capable of restarting into a forward or reverse rotating motor at any speed. The VFD shall also incorporate a 5 second control power loss ride through to eliminate nuisance tripping.
7. VFD Interface Features:
- a. Cover mounted alphanumeric display with keypad control panel. Display readout shall be in plain English phrases, (without codes), for operating and diagnostic data. 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. Display shall differentiate between: input under voltage, input phase loss or blown fuse, instantaneous overcurrent, sustained motor overload, heat sink over-temperature, overvoltage, etc. Diagnostic test unit may be of the plug-in type, with one test unit provided for several VFD's. If plug-in type unit is provided, one shall be provided for each building.
 - 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.

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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. The VFD shall operate a dynamometer at full load and speed shall be cycled during the test. All optional features shall be functionally tested at the factory for proper operation.
- b. Factory trained and authorized start-up and service training for Owner's personnel.
- c. One year warranty on all parts and labor. Extended warranty/service shall be available from the drive supplier. Spare parts are to be available locally.

26 32 13 – ENGINE GENERATORS

A. General information:

- 1. All generators provided for a project shall be new. Used generators are not acceptable.
- 2. Generators shall be natural gas sets.
- 3. Generator shall have rated kW/kVA output at 5000 feet above sea level.
- 4. Generator air emissions must be evaluated for inclusion into CSU's Title V Operating Permit. Coordinate requirements with University Representative.
- 5. Sound Limitations
 - a. The noise generated by the installed generator set operating at 100 percent load shall not exceed the following sound pressure levels in any of the indicated frequencies when measured at a distance of 75 feet 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 feet from the engine at 45 degrees apart in all directions for vertical piping. Submit data to demonstrate compliance with these sound limitation requirements. Also, submit certification from the manufacturer stating that the sound emissions meet the specifications.

Frequency Band (Hz)	Maximum Acceptable Pressure Level (Decibels)
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

6. Communications

- a. Provide communications data link with modbus RTU or Native BACNet.

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- b. Monitor all generator alarms and warnings, including generator start and stop.
 - c. Provide tie-in back to CSU Housing and Dining Services Facilities for monitoring.
7. 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. Engine generator set shall be operated at 75% of rated load for at least 2 hours and then 100% rated load for at least 4 hours. 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.
8. Remote Alarm Panel: Provide a remote alarm panel in accordance with NFPA 110 level 1. The panel shall be supplied with an enclosure.
9. Building Automation System (BAS) Alarms
- a. Provide complete remote monitoring of the generator and automatic transfer switch to include all alarms provided on the local alarm panel. User shall be able to remotely reset and acknowledge warning type faults on generator and transfer switch.
 - b. Communications shall be via Modbus or BACnet.
 - c. Provide remote diagnostics and system performance data.
 - d. Provide enhanced security with username and password protection
10. Local Software Access
- a. 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.

26 51 00 – INTERIOR LIGHTING

A. Acceptable Products:

- 1. LED lighting for all general application.
- 2. Solid-State fluorescent ballasts –Advance Transformer Co., MagnaTek, Sylvania.

B. General Information:

- 1. Colorado State University is committed to conserving electrical energy by incorporating interior and exterior lighting technologies that are both energy efficient and cost effective. At a minimum, the design shall comply with the latest International Energy Conservation code.
- 2. All light intensity design will be done in accordance with the recommendations of the Illuminating Engineering Society of North America.
- 3. Provide photometric calculations based on zonal cavity and surface reflectance.
- 4. Provide occupancy sensing devices in spaces that are unoccupied for long periods of time.
- 5. Provide daylight zone control per IECC. Manual switched zones or dimming ballasts are preferred over step dimming ballasts in continuously occupied areas (i.e. classrooms, offices). Step dimming ballasts may be used in hallways, stairwells or other transient spaces.

C. Interior Luminaires:

- 1. Standard luminaire for interior office and lobby and classroom spaces is the 2 x 4 foot or 2 x 2

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foot LED fixture with a lamp color of 4000K; Indirect light luminaire design.

2. Corridor and stairway light intensity shall be sufficient to illuminate surfaces for nighttime cleaning. Provide a minimum of 10 foot-candles in stairwells per NFPA 101.
3. Fixture locations should allow easy replacement of lamps if applicable. Unusual locations that require reaching over or climbing onto fixed equipment or furnishings should be avoided. Consider wall mounted fixtures for high ceiling spaces.

D. Use of LED Luminaires

1. LED luminaires shall be manufactured from a company that has been in business for 5 years or longer. LED fixtures shall have a minimum of 50,000 mean life and have a minimum 5 year warranty. Color shall be 4000K with a minimum CRI of 80

E. Lamps:

1. LED lamps are preferred; coordinate with Facilities Electrical Engineer to determine if acceptable.
 - i. LED lamps shall be modular- that is, if the LED component fails, the LEDs can be replaced without having to replace the whole fixture. LEDs welded or riveted to the fixture housing are unacceptable.
 - ii. 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.
 - iii. LED retrofit lamps that replace existing T8 lamps shall be of the type that bypasses the fluorescent ballast. The fluorescent ballast shall be removed from the fixture.
 - iv. LED fixtures and lamps shall only be specified from companies that have been in business for at least 5 years.
 - v. LED fixtures, lamps and drivers shall include a 5 year warranty.
2. Where used, the current standard fluorescent lamp at the university is the 28-watt, high-output T-8, with a 3500K color temperature and a Color Rendering Index (CRI) of 85. With prior approval, Facilities Management-Design and Construction will allow deviations from this standard in the following instances:
 - a. Fixtures specified for projects with a high ceiling (above 12ft) may use T-5HO lamps having 3500K color temperature and a 85 or better CRI.
 - b. Specialty fixtures such as recessed cans or wall-washers may use compact fluorescent or biax lamps having 3500K color temperature and an 85 or better CRI.
 - c. Consider using extended life fluorescent lamp/ballast combinations (approx. 60,000 hours) for difficult to reach applications like atriums or gyms.
3. Incandescent lamps are prohibited in general. For special cases where incandescent lamps are essential, incandescent fixtures may be specified only with approval from Facilities Management-Design and Construction
4. Fluorescent lamps controlled with dimmer switches shall be burned in for 100 hours at full intensity before being dimmed. The Contractor is responsible for burn-in and replacement of

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failed lamps prior to Final Acceptance.

F. Ballasts:

1. Provide electronic ballasts compatible with energy saving four-foot 28 watt high-output T-8 lamps. Ballasts shall be self-protecting, high power factor, less than 10% total harmonic distortion, and compatible for use with lamps other than energy saving type.
2. When matching existing lamps in minor remodel projects, ballasts other than the above type can be considered.
3. Ballasts shall be wired with their lamps in a parallel. Series ballasts are not permitted.
4. In order to stay abreast of changes in the lighting industry, with prior approval, Facilities Management-Design and Construction will encourage deviations from the standard ballast in the following instances:
 - a. Fixtures specified for projects affecting a large portion of a building or building floor may use new technology ballasts which are at least as energy efficient as the current standard electronic ballast.
 - b. Specialty fixtures such as recessed cans or wall-washers shall use electronic ballasts.
5. All ballasts for PL compact fluorescent lamps shall be solid state with “End of Lamp Life” technology to remove the lamp from the circuit. Use of “end of life” lamps with non-protected ballasts not permitted.

G. Exit Lights:

1. Exit light hardware shall use Light Emitting Diodes (LED) as their source of illumination. Exit signs shall be Energy Star Compliant.

H. Emergency Lighting:

1. When emergency light and power is required, consideration should be given to providing an emergency generator if the load permits. Battery powered emergency lighting should be considered only when loads are too small to justify an emergency generator.

26 56 00 – EXTERIOR LIGHTING

A. Sole Source Products

1. Pedestrian Walkways Fixtures
 - a. New Areas

1. Kim Lighting, Model SAR PicoPrism, Light Grey

a. LED: 1SA-SAR-x-P-70-40L-4K-[vtg]-LG-[HSF or VSF]

2. Streets/Parking Lot Fixtures – Kim Lighting Model AR PicoPrism, Light Grey

a. LED: 1A-AR-x-P-70-80L-4K-[vtg]-LG-HSF

B. Acceptable Products

1. Pedestrian Light Poles – 15 feet above ground, round tapered fiberglass tenon top with

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adjustable slip fitter for luminaire orientation.

- a. Anchor Base
 - 1. Whatley, Model: TR45-15-AB-GRY-SMS-99
 - 2. Lithonia, Model: RTF 16 6-1X DM19 FBC DNA
- b. Direct Burial Tenon
 - 1. Whatley, Model: RT45-15-DE-GRY-SMS-23-50
 - 2. Lithonia, Model: RTFDB 20 6-6X T20 DNA

2. Street/Parking Lots – 30 feet (Above Ground) with 8 foot mast arm

- a. Direct Burial
 - 1. Whatley, Model: TR52-30-DE-GRY-SMS-DTC-MA-96-GRY
 - 2. Lithonia, Model: RTFDB 35 8-5X DM19 FBC DNA
- b. Anchor Base
 - 1. Whatley, Model: TR50-30-AB-GRY-SMS-DTC-MA-96-GRY
 - 2. Lithonia, Model: RTF 30 10-5X DM19 FBC DNA

C. Exterior Poles and Luminaires:

1. Campus design foot-candle levels are as follows:
 - a. Parking lots: .2 fc Minimum
 - b. Roadways: .3 fc Minimum
 - c. Sidewalks: .5 fc Minimum
2. General sidewalk and bike-lane illumination shall be achieved using 55 Watt LED luminaires. The color of the luminaires shall be factory light gray.
3. The luminaries shall be installed on tenons on top of 19 foot direct embedded or 15 foot anchor base, heavy-duty, round tapered fiberglass poles. The pole shall have a smooth finish of light grey color. The 19 foot direct embedded poles will be embedded 4 feet into the ground resulting in a 15-foot nominal mounting height. The design of the pole embedment shall be non-shrinkable backfill or 60psi flowfill conforming to the pole manufacturer's recommendations. The 15 foot anchor base pole shall be mounted on a 24 inch diameter caisson. If poles are within 5 feet of a parking lot curb, the caisson foundation shall be extended 30 inches above ground level to prevent vehicles from damaging the pole. See Drawing Appendix for pole and foundation details.
4. Where new sidewalk or bike-lane illumination is provided near existing 15 foot, concrete octagonal poles, use new, matching, concrete octagonal poles with bolt-down bases, if available. Foundations for these poles shall comply with the manufacturer's recommendations.
5. Conductors feeding pole-mounted luminaires shall be THWN stranded copper in minimum 1 inch PVC underground conduit. 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 percent.
6. Control of exterior luminaires shall be by photocell. Where practicable, a single photocell will activate a lighting contactor to control multiple luminaires. Where necessary, photocell control of single luminaires will be allowed. No time clocks are allowed, unless overridden by photocell.
7. Other types of luminaires used for architectural effects on or around buildings shall be subject to review and approval by Facilities Management. Exterior incandescent fixtures are not allowed. Use metal halide or LED light sources for exterior lighting wherever possible.

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8. When pole installation is complete, numeral stenciling shall be painted or equivalent as directed by the Utilities or Electric Dept. Contractor shall coordinate with the Electric Shop for pole number.
9. Bollard Lighting Systems are discouraged due to the abuse they sustain on Campus. Not allowed