DIVISION 26 – ELECTRICAL

See Part II for additional information regarding Lighting, Energy Efficiency, etc.

DESIGN CRITERIA

Verify points of connection to existing utilities with the University's Representative. All utility service, including electric, telephone, fire alarm, data, etc. are to be underground. Wire building for telephone, data, EMS, and fire alarm.

Building electrical systems should be 480/277 volts, 3 phase, 4 wire and/or 208/120 volt, 3-phase, 4-wire for lighting and power.

Harmonics - Building harmonics shall be evaluated and documented by the Design Professional. Submit harmonics report to University's Representative for review. Identify corrective measures if harmonics exceeds building requirements. Following are a few possible corrective measures: Separate neutrals for branch circuits, full size grounding, K-rated transformers, upsize panel board neutral conductor, reduce total harmonic distortion of electronic ballasts, etc. Discuss with University's Representative prior to establishing any of the corrective measures.

CORRIDOR RECEPTACLES

Provide dedicated 20-amp, 120-volt circuits to feed corridor 20-amp duplex receptacles only (4 maximum per circuit). Spacing shall be no more than 50 feet. Maximum distance from any end wall shall be 25 feet.

POWER SYSTEM STUDY

1. Perform Short Circuit, Protective Device Evaluation and Protective Device Coordination Studies. Study shall be prepared and signed by a California registered Electrical Engineer. Submit studies to University's Representative prior to receiving final acceptance of distribution equipment shop drawings or prior to release of equipment for manufacture. If formal completion of studies may cause delay in equipment manufacture, acceptance from University's Representative may be obtained for preliminary submittal of sufficient study data to ensure that selection of device ratings and characteristics will be satisfactory. Provide for both normal and emergency systems.
2. Studies shall include all portions of electrical distribution system from the point of connection, primary of service transformers down to and including 480V and 208V distribution system. Normal system connections and those which result in maximum fault condition shall be adequately covered in the study.
3. Study report shall summarize results of system study in a final report. The following sections shall be included in the report:
    a. Description, purpose, basis and scope of study and single line diagram of that portion of power system which is included within scope of study.
    b. Tabulations of circuit breaker, fuse and other protective device ratings versus calculated short circuit duties and commentary regarding same.

c. Protective device time versus current coordination curves, tabulations or relay and circuit breaker trip settings, fuse selection and commentary regarding same.
d. Fault current calculations including a definition of terms and guide for interpretation of computer printout.

4. Protective Device Testing, Calibration and Adjustment: Equipment manufacturer shall provide the services of a qualified field engineer and necessary tools and equipment to test, calibrate and adjust the protective relays and circuit breaker trip devices as recommended in the power system study.

LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES 26 05 19

PRODUCTS

Conductor - Stranded copper. Minimum size: #12 AWG, unless specified otherwise.
Insulation - THWN for wet or underground locations and THHN for dry or damp locations. Other insulation may be specified, depending on use.

Wire Connectors

1. For wires size #8 AWG and smaller: insulated pressure type (with live spring) rated 105 deg. C, 600V, for building wiring and 1000V in signs or fixtures.
2. For wires size #6 AWG and larger: compression type with tape insulation.
3. Outdoors and below grade: All sizes to be compression type with heat shrink style watertight splice covers.

EXECUTION

Install all wiring in raceways. All cables and wires passing through manholes and handholes shall be full looped inside the manhole and handhole and supported on galvanized steel racks.

Code size ground wire installed in all raceways, secured using approved methods to each pole box, junction box, and equipment housing.

Provide wire markers where number of conductors in a box exceeds 4.

Wire Color Code - Color code all conductors. Wire sizes #6 AWG or smaller shall have integral color coded insulation. Wire sizes #4 AWG and larger may have black insulation but identified by color coded electrical tape at all junction, splice, pull, or termination points. Color tape shall be applied 1/2 lap to at least 6 inches of conductor. Color Code wires as follows (confirm with University's Representative)

Conductors	120/208 Volts	277/480 Volts
Phase A	Black	Brown
Phase B	Red	Orange
Phase C	Blue	Yellow
Neutral	White	White or Gray
Ground	Green	Green

Color coding of wires used for signal and communication systems are specified under the respective sections for these systems.

TESTING

Megger and record insulation resistance of all 600 volt insulated conductors size #4/0 AWG and larger, using a 500 volt megger for 1 minute. Make tests with circuits isolated from source and load.

GROUNDING 26 05 26

The grounding system shall provide a connection to earth for the system derived neutrals, for the service equipment enclosures, and for the distribution cable shield drain wires. The grounding system shall provide control of the voltage gradient on the finished surfaces adjacent to the pad mounted service equipment. The Grounding System shall include all of the following elements:

GROUND ELECTRODES

1. Ground Grid - A cable loop in the earth, with driven ground rods, in a ring around the service equipment pad/vault, with connecting cable. Minimum of 1 grounding rod inside the transformer and 1 outside the pad.
2. UFER Ground - A length of copper cable embedded in the concrete foundation of the facility being served.
3. Metallic Piping - A connection to the interior metal piping system.

GROUND BUSES

Provide at each Service Distribution Panel for the joining of ground connections, and to provide an accessible grounding system test location. From each Ground bus make the following ground connections:

1. The metal enclosure of the associated Load Service Distribution Panel.
2. The metal tank of the associated Load Service Transformer.
3. The ground bus in the facility panelboards. This bonding cable to be run in the same raceway with the facility service feeder cable.
4. Neutral busing of each service transformer to the system neutral(s) is prohibited.

GROUND CONNECTIONS

Provide a separate copper cable connection from each of the ground electrodes to the system ground bus at each of the Service Distribution Panels. Provide the code required size of grounding conductor between the transformer secondary compartment and the building main panel ground.

MEDIUM VOLTAGE DUCT BANK GROUNDING

In the core campus area, install a 2/0 copper conductor (or larger) in all H/V duct banks. The 2/0 conductor shall be attached to the ground rods placed in the duct bank system. Ground rods shall be installed in splice locations and all equipment and material in these locations shall be bonded to the 2/0 copper conductor.

GROUND BONDS

Ground Bus to Trans Neutral..... Two No. 2/0 AWG

Ground Bus to transformer enclosure, distribution panel enclosure, cable box cover, trench cover and ground electrode loop ..... No. 2/0 AWG

GROUND RODS

Copper clad steel rods, 1-inch by the required dimension, in sectional 10 foot lengths with pointed end, driven to a depth where the rod top is not less than 6 inches below finish grade at the Equipment Pad and two inches above the floor in the Equipment Vault. Protect rod top with a driving tool while driving to prevent deformation or other damage.

CABLE CONNECTIONS

1. To Ground Rods - Exothermic weld, Cadweld or equal, utilizing weld molds furnished by the weld manufacturer and the type and size recommended by the weld manufacturer.
2. Ground Cable Splices - Exothermic weld, Cadweld, or equal, utilizing molds of the type and size recommended by the weld manufacturer.
3. To Ground Buses and to Equipment - Pressure indented copper cable terminal, one hole: Burndy HYLUG, T&B Blue, or equal. Install with inch galvanized or cadmium plated steel machine bolts with beveled washer each side.

TESTING

Grounding test shall be by fall-of potential method by an independent testing agency.

HANGERS AND SUPPORTS 26 05 29

CONDUIT SUPPORTS

Single point beam clamps not allowed. Conduits shall not be attached to ceiling support wires. For individual conduit runs not directly fastened to the structure, use rod hangers. For multiple conduit runs, use trapeze type structural channel conduit support designed for maximum deflection not greater than 1/8 inch. In new construction, conduits installed inside of walls must have approved clamp supports. No twisted wire allowed.

EQUIPMENT MOUNTING AND SUPPORT HARDWARE

Steel channels, bolts, washers, etc., used for mounting or support of electrical equipment shall be galvanized type. Where installed in corrosive environment stainless steel hardware shall be used.

RACEWAY AND BOXES 26 05 33

Sizes for conduits, unless specifically shown otherwise, shall meet the latest California Electric Code using 30% fill. Minimum conduit size shall be ¾".

MATERIALS

Rigid steel conduit with threaded fittings shall be used in the following locations:

1. Damp and wet locations including outdoor service yards and on roof.
2. Exposed locations below 8' subject to mechanical injury.
3. In concrete walls or block walls.
4. In concrete vaults.

EMT connectors and couplings shall be steel compression with insulated throat type indoors.

Wireway: Code gauge steel, with knockouts and hinged cover. Corrosion resistant gray baked enamel finish. Wireways smaller than Wiremold brand 700 are not acceptable. Wireway with preassembled devices installed are not acceptable, i.e. Wiremold 2000 and 2200.

Use flexible steel conduits with steel Tite-Bite type connectors in the following applications and install a code sized ground wire 3-foot maximum length on flexible conduit except as authorized by University's Representative:

1. Recessed lighting fixtures.
2. Motor connections.
3. Connection between fan plenum and structure.
4. At expansion joints.
5. At transformers and other equipment which produces vibration.
6. At damp and wet locations or where exposed to weather, flexible steel conduit shall be liquid tight type.

Flexible steel conduits (with code size ground wire) up to 20' in length are permitted between receptacles and between light fixtures within a single room. All home runs to panels and conduit between rooms shall be EMT.

EXECUTION

Duct shaft - Conduits shall not cross any duct shaft or area designated as future duct shaft horizontally.

Pull Strings - Install 1/8 inch diameter yellow polyline pull line in all conduits intended for future use. Tag pull lines for item served.

Sleeves – Provide at all penetrations of footings, basement walls, or floor slabs.

UNDERGROUND DUCTS AND RACEWAYS 26 05 43

In addition to the requirements listed above, the following applies to underground ducts and raceways. Provide line markers per Section 33 05 26.

PRODUCTS

Direct Burial and Concrete Encased Raceway - PVC Schedule 40 Duct and end bells except for the following locations which shall be rigid steel conduit:

1. Provide one 10 foot section of rigid steel conduit at point of penetration of foundation, footing or basement wall, with equal lengths inside and outside building line.
2. Make all risers to grade, including elbows. Risers to begin 18 inches below grade and extend 16 inches above grade.
3. Exposed in vaults.

Rigid steel conduit in direct contact with earth, sand or encased in concrete must be double-wrapped with 3M 10-mil tape or equal.

Elbows - Factory made. Use a minimum radius of 6 times trade size.

Handholes - pre-cast concrete type with structurally reinforced roadway type bolt-down galvanized steel covers and required extension collars. Units shall be provided with concrete bottoms and sumps.

EXECUTION

Multiple runs shall maintain 3-inch minimum separation between runs. Provide plastic spacers at maximum 5 feet-0 inch centers to maintain 3 inch spacing between conduits. Do not install plastic conduit in rock base. Provide double wrapped GRC elbows on runs greater than 100 feet or on runs with more than two 90-degree elbows.

PVC conduit 1-1/2 inch size and smaller shall be installed on 2 inch sand base and covered by 2 inch sand backfill. In planting areas provide 2-inch concrete cap.

Install 3" minimum concrete encasement on raceways larger than 1-1/2 inch conduit or duct banks that include two or more raceways in a single trench. Drive two reinforcing bars to anchor the conduits at 10 feet-0 inch centers to prevent floating during concrete pour.

Burial Depth

1. Concrete encased: 24-inch minimum for 600V or lower systems to top of concrete encasement.
2. Concrete capped: 24-inch minimum to top of conduit.
3. Conduits without concrete encasement or cap: 24-inch minimum to top of conduit.
4. Conduits under buildings: 18 inches below bottom of floor slab.

Handholes shall be left in a clean condition with all debris removed and with all cables supported on approved cable supports. All stubs for handholes shall be concrete encased and shall extend 5 inches beyond handhole.

All electric conduit or ducts shall be at least 10 feet from steam lines unless engineered to prevent heat damage.

TESTING

All underground conduits and ducts 2 inch and larger shall be proven clear by pulling through a mandrel 0.25 inches smaller than the inside diameter.

IDENTIFICATION 26 05 53

SWITCH AND RECEPTACLE LABELS

Provide clear color base dymo labels on all lighting switches and convenience and special purpose receptacles to show panel and circuit number to which the device is connected.

CABLE BOX AND VAULT COVERS

Bronze plate, machine engraved with Vault, Manhole, or Box designation in 3/8 inch high capital letters. Marker attached with epoxy adhesive to the cover. Cable Box and vault covers to have 'ELECTRIC' welded onto box or vault rim.

CABLE BOX RACEWAY ENTRANCES

Apply stenciled label on wall to identify destination of raceways. Use building name, equipment name, manhole number, or cable box number.

NAMEPLATES

Provide rigid plastic laminated Impact Acrylic plate, 2 layer, 3/16 inch min thickness, machine engraved with 3/8" high lettering, all caps, on black background. Provide nameplates for meters, transformers, panels, motor starters, disconnect switches and all associated devices. Black background with white letters (normal power), red background with white letters for emergency power. For remote devices (disc. switches, etc.) and all panels, indicate source of power.

WARNING SIGNS

Provide plastic laminated Impact Acrylic plate, 2 layer, 3/16 inch min thickness, machine engraved with red lettering, all caps, on white background. Lettering 2 inches high. Provide label on all motors: "Caution, Automatic equipment. May start at any time." Provide warning signs for service transformers.

FEEDER TAGS

Engraved laminated Impact Acrylic Tag: Engraved with white lettering on black background, letter 3/8 inches high with 1 piece nylon tie.

PHASE MARKERS

Cable Phase Markers: Clear plastic over wrap-to-wrap 1 –1/4 times (min) around cable. Label colored per color-coding with phase letter printed 1 inch high. Apply marker to each cable.

WIRE MARKERS

Slipon Wire Markers: PVC wire marker with permanent machine printed or embossed lettering.

LIGHTING CONTROL 26 09 23

GENERAL REQUIREMENTS

The lighting control system shall be programmable and the status readable using a USB connection to a "MS Windows" based computer operating system running the supplier's software package. Systems which require the computer to stay on-line and connected 24/7 are not acceptable.

One set of any interconnecting cables, adapters and/or software program required to operate, troubleshoot, program, display the status of or interface with the system shall be supplied. Software and cable or adapter costs shall be included in any bid.

The lighting control system manufacturing company shall be regularly engaged in the manufacture of lighting control equipment and ancillary equipment, of types and capacities required, whose products have been in satisfactory use in similar service for not less than 5 years. Systems must retain their program internally for up to one year including a loss of power. Systems must automatically restore themselves during a power outage to its condition prior to the outage. If any relay panel, control, switch or sensor shall fail, the remaining portion of the system shall continue operating with only a loss of the failing component. A loss of control input power or control operating system shall cause the lighting relays to fail in the “ON” or “Emergency” position. All relays shall have a way to place the relays in a “manual ON” bypass position for use during troubleshooting or operating system loss. The lighting control system must be able to operate in a simulated fully-operational condition for troubleshooting and programming purposes while the relays are locked in the “ON” position.

The lighting control system must have remote access ability for the factory to access the system and help troubleshoot, program, or alter the system without being on-site. This factory service must be available 24 hours a day, 365 days a year. Normal factory assistance using this connection shall be available after the required warranty period. A modem or similar device that could be connected within 100 feet to a phone line is acceptable. This modem or connection hardware shall be included in the system. If the system requires an internet access point, an empty ¾” conduit shall be run between the main access point and the designated telecommunication location.

The lighting control system shall have the capability of integrating into building management system (BAS) or energy management system (EMS) with the key feature being the ability to, but not limited to monitoring the lighting zones.

LIGHTING CONTROL SYSTEM

CENTRALIZED vs DISTRIBUTED SYSTEM ARCHITECTURE
The specification of a central or distributed system will depend on the size of the building. Centralized systems are best suited for smaller buildings while distributed systems make more sense for medium and large buildings. The benefits of a distributed system are scalability, flexibility, and reduced material/labor cost.

LIGHTING CONTROL PANELS
Lighting control panels shall be UL 916 Listed. Lighting control panels controlling emergency circuits shall be ETL listed to UL 924. Emergency source circuits controlled in normal operation by a relay panel shall fully comply with NEC 700-9(b). Electrical contractor is responsible for verifying compliance.

The lighting control panels shall contain all necessary hardware (transformers, relays, timers, fuses, switches, terminals etc.) to control and/or connect to the lighting circuits specified for

control. All lighting controls shall be pre-assembled, wired, and tested to operate as a complete integral system and shall provide the lighting control features specified in this section.

PHOTOCELLS

Photocells to be mounted in location indicated on the plans. Photocells shall produce digital outputs for their readings. Photocells used for exterior lights shall provide multiple trip points from 1 roof mounted unit. All trips points shall be able to be changed remotely via Internet or dial up modem as well as at the lighting control panel. Photocells requiring manual trip point adjustment are not acceptable. Photocells used for interior lighting control shall have multiple settings such as start-point, mid-point, off-point, fade-up, fade-down, etc. All settings shall be remotely accessible and adjustable. The photocell current reading shall be remotely readable at the lighting control panel. Photocells shall be able to be used as inputs for multiple switching or dimming circuits. Systems providing local adjustment only are not acceptable.

CORRIDORS, RESTROOMS AND LOBBY OR COMMON AREAS

Common areas shall be on at least 3 controlled relays and 4 or more if daylight harvesting is appropriate per Title 24. Multi-stage lighting levels shall be available and installed into the building's system. Subject to the quantity of light fixtures in the area, the switched circuits shall be controllable with all circuits for the designated area available at each fixture's connection point.

Minimum lighting level shall be maintained at intersections of corridors, elevator and exit doors, stairwells and building entry points. Three additional wires/switched lines shall be run to each junction box or light fixture in the same-type area to allow graduated lighting levels and daylight harvesting and/or occupancy sensor controls to be incorporated and adjusted for that area. Light fixtures will be initially identified with the appropriate circuit connection out of the three (or four) circuits, but future connection changes and all circuits must be available at each fixture without pulling new wire.

Any restroom shall have a switch at the entrance for public use that triggers the occupied level lighting. Ceiling occupancy sensor(s) shall also trigger, maintain while occupied, and when unoccupied return the lighting to the unoccupied lighting level after 15 minutes. All restrooms and corridors shall have an override switch for maintenance/custodial use within 50 feet of the restroom or corridor. A switch in the janitorial closet if within 50 feet of the area is acceptable.

INDIVIDUAL CONTROLS

Refer to Interior Lighting and Exterior Lighting sections of CSDG for individual space controls.

DIMMING SYSTEM

The campus standard for light dimming equipment has the following features.

1. Continuous dimming curve (not universal dimming as other products).
2. Field programmable feature that adjusts to a single source.
3. Published "in-rush" current information.

BALLASTS

1. Key qualifications for electronic dimming ballast performance and reliability; manufacturer shall take sole responsibility for electronic dimming ballasts and dimming controls.
2. Dimming range of electronic dimming ballasts shall be from 100 percent to 1 percent luminance level for T8 and T5 lamps.
3. Electronic dimming ballasts shall not be damaged by miss-wiring line voltage and control wire inputs.
4. Electronic dimming ballasts shall internally limit in-rush current to not exceed three amps at 277 volts or seven amps at 120 volts to avoid computer problems, nuisance circuit breaker trips, and control contact malfunctions.

DIMMERS

1. Integral Dimming - preset dimming control shall incorporate an air gap switch relay, which shall be accessible without removing the faceplate. The air gap switch shall be capable of meeting applicable requirements of Underwriters' Laboratories, Inc. (UL) 20 for air gap switches in incandescent dimmers.
2. All devices shall be UL listed specifically for the required loads (i.e., incandescent, fluorescent, magnetic low voltage transformer, and electronic low voltage). Manufacturer shall provide file card upon request. Universal dimmers shall not be acceptable.
3. All dimmers and switches shall provide power-failure memory. Should power be interrupted and subsequently returned, the lights will come back on to the same level set prior to the power interruption. Restoration to some other default level is not acceptable.
4. Manufacturer of wall box dimmers shall be the same as manufacturer of architectural dimming systems.

DIMMING PANELS

1. Panels shall be completely pre-wired by the manufacturer. The contractor shall be required to provide input feed wiring, load wiring, and control wiring. No other wiring or assembly by the contractor shall be permitted.
2. Panels shall be thermal-magnetic in construction for both overload and dead short protection. The use of fully magnetic breakers shall not be acceptable, even when used in conjunction with individual dimmer thermal cutouts.
3. Panels shall be cooled via free-convection, unloaded by fans, and capable of continuous operation to all of these section specifications within an ambient temperature range of 0 deg. C (32 deg. F) to 40 deg. C (104 deg. F).
4. Panel shall provide capability to electronically assign each circuit to any zone in the dimming system.
5. Panels using mechanical switches, rewiring, or EPROMS shall not be acceptable.

MODULAR DIMMING CARDS

1. One type of modular dimming card shall be used for all sources. Systems requiring different types of modules or modular dimming cards shall not be acceptable.

2. A positive air gap relay shall be employed with each dimmer to ensure that the load circuits are open when the “off” function is selected at a control station. These relays need not be integral to the dimming module but must be integral to the dimming panel.
3. Lighting control manufacturer shall provide and warrant both the relays and the necessary control interface(s) as part of the control system.

LIGHT SOURCES

1. Dimmers shall operate sources/load types with a smooth continuous Square Law dimming curve. Dimmers shall also be capable of operating these sources on a non-dim basis.
2. Dimmers shall be electronically assigned to the appropriate load type/dimming curve and be reassigned at any time. Universal-type dimmers that do not adjust to the dimming curve shall not be acceptable.

MEDIUM-VOLTAGE TRANSFORMERS 26 12 00

SERVICE TRANSFORMERS, PAD MOUNTED

Dead front pad mounted unit transformer (PMT), front access only, self-cooled, oil insulated, complying with the ratings. Transformers shall be installed so they are not visible to the general public (behind walls or concealed by other means).

Clearance: Maintain eight feet working clearance in front of transformers (PG&E UG-1).

Ratings -

Primary Voltage	12,470 volts
Secondary Voltage	As Specified on the Drawing
Primary Windings	Three Phase Delta, copper
Secondary Windings	Three Phase Wye, copper
Continuous kVA Rating	As Specified in the Schedule on the Drawing
Primary BIL	95 kV, minimum
Secondary BIL	30kV, minimum

Primary Connection - Loop feed, six 200 amp universal busing wells.

Primary Switching - Three, two position load break, load make switches; a switch for feeder A side, a switch for feeder B side and a switch for transformer winding. Primary switches, arranged as shown on the Drawing. Switches rated 200-amp continuous, 6000 amp for 1 second (minimum).

Primary Fusing - Internal Fault Protection: Current limiting fuses, Class E, in-tank installed. Overload Protection: Expulsion fuses, dead front Bay-O-Net installed. Furnish one spare set of fuses in original cartons.

Primary Taps & Tap Changing - Four full capacity primary taps, 2.5 percent each (2 taps above & 2 taps below operating voltage), with external operated no load tap changing switch. Switch with tap connection indicating plate readable from 5 feet away.

Secondary Connections - Spade bushings: National Electrical Manufacturers Association (NEMA) drilled copper terminal, 1.75 inch hole spacing. Provide secondary bus supports using an insulating material to prevent spade from bending due to cable weight.

Terminal Compartments - Provide terminal compartments enclosing primary and secondary cable connections and transformer auxiliary equipment. Compartments constructed of formed steel with full width and height doors for each compartment.

Compartment dimensions as follows:
Height: The maximum of 66 inches or the transformer height plus 2 inches (approx.)
Depth: 18 inches minimum, 24 inches maximum.
Width: Primary Compartment 42 inches min.; Secondary Compartment 24 inches min.

Finish - Prior to prime coating, all welds shall be ground smooth. Rust inhibiting prime coat over cleaned and degreased surfaces. Vinyl paint for finish coat all surfaces. Color shall be Munsell No. 7GY3.29/1.5 Green.

Latches - Three Point Vault Style.

Grounding Pads - Steel ground pad welded to tank wall in primary and secondary compartment. Each pad drilled and tapped for two 3/8 inch (min.) steel bolts.

Auxiliary Devices - The following is auxiliary equipment to be furnished by the transformer manufacturer with the transformer.

1. Pressure relief valve.
2. Oil Level Gauge: With normal level at full load rated temperature rise indicated.
3. Oil Temperature Gauge: Calibrated in deg. C, with full load temperature rise indicated.
4. Bronze Drain and Sampling Valve: 1-inch trade size, minimum, with FPT plugged discharge.
5. Oil Fill Connection: Capped, 1.25-inch trade size, minimum.
6. Ground Connection Pads: One each in primary and secondary compartments, drilled and tapped for two 3/8 inch steel bolts (minimum) each.

Testing - Field testing requirements for oil filled transformers to include ASTM D877 dielectric liquid test and other NETA requirements.

CAST COIL DRY TRANSFORMERS
For use in special conditions only. Approval of the University's Representative is required. The requirements for Service Transformers, Pad Mounted apply except as modified below.

Primary Winding - cast in Epoxy Resin
Secondary Winding - Encapsulated in Epoxy Resin
Core - of laminated transformer steel
Enclosure - Ventilated Steel with hinged doors and access panels

Ratings

Secondary BIL	10 kV
Secondary Connection Arrangement	Wye
Rated Ambient Temperature	40 deg. C
Rated Temp Rise, Base Rating	80 deg. C
Base kVA Rating	As Called for
Overload Rating	130 percent of Base kVA rating(min)
Maximum Losses - No Load	As called for
Load	As called for

Setting and Mounting - The assembly constructed on a steel channel base arranged for four point mounting only. The unit provided complete with vibration isolating mountings. The units each furnished complete with required anchor bolts.

Primary Service Cable - Shielded copper cable entering vertical on the primary end. Cable connected to the transformer primary bussing with two hole NEMA spade pressure connectors. Cable insulation and shield will be terminated in a slip on stress cone terminator.

Secondary Service Cable - Copper cable entering vertical on the secondary end.

LOW-VOLTAGE TRANSFORMERS 26 22 00

Dry type transformers shall be copper-wound, meeting US Department of Energy's Candidate Standard Level Three (CSL-3) efficiency. Transformers shall be designed to exceed the latest requirements of the California Code of Regulations Title 20 and Title 24 and NEMA TP-1 efficiency standards.

All sizes of transformers shall have a 115 degree centigrade temperature rise rating, K-rated and naturally ventilated (fan-assisted cooling are not acceptable). Housekeeping pads are required for floor mounted transformers. Provide external vibration isolators.

TESTING

Perform inspection and test procedures per Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems, of Inter-National Electrical Testing Association (NETA) Standard latest edition.

SWITCHBOARDS AND PANELBOARDS 26 24 00

Service to distribution equipment must be sized to their rated capacity and not the calculated load. Main circuit breaker shall have a local open and closed buttons with adjustable trip settings. All large frame circuit breakers shall be equipped with lock-out and tag-out devices. Provide 25% spare capacity. Each panelboard shall have a dedicated feeder and a hinged door-in-door cover. Provide copper bussing for switchboards and panelboards. AIC rating to conform to power

system study results. Housekeeping pads are required for the main switchboard and other electrical equipment in mechanical rooms.

TELECOMMUNICATIONS SPACE (TS) ELECTRICAL REQUIREMENTS

1. A sub-panel or at a minimum, ALL TS's shall be provided dedicated electrical service in all ADF/BDF/IDF (ER/TR) rooms. The estimated electrical load for the telecommunications space shall not exceed 80% of the panel.

2. Dedicated power circuits from shared panel boards shall be provided with both transient voltage surge suppression and electrical high frequency noise filtering.

3. If a low number of telecommunications spaces are planned, one electrical panel may serve multiple telecommunications spaces as a design alternative.

4. Sub-panels shall be located near the room entrance door, whenever possible, to conserve wall space and should be connected to an emergency power source if available to the building. Emergency power is especially important in the TS's that house Digital Loop Carrier systems to ensure voice and emergency systems remain operational during power outages that may extend past the systems battery backup capability.

5. HVAC systems shall not use the same electrical panel that is used to support telecommunications spaces.

ELECTRICITY METERING 26 27 13

Provide each new building, or portion thereof with a separate electrical meter. Major renovations shall provide new meters. Verify with the University's Representative.

POWER MONITORS

Provide one Power Monitor at each of the service transformers as part of the service instrumentation along with Current Transformers (CT's) and Voltage/Potential Transformers (PT'S), and necessary terminal and shorting blocks. Isolate the service instrumentation panel and power monitor from the distribution bussing in the switchgear with a physical barrier.

Integration with Campus System

1. The instrumentation shall integrate into and shall be capable of communication with the Campus distribution SCADA System. The Monitoring Unit shall be capable of communicating two ways with the Campus Distribution Central SCADA Unit by means of Fiber Optic Cable, RS232 or RS485 Lines, or by Modem, Ethernet and telephone lines.
2. Where more than one power monitor is installed per building, connect them together using 22 AWG, shielded, twisted pair, 4 conductor RS485 serial cable using straight-line or loop topology.
3. When using the straight-line topology, a termination resistor is required on the last meter on the line. From the first meter, install a communications cable (CAT5, serial or equal)

to the communications box that contains the fiber optic transceiver or the RS485-to-Ethernet converter and the data NAM.

Provide pre-shipment testing of the Power Monitor and Service Instrumentation Panel with written certification that the communications system, consisting of the communications converter and fiber optic transceiver, are fully operational and set to interface with the University of California, Davis Power Distribution SCADA System.

PRODUCTS

Power Monitor - Power Measurement Ltd, Siemens or equal.

1. Power Measurement Ltd model: 7650 ION, for monitoring systems greater than 600 volts.
2. Power Measurement Ltd model 7350 ION (P7350 A0B0B0A0E0A)(0-20 mA, Analog Input), for monitoring systems less than 347 VAC Line to Neutral or less than 600 VAC line to line.
3. Siemens, (greater than 347 VAC L-N, Model 9610 or 9510: Less than 347 VAC L-N, Model 9350 with 0-20 mA analog Inputs.

Communications interface: RS485 to Ethernet converter (Preferred: Lantronix UDS-10-01) or equal. Optional DB25M-Terminal block (Phoenix Contact SUBCON 25/M-SH) or equal.

FIBER OPTIC TRANSCEIVER

The Fiber Optic Transceiver shall match existing equipment connected to the Campus Utilities SCADA network to ensure consistent communications between devices and the central server. The current H&L 542B Transceiver with PML option has serial ports 1 and 2 are EIA-232. Serial port 3 is a fully opto-isolated EIA-485 port. Provide two fiber optic ports for transmitting and receiving optical loop signals over multimode fiber cable. Unit has a built in Repeater and Synchronizing circuit. Install transceiver in National Electrical Manufacturers Association (NEMA) 1 steel enclosure.

Manufacturer and Vendor

Manufacturer	Type	Cat No.	Vendor
H&L Instruments	FiberOptic	542B (PML option)	Manufacturer

Each instrumentation set shall consist of a single solid-state digital monitoring unit with front of panel display and display control. Parameters to be monitored and displayable shall include the following: Volts, Amps, kVA, kVAR, kWD, PF, kWh, and kVarh. In addition, with the Campus Central SCADA Unit, the Monitor shall be capable of voltage/current wave form analysis.

EXECUTION

Power monitors and associated components shall be mounted between 3 feet and 6 feet from the finished floor.

Conduits

1. Install a 2 inch empty conduit from the power monitor to the telecommunication building distribution frame (BDF).
2. Install a ¾ inch conduit between the power monitor and the main energy system panel.
3. The EMS contractor shall run wiring and interface the power monitor to the building energy management system for remote monitoring.

Sub-Metering
Provide sub-metering for building lighting system, plug loads, and HVAC. Consult University's Representative for additional sub-metering to meet project goal.

Programming

1. Programming shall be verified by the University's Representative upon energizing the service.
2. Programming of the monitoring units shall be done from the front panel.
3. The unit shall also be capable of down loading programming from the Campus SCADA Master Unit.
4. Key programming information (Phase Current Transformers ratio, Phase Voltage Input values, phase rotation, volts mode (wye or delta) etc.) to be clearly documented and accessible for site verification of programming during initial testing of the devices.

WIRING DEVICES 26 27 26

Wall (Local) Switches - Totally enclosed, AC rated, premium industrial specification grade, white, or match existing finish. 120/277V, 20 amps.

Duplex convenience receptacles - premium industrial grade 3 wire grounded, nylon face, rated 20 amps, 125V. Receptacles connected to emergency circuit shall be red in color, all other devices shall be white or match existing face.

Ground fault interrupter (GFI) receptacles: 3 wire grounded, white, or match existing finish, rated 20 amps, 125V. Provide waterproof lift cover for outdoor installation.

Unless otherwise noted on drawings, mounting heights of devices shall be as follows:

Switches:	42 inches
Receptacles:	18 inches

Install all receptacles uniformly with U-ground slot down. Twist lock and power receptacles, ground up.

TELECOMMUNICATIONS SPACE (TS) ELECTRICAL REQUIREMENTS
Convenience duplex receptacles shall be:

1. Mounted in each room at +18-inches AFF and horizontally spaced not to exceed 6-feet around the perimeter of the room.

2. Non-switched, 120VAC 20 Amp, duplex and divided equally on branch circuits, (i.e. all receptacles in the same room shall not all be on the same circuit). Minimum of 2 circuits shall be provided per room alternating duplexes around room with no more than four (4) receptacles on the same circuit.
3. Each receptacle shall be clearly marked with its respective circuit number.

Equipment Rack and Cabinet Electrical Requirements

1. Equipment racks identified for electronic equipment shall have the following installed:
   a. One (1) quad device box containing two (2) duplex 20 Amp, 120V AC NEMA 5-20R-spade receptacles located on separate dedicated circuits in the room sub-power panel.
   b. Device box shall be mounted on the backside of each rack 15-inches Above the Finished Floor (AFF). The placement of this device box and its EMT conduit shall not block or interfere with the equipment mounting area (rails) on either side of the rack.
   c. A minimum of 24-iches of flexible conduit shall be used to attach electrical service to the equipment rack. Flexible conduit is required to prevent the shearing of the conduit during a seismic event.
   d. Reference Division 27 11 16, Communications Cabinets, Racks and Enclosures, Fig. 31.
2. Enclosed cabinets identified for electronic equipment shall have the following installed:
   a. Two (2) quad device boxes containing two (2) duplex 20 Amp, 120V AC NEMA 5-20R-spade receptacles to separate dedicated circuits located in the room sub-power panel.
   b. One (1) device box shall be mounted toward the back of the cabinet near the top inside area of the cabinet to provide electrical power to the cooling fan(s). The second device box shall be located 15-inches above the floor toward the back of the cabinet.
   c. The device boxes and EMT conduit shall not block or interfere with the equipment mounting area (inside and outside mounting rails) within the cabinet.
   e. Reference Division 27 11 16, Communications Cabinets, Racks and Enclosures, Figure 30.
3. Special considerations:
   a. ADF equipment racks and cabinets shall have 30 Amp, 120V AC NEMA 5-30R-spade receptacles in place of the 20 Amp, 120V AC NEMA 5-20R-spade receptacles.
   b. Provide a duplex 20 Amp, 240V NEMA 6-15R receptacle for a DLC cabinet.

LOW-VOLTAGE CIRCUIT PROTECTION DEVICES 26 28 00

CIRCUIT BREAKERS

Provide molded case circuit breakers conforming to Underwriters' Laboratories, Inc. (UL) 489:

1. Breaker shall be thermal-magnetic type common trip with one operating handle and solid state 7 or 9 function trip unit.
2. Adjacent poles shall be connected to phases A,B,C, respectively.
3. Minimum symmetrical interrupting current rating shall be as indicated.
4. Connectors shall be designed for use with copper, copper clad, or aluminum conductors.
5. Mounting shall be “bolt-on” type, removable without disturbing any other breaker.

SAFETY DISCONNECT SWITCHES

Heavy duty type, 600v, HP rated for motors. All disconnect switches shall be National Electrical Manufacturers Association (NEMA) Type HD; lockable in the "Off" position. Provide defeater mechanism to bypass this mechanism.

ENCLOSED CONTROLLERS 26 29 13

MOTOR CONTROL

Motor starters need ambient compensated overload relays with single-phase protection. Starters mounted in high ambient temperatures do not provide required protection for motors. The common starter depends on an element heated by the current draw of the motor, ambient temperature adds or decreases to this. Without single-phase protection, motors will burn out when source power loses a phase. The solid-state type overload relay provides both of these protections, since it monitors the actual current the motor is drawing with built-in phase loss protection. We have utilized both the Westinghouse and Furnas solid state type starters in Motor Control Center starter replacement with good success. Provide manual thermal protection for all motors not integrally equipped with thermal protection. Include loss of phase protection. Provide power factor correction.

PRODUCTS

Overload Relay - Electronic Solid State type, (no heaters), with Phase Loss protection, short circuit protection, FLA adjustable trip over 2:1 range.

Control Voltage - 120vac unless otherwise specified. Individual mounted starters may have control transformer within enclosure. Starters mounted in Motor Control Centers to have control circuit from separate source, common to all starters. Control circuits to be disconnected when the disconnecting means is in the open position (Ref. 93 NEC 430-71), a minimum of 2 control circuit disconnect contacts to be provided, one for the starter and one for other circuits fed through the starter auxiliary contact.

Auxiliary Contacts - Each starter to have a minimum of two NO auxiliary contacts with provision to add a minimum of two more.

Selector Switch -To have HOA (Hand-Off-Auto) selector switch mounted in cover.

Pilot Light – Red LED pilot light mounted in cover to be activated through a starter auxiliary contact, (not across the coil, or parallel with the coil).

Starters for fractional horsepower 120V motors shall be manual type unless shown otherwise, equipped with built-in overload protection and pilot light.

VARIABLE-FREQUENCY MOTOR CONTROLS 26 29 23

The Variable Frequency Drive (VFD) assemblies for use on a standard NEMA Design B induction motors shall be UL listed, as one entire assembly, and bear the UL label. All circuit boards shall be completely tested and burned-in prior to assembly into the completed VFD. Factory test complete VFD to ANSI/UL Standard 508. Functionally test all options, perform dynamometer test at full load, cycle load and speed during factory tests. VFD manufacturer shall have a failure analysis laboratory to evaluate the failure of any component. Provide power factor correction.

A site-specific preliminary harmonic analysis, showing total voltage harmonic distortion (THD) and total current harmonic distortion without additional external devices or external filters must be submitted. Compliance shall be empirically verified by the VFD manufacturer with onsite field measurements of the harmonic distortion at the point of common coupling with and without VFD's operating. The building distribution transformer(s) shall be the point of common coupling. In the event that field measurements demonstrate that harmonic distortion exceeds the levels claimed by VFD manufacturer, then VFD manufacturer shall provide and install (at no additional cost to the University) the equipment required to reduce harmonic distortion to acceptable levels.

Warranty - The VFD shall be warranted against defects in material and workmanship for a period of 36 months from the date of shipment or 24 months from date of start-up, whichever is longer. Additional warranty coverage shall be available in the form of an annual service agreement at an annual fee based on the capacity of the VFD.

PRODUCTS

The VFD shall be of an advanced Pulse Width Modulation (PWM) type capable of achieving full motor performance with no de-rating of motor output due to current waveform distortion. The VFD must be capable of operating multiple motors in parallel with the ability to switch motors on and off independently via external contactors. VFDs shall be manufactured by Asea Brown Boveri (ABB), Graham/Danfoss, Siemens, or equal.

1. The VFD shall include the following ratings, adjustments, and parameters:
    a. Power unit rating: 100 percent continuous, 110 percent intermittent for one minute when previously operating at full load.
    b. Minimum efficiency: 98 percent at max. output; 92 percent at 50 percent output.
    c. Power Factor
        1) Displacement > 0.95
        2) True (Including Harmonic Distortion) > 0.85
    d. Rated input voltage: 480V, 3 phase, 60Hz and 230V 60Hz available.
    e. Output voltage: 0-480V or 0-230V 60Hz.
    f. Allowable wire length to motor: 200 ft. (unless VFD schedule shows greater wire length).
    g. Automatic motor tuning.

2. The VFD must be capable of operating in the following service conditions:
   a. Ambient Temperature: 0 to 40 degrees C (32 to 104 degrees F).
   b. Relative Humidity: 0 to 95 percent, noncondensing.
   c. Elevation: 0 to 3300 ft. (100 meters) above MSL.
   d. AC line voltage variation.
      1) 480 V: 440-10 percent to 500+10 percent; 45-65 Hz
      2) 230 V: 200-10 percent to 230+10 percent; 45-65 Hz
3. Singularly, each VFD shall produce a maximum of 3 percent harmonic voltage distortion (THD) without additional external devices or external filters, and simultaneous operation of multiple VFD's shall not add more than 5 percent total harmonic voltage distortion back to the bus when measured at the point of common coupling without additional external devices or external filters. The building distribution transformer(s) shall be the point of common coupling.
4. Each VFD shall consist of a converter, inductor, and inverter section. The input of the VFD shall be ground fault protected and require no isolation transformer. In addition, the input of the VFD shall be able to withstand switching of the input line power up to 20 times per hour without damage.
5. The power section shall allow the following faults to occur without damage to the VFD:
   a. Single-phase fault or three phase short circuit.
   b. Phase to ground short circuits.
   c. Severe overloads.
6. The VFD must withstand unlimited switching of the output under full load without damage to the VFD. Operation of code required disconnect switch on load side of drive, whether motor is operating or not, shall not have any adverse affect on the drive. Control conductors from the disconnect to the drive shall not be required for safe and reliable operation of the drive. To ensure safety of the equipment, the VFD shall include these protection features:
   a. Over current protection.
   b. Over speed protection.
   c. Power unit over temperature protection.
   d. Electronic Thermal motor protection.
   e. Responsive reaction to motor winding temperature detectors.
7. The VFD shall be a NEMA enclosure as specified in the VFD schedule, designed for wall mounting. All standard and optional features shall be included within the VFD enclosure, unless otherwise specified.
8. A stand-alone PID controller shall be standard in the drive, allowing a pressure or flow signal to be connected to the VFD, using the microprocessor in the VFD for closed loop control.
9. Minimum of 500 milliseconds power loss ride through without drive trip or loss of programming.
10. The VFD shall operate satisfactorily when connected to a bus supplying other solid-state power conversion equipment which may be causing up to 10 percent total harmonic voltage distortion and commutation notches up to 36,500 volt microseconds.

Adjustments

1. VFD adjustments shall be set digitally via menu driven selections accessible from the front panel of the VFD and include the following:
   a. Max. Speed: 0-200 percent base speed (0 to 120Hz).
   b. Min. Speed: 0-200 percent base speed (0 to 120Hz).
   c. Jog Speed : 0-200 percent base speed (0 to 120Hz).
   d. Independent accel/decel time: 0.1 to 1,800 seconds.
   e. Current Limit: 0 to 100 percent cont., 160 percent for up to 1 minute.
   f. Torque Characteristics: Variable.
   g. Start Voltage (Voltage Boost).
   h. Start Compensation (Volts per Amps Boost) 0 to 20V/A.
   i. Dynamic Slip Compensation: 0 to 200percent. Speed regulation: 0.5percent with up to 90 percent load change.
   j. Starting Torque at motor shaft: 160 percent.
   k. Four Independent Parameter sets.
   l. RS-485 Serial Communications.
   m. Programmable Carrier Frequency 2-14 kHz.
   n. Flying Start into motor rotating in either direction without creating fault.
   o. Four bypass frequencies w/ adjustable bandwidth.
2. The VFD shall operate in the AUTO or MANUAL modes and, as a minimum, shall include the following front panel mounted switches and indicators:
   a. 2 line by 14-character alphanumeric English language display with ability to exhibit any two parameters simultaneously. (Code numbers are not acceptable.) LCD displays shall be backlit.
   b. Local/Remote switch.
   c. Digital indicator of freq., current, volts, torque, Hp, kW, kWhrs, Motor or VFD Electronic Thermal Relay (ETR), Run Hours.
   d. Manual speed control.
   e. Run / Stop Switch.
   f. Fwd / Rev Switch.
   g. Power on and run indicator.
   h. Fault indication including: current limit, over voltage, under voltage, overload, or thermal motor protection.
3. The VFD shall have provisions to lock out unauthorized access to alter or reprogram the VFD's set points.

Control Requirements

1. The VFD shall be capable of operation with either a two wire maintained contact motor control circuit or a three wire start/stop momentary contact motor control circuit. The VFD shall have an automatic restart circuit to automatically return the drive to full operation after a protective trip. The number of restart attempts, attempt duration and time between reset attempts shall be programmable. In addition, the VFD must accept the inputs and provide the outputs listed below:
   a. Analog input: 0-10Vdc, 0-20mA, 4-20mA, 20-0mA or 20-4mA. Linearity deviation between control signal and motor speed: +or-1 percent of rated motor speed.

b. Digital Inputs: 8 each programmable for reset, start, stop, quick stop, reversing, change to preset speed (up to 8 preset speeds), change parameter set, increase speed, decrease speed, current limit over ride.
c. Analog outputs: 2 each programmable to provide 0-20mA or 4-20mA proportional to frequency, torque, current or power (Kw).
d. Digital outputs: 2 each programmable to indicate ready, run, trip, current above preset, frequency above preset, or electronic thermal overload.
e. Input for motor thermocouple.

2. The drive control card shall be fully interchangeable between all drive sizes fractional through 300 HP to provide a consistent user interface, including display, keypad and terminal connections.
3. All control input and output terminals are isolated from power and ground with isolation capable of withstanding 2,500 volts RMS for one minute.

BYPASS

Review VFD Bypass requirements with University's Representative.

Manual Bypass

1. Manual transfer to line power shall be via 3 contactors sized for applicable voltage and motor current. One contactor shall be between the VFD output and the motor. The second shall be between the bypass power line and the motor, providing across-the-line starting. The third contactor shall be between the line voltage and VFD input. Transferring load via contactors shall disconnect VFD inputs from line voltage and outputs from the motor, thus providing the ability to safely trouble shoot and test the VFD while operating in the bypass mode. A fused disconnect switch is required. Bypass and VFD output contactors to be electrically and mechanically interlocked to prevent both being closed at the same time. Include motor thermal overload protection in bypass and VFD modes. If the drive can provide the bypass feature as an integral part of its construction, this shall be acceptable.
2. Provide two 3-position selector switches to control bypass contactor and the VFD input and output contactors: 1) Normal-Off-Test and 2) Drive-Off-Bypass. Selector switches to have pad-lockable switch covers.
3. Door mounted status lights shall include power on, drive, bypass, and safety.
4. Provide terminal strip for connection of fire, smoke contacts, external start command and VFD control signal. All external interlocks shall function in hand, auto, or bypass. External start/stop signal to be functional in auto and bypass modes.
5. 120 vac control power to be supplied by fused transformer.
6. Provide NEMA 1 enclosure for bypass components. NEMA 4 enclosure required for outdoor applications. Bypass and VFD enclosures to be factory wired and assembled on a common back-plate.
7. Manual Bypass and Accessories to be furnished and mounted by the VFD manufacturer.
8. Two contactor bypasses and knife switches are not acceptable.

Automatic Bypass with Magnetic Contactors

In rare applications, such as critical service pumps with no secondary pump for backup, the VFD shall be specified with automatic bypass. The automatic bypass shall include all of the features specified in the manual bypass plus the following additional feature: Output from the VFD run contact shall control the contactors so that a VFD failure shall automatically transfer the motor to across-the-line starting.

EXECUTION

Install VFD in dry, clean and accessible area. Provide appropriate environmental conditions for VFDs to allow them to dissipate heat effectively. Provide filtering as required.

SHAFT GROUNDING

Modern AC or DC variable speed motors have been shown to develop an electrical potential between the shaft and the frame of the motor. Shaft-to-frame voltages above 3 volts generally cause current flow across the bearings. When current flows across a bearing, metal is transferred causing frosting, pitting, and fluting of the bearing races resulting in premature failure of the bearings. Grounding the shaft to the frame provides a path for the current to flow around the bearings eliminating the bearing damage caused by shaft potentials. All VFD s installed on campus for fan and pump motors without insulated bearings shall include a shaft grounding brush, designed to reduce shaft voltage levels to less than 3 volts, as manufactured by Shaft Grounding Systems, Inc. Minimum brush wear life expectancy is 3 years.

Seals - In systems designed for wet, or severe, environment applications, the brush contact area shall be sealed to keep contaminants from entering the Shaft Grounding System.

PACKAGED GENERATOR ASSEMBLIES 26 32 00

GENERAL

Generators must comply with Yolo-Solano Air Quality Management District (Y-S AQMD) Rule 2-32 (Stationary Internal Combustion Engines), meet the new State "Air Toxic Control Measures" (ATCM) emission standards for particulate matter (PM), and "California Air Resources Board Tier Certification Standards for off-road compression-ignition (diesel) engines." The PM emission rate shall be less than or equal to 0.15 g/BHP-hr. Authority to Construct (ATC) must be obtained from the air district prior to installation or operation of generators. The Engine Generator assembly and the Transfer Switch are to be furnished as one complete operating system and factory built, tested and shipped by a single manufacturer.

Technical support & service - The Manufacturer shall provide through a single source supplier who will be the Manufacturer's authorized local representative, initial start-up services and be responsible for conducting field acceptance testing. To have factory trained service technicians to provide 24-hour service availability who are qualified to isolate and correct any typical malfunction of the Engine, Generator, Voltage Regulator system control, Automatic Transfer Switch, and implement repair. The Supplier shall have service facilities within 80 miles of the Davis Campus.

Furnished Documentation - Provide all computer operating software, hardware and associated licensing that is specific to a particular unit (in addition to what may be generic to all units), such as special programming software and hardware used to interface between laptop and generator. Provide in-power PC based service tool for engine and generator adjustments and maintenance diagnostics with correct dongle for interfacing and adjusting engine, generator and automatic transfer switch. Total of three (3) sets of software.

Warranty - A warranty by a generator set manufacturer which places responsibility on the engine or generator manufacturer shall not be acceptable. Warranties shall start per the Contract Documents and extend for 2 years.

PRODUCTS

The Electric Engine Generator System shall be rated by the manufacturer for “standby” operation for 3 phase, 4 wire, 60 HZ at 1800 RPM (KW, KVA, and Volts, as specified at 0.8 PF). The engine and generator housings to be mechanically connected together mounted on a heavy-duty steel base with vibration isolators. Base shall be high enough to easily drain the engine oil. An engine oil drainpipe and valve assembly shall be installed by the manufacturer, to extend outside the base. The engine oil and fuel filters shall be spin-on type. Provide rodent protection for the entire generator package unit (the Unit shall be screened to prevent mice and rates to enter the unit).

Provide outside security light on both emergency and normal power and inside light and a convenience receptacle on both emergency and normal power. Provide water access within 25 feet.

Provide work platforms around generators with sub-base fuel tanks 300 gallons or larger with sub-base height of 18 inches or more. Platforms to be at all generator access doors. Platforms are to include guardrails and access ladders. Access panels must have ability to fully open with platform in place. The system shall have the following electrical characteristics:

1. Voltage regulation shall be within 2 percent of rated voltage.
2. Frequency regulation shall be within 5 percent from steady state no load to steady state full load.
3. Harmonic distortion - The sum of AC voltage waveform harmonics, from no load to full linear load shall not exceed 5 percent of rated voltage. No single harmonic shall exceed 3 percent of rated load.
4. Telephone Influence Factor (TIF) shall be less than 50 per NEMA MGI-22.43.

Engine - Four-cycle, 1800 RPM. Water-cooled, Rated to operate at 10 percent overload for one hour at specified elevation and ambient limits. Turbocharged, after-cooled, and timing retard.

Engine Emissions - Y-S AQMD certified catalytic converters may be required to comply with the new ATCM emission standards. Engines equipped with a certified catalytic converter shall be provided with an exhaust stack thermometer and pressure gauge installed on upstream side of the catalytic converter.

Provide a permanent load bank for generators sized at 500-KW or larger. The load bank shall be a complete system with all necessary controls, wiring, and devices to provide a functional system. The load bank shall have field configurable capability to provide automatic loading, automatic exercise, regenerative control, base loading and manual loading capability. Sizing of load banks may be reduced to 70 percent of the total generator capacity. The load bank shall be forced air cooled. The cooling fan(s) shall be an airfoil profile with direct drive by a three (3) phase, TEFC, 1800 RPM induction motor. The motor shall be rated at the maximum brake horsepower of the fan propeller for the applied static pressure load, temperature and altitude parameters. For generators sized at less than 500-KW, provide provisions for future connection (additional lugs for hook-up) of a portable load bank.

Fuel - Diesel (preferred for ease of reserve fuel requirements), or natural gas and propane with manual changeover dual fuel system (to meet requirements of "On-site Reserve Fuel Supply", Re: National Electric Code, NFPA70, 700-12 b & c). Provide fuel leak detection system in fuel tank, complete with wiring and controls.

Engine Jacket Heater - Thermal circulation type with internal thermostat and heavy duty relay type contactor sufficient to handle the current requirements of the heater. (Thermostat normally furnished with unit does not have contact rating for long life). Provide shut off valves for block heater.

Generator

1. Shall be single bearing, self-aligning, four pole brushless synchronous type, revolving field, with amortisseur windings, and direct drive centrifugal blower for proper cooling and minimum noise. No brushes will be allowed. Generator shall be direct connected to the engine flywheel housing, generator shaft to be connected to the engine flywheel by a flexible stainless steel plate to insure permanent alignment. Gear driven generators are not acceptable. Generator design shall prevent potentially damaging shaft currents.
2. Insulation shall meet NEMA class F. The maximum temperature shall not exceed 105 degrees C at 40 degrees C ambient.
3. The 3-phase broad range reconnectable generator shall have 12 leads brought out to allow connection by user to obtain any of the available voltages of the unit.
4. Voltage Regulator shall be temperature compensated, solid-state design, and shall function by controlling the exciter magnetic field between stator and rotor. Shall be of an asynchronous pulse width modulated design that is insensitive to severe load induced wave-shape distortion from SCR or Thyrister circuits such as those used in battery charging (UPS) and motor speed control equipment (VFD). Regulator design shall include a torque-matching characteristic to allow the engine to use its fullest power producing capacity (without exceeding it or over compensating) at speeds lower than rated, to optimize motor starting capability and provide the fastest possible recovery from transient speed dips. Regulators that use a fixed volts per Hertz characteristic are not acceptable.
5. Exciter shall be three phase, full wave, rectified, with heavy-duty silicon diodes mounted on the common rotor shaft and sized for maximum motor starting loads. Systems using

three wire solid-state control elements (such as transistors or SCR's) on the rotor shall not be acceptable.

6. Provide an exciter field automatic circuit breaker, mounted on the control panel, of the manual reset only type (cannot be used as a manual disconnect) for protection of exciter field and regulator.
7. Provide fixed service ladder to roof enclosure for all combination type 500 kw and larger generators and tank packages.

Control Panel

1. The control shall have automatic remote start capability. A panel mounted selector switch shall stop the engine in the STOP position, start and run the engine in the RUN position, and allow the engine to start and run by closing a remote contact when in the REMOTE position.
2. Provide a generator mounted control panel for complete and control and monitoring of the engine and generator set functions. Panel shall include automatic start/stop operation; adjustable cycle cranking, digital AC metering (0.5% true rms accuracy) with phase selector switch, digital engine monitoring, shutdown sensors and alarms with horn and reset, adjustable cool-down timer and emergency stop push-button. Panel shall incorporate self-diagnostics capabilities and fault logging. Critical components shall be environmentally sealed to protect against failure from moisture and dirt. Components shall be housed in a NEMA 1/IP22 enclosure.
3. Provide the following digital readouts:
   a. Engine Oil Pressure
   b. Coolant Temperature
   c. Engine RPM
   d. System DC Volts
   e. Generator AC Volts
   f. Generator AC Amps
   g. Generator Frequency
   h. KW Meter
   i. Percentage of Rated Power
   j. KVA Meter
   k. KVAr Meter
   l. Power Factor Meter
   m. KWHR Meter
4. Provide a 12 light engine monitor on the control panel; 1 red light for each of the 4 shutdowns (except the remote manual stop), and 1 yellow light each for the high engine temperature and low oil pressure pre-alarms, and 1 green run light, a flashing red light to indicate the generator is not in the automatic start mode, a yellow light to indicate low coolant temperature, a yellow light to indicate low fuel, and 2 red lights for auxiliary use (for a total of twelve lights). A panel-mounted switch shall reset the engine monitor and test the lamps. The engine generator starting batteries shall power the monitor. Operation of shut down circuits shall be independent of indication and pre-alarm circuits. Individual relay signals shall be provided for each indication for external circuit

connections (not to exceed 1/2 amp draw) for a remote annunciator. A common contact for external connection to audible alarm shall be provided. Auxiliary contacts: Supply auxiliary output contacts to monitor engine alarm panel remotely.

5. The NEMA 1 enclosed control panel shall be mounted on the generator set with vibration isolators. The control shall include surge suppression for protection of solid state components. A front control panel illumination light with ON/OFF switch shall be provided. Control panel mounted meters and devices shall include; Engine oil pressure Gauge, Coolant Temperature Gauge, DC Voltmeter and Running Time Meter (hours); Voltage adjusting rheostat, Locking screwdriver type to adjust voltage +/- 5 percent from rated value; Analog AC Voltmeter, dual range, 2 percent accuracy, Ammeter, 2 percent accuracy, Analog Frequency Meter 45-65 Hz. +/- 0.6 Hz accuracy; 7 position selector switch.

Accessories - The following are to be furnished by the manufacturer/supplier as part of the complete engine generator system; starting batteries, sized as recommended by the manufacturer with battery cables and connectors, battery tray, battery charger powered by 120 VAC (this is in addition to the alternator mounted on the engine).

STANDBY POWER

Emergency generator alarms shall be interfaced with the campus remote monitoring system.

TRANSFER SWITCHES 26 36 00

Transfer switch to have a full rated neutral with lugs for NORMAL, EMERGENCY and LOAD neutral conductors inside cabinet (4 pole with a switched neutral). Equipped with direct acting linear operators for simple, reliable and fast acting during automatic operation.

Switch - Factory equipped with the programmed transition delay feature. This feature shall provide a field adjustable time delay during switching in both directions, during which time the load is isolated from both power sources, to allow residual voltage of motors or other inductive loads (such as transformers) to decay before completing the switching cycle. The programmed transition feature shall have an adjustable time of 0 to 7.5 seconds minimum.

Signal - Provide a signal before transfer contacts, adjustable from 0.1 to 10 seconds, to send to elevators or other controls prior to transfer.

Front Panel Devices - Provide devices mounted on front of main cabinet door consisting of switch position indicator lights, white NORMAL, amber EMERGENCY, normal source available green, emergency source available red, and key operated switch to provide the following positions and functions. TEST; simulated normal power loss to control unit for testing of generator set, including transfer of load.

Provide analog AMMETER, VOLTMETER and FREQUENCY METER.

INTERIOR LIGHTING 26 51 10

Lighting levels shall conform to Illuminating Engineering Society of North America (IESNA) standards (see the IESNA Lighting Handbook: Reference & application or the IESNA Lighting Ready Reference). Zone lighting or task lighting shall be utilized whenever energy efficiency can be improved by these measures. See CSDG Part II, Energy Efficiency Requirements for additional information. Refer to the "Residential Lighting Design Guide: Best Practices and Lighting Designs to Help Builder Comply with California's 2005 Title 24 Energy Code" published by the California Lighting Technology Center (CLTC) for residential lighting guidelines.

USER CONTROLABILITY OF LIGHTING

Provide individual lighting controls for the building occupants, enabling adjustments to suit individual task needs and preferences. Provide lighting system controllability for all shared multi-occupant spaces enabling adjustment to meet group needs and preferences.

For large open spaces such as open plan offices, consider the size of the space and the potential for additional zones of lighting control. Observe the space and determine how the area may be divided and where the additional lighting controls would be in relation to the location of the occupants in the each area. Use 1,000 square feet as a general rule of thumb for the size of the area. Review the plan with the University's Representative for approval.

LIGHTING CONTROLS

See Section 26 09 23 for additional lighting control requirements.

OCCUPANCY SENSORS

Follow the table below for occupancy sensor applications.

Application	Sensor Technology	Mounting Location	Operating Mode	Special Considerations
Bathroom	Ultrasonic	Ceiling	Auto On/ Auto Off	Required for 2 water closets or more with connected load of 150 watts or more
Lecture Hall, Classroom	Dual Technology	Ceiling	Manual On/ Auto Off	
Laboratory	Dual Technology	Ceiling	Manual On/ Auto Off	
Hallway, Stairwell, Lobby, Common Areas	Passive Infrared	Wall, Ceiling, Corner	Auto On/ Auto Off	See Special Applications
Private Office	Passive Infrared	Wall	Manual On/ Auto Off	Adaptive Learning, Off Alert, Limited Occupancy, Bi-Level Switching

Open Plan Office	Dual Technology	Ceiling	Manual On/ Auto Off	May need to overlap sensor coverage
Gymnasium	Passive Infrared	Ceiling	Auto On/ Auto Off	
Library Stacks	Passive infrared	Corner	Auto On/ Auto Off	
Cafeteria	Dual Technology	Ceiling	Auto On/ Auto Off	

DAYLIGHT HARVESTING SYSTEMS (PHOTOSENSORS)

Follow the table below for daylight harvesting applications.

Application	Control Loop Version**	Electric Lighting Control
Classroom*	Open-Loop or Closed-Loop	Step Dimming
Lecture Hall*	Open-Loop or Closed-Loop	Step Dimming
Laboratory*	Open-Loop or Closed-Loop	Continuous Dimming
Hallway, Stairwell, Lobby, Common Areas	Closed-Loop	Switching
Private Office	Closed-Loop	Continuous Dimming
Open Plan Office*	Open-Loop or Closed-Loop	Continuous Dimming
Gymnasium	Open-Loop	Switching
Cafeteria	Closed-Loop	Step Dimming

* The use of an open-loop or closed-loop system will depend greatly on the size of the space, size of the windows, and use of the space. Typically, an open-loop system will be used for a larger area while a closed-loop system will be used for a smaller area. Consult the manufacturer for more information regarding the appropriate system to use.

** The control algorithm implemented within the version will depend on the manufacturer and zone control will depend on the size of the space.

AUTOMATIC TIME SWITCH

Provide Automatic Shut-Off Timer Switch for bulletin board lighting (15 minutes maximum ON time) and janitor closets/utility rooms (4 hour maximum ON time).

GLARE REDUCTION

Exterior

Design interior lighting so that the angle of maximum candela from each interior luminaire as located in the building shall intersect opaque building interior surfaces and not exit out through the windows OR maintain all non-emergency lighting on a programmable timer that turns lighting off during non-business hours. Provide manual override capability for after hours use.

Interior

Minimize glare from exposed lamps and avoid fixtures with high brightness.

FIXTURES

The use of incandescent or halogen fixtures must be approved by the University's representative in writing. If a high color rendering lamp or point source of light is necessary, consider the use of 130-volt halogen lamps. In rooms where incandescent lighting and fluorescent lighting are provided for different uses, provide an interlock so that only one type of light source can be used at one time.

Interior fixtures shall be standard manufacturer models with standard colors and finishes or match existing. All custom colors and finishes shall be approved in writing by University's Representative. Low brightness lenses shall be utilized for offices, classrooms, and laboratories.

LAMPS AND BALLASTS

The preferred lamp is a 25 watt, reduced wattage, 4 foot, T8 lamp (F25T8) due to its energy savings potential. There are situations where a reduced wattage lamp should not be used and a 32W, standard wattage 4 foot, T8 lamp (F32T8) must be used. The conditions where a reduced wattage lamp is unacceptable are:

1. If the ambient temperature around the lamp is below 70F for a F25T8 lamp.
2. If used on a dimmable ballast.
3. If used in an air handling fixture or near an air handling unit.
4. If used on an emergency inverter ballast.
5. If its use will lower the light level below the IESNA recommendations.

Suggested Minimum Ballast Product Quality Requirements

1. Ballast shall have a 3 year manufacturer's warranty and shall have been on the commercial market for a minimum of two years. Ballast shall be UL listed Class P and sound rated A.
2. Ballast must be instant start or program start. Cannot be a hybrid (magnetic front end with electronic backend).
3. Ballast shall maintain light regulation of +/- 10 percent with +/- 10 percent input voltage variation.
4. Current total harmonic distortion shall be less than 10 percent.
5. Flicker shall be 15 percent or less with any lamp suitable for the ballast.
6. Ballast shall be designed to withstand line transients per IEEE 587, Category A.
7. Ballast shall meet FCC Rules and Regulations, Part 18.
8. Ballast shall operate at 20 kHz or greater.
9. Ballast shall have a power factor greater than 0.90.
10. Maximize use of 3 and 4 lamp ballasts.

Suggested Minimum Lamp Product Quality Requirements

1. Specify 4100 Kelvin for F32T8 lamp's correlated color temperature (CCT) except residential which should use 3500K.
2. Specify 800 series for F32T8 lamp's color rendering index (CRI).
3. Specify high performance series for F32T8 lamp (minimum lamp life of 20,000 hours for instant start operation at 3 hours per start).

4. The University encourages the use of the LED light sources where appropriate.

SPECIALTY APPLICATIONS

Use bi-level luminaires in stairwells. A bi-level luminary integrates an occupancy sensor into the fixture which either switches one lamp off or “dims” the entire fixture to a maximum of 50% when the space is vacant.

Use Integrated Classroom Lighting Systems (ICLS) in classrooms. ICLS is a design approach developed by the California Energy Commission though the PIER program. An ICLS integrates suspended fixtures with occupancy sensors, entry switches, and teacher control keypad into one package that provides reduced connected load, improved lighting quality, and improved occupant satisfaction.

Use task/ambient lighting in offices, laboratories, and other task/ambient oriented spaces. Task/ ambient lighting approach involves using tasking and ambient lighting to get the appropriate light level need to perform a task. Using the task/ambient lighting approach, energy efficient task lighting (such as the Integrated Office Lighting System – IOLS) should be specified thus allowing the ambient lighting power to be reduced. Ensure the CCT of the general and task lighting match.

Laboratories should incorporate best practices as applicable from the "Labs for the 21st Century: Best Practice Guide – Efficient Electric Lighting in Laboratories" (http://www.labs21century.gov/pdf/bp_lighting_508.pdf) including:

1. Use indirect/direct lighting fixtures with at least 70% up light and at least 5% down light.
2. Make all light measurements 12" in from edge of work surfaces at 24" increments along the length of the work surface.
3. Evenly distribute the illumination over the full length of the bench.
4. Pay attention to reflective surfaces and glare.
5. Where a large amount of daylighting is available, the use of a higher CCT may be appropriate.
6. Provide a locally controlled task light level not to exceed 100 fc at 12" in from edge of work surface at all locations where critical task work may be performed. Tailor the light level to the specific task, closer to 100 fc for critical work, closer to 50 fc for non-critical work.
7. Match task lamp color temperature to general illumination color temperature.

TELECOMMUNICATIONS SPACE (TS) LIGHTING REQUIREMENTS

Room Lighting shall be mounted a minimum of 8-feet, 6-inches above the finished floor. Provide a minimum equivalent of 50 foot-candles when measured three feet AFF. Locate the lights parallel to the front and back of the equipment racks on both sides and in the middle of all aisles between racks or cabinets. Recommend at least one light fixture be on an emergency power circuit, if available in the building. Lighting shall not receive power from the same electrical distribution panel breaker as the telecommunications equipment in the TS.

EXIT SIGNS 26 53 00

Emergency EXIT signs are to be the LED type. Maximum wattage per sign shall be less than 7 watts and the minimum warranty shall be 5 years. Signs are to be painted white and use green LED’s. Tritium exit signs are specifically prohibited for use on the UCD Campus.

EXTERIOR LIGHTING 26 56 00

New installations shall comply with the latest edition of the (IESNA) Lighting Handbook and California Building Code Title 24. Light areas where exterior lighting is specifically required for safety and security. A photometric study is required to ensure the minimum lighting levels are met for each application category.

Lighting controls shall be on a separate independent circuit from the lighting circuits. All exterior lighting systems shall be individually metered at the source. Provide two switched conductors to each exterior fixture. Conductors should be located such that any fixture can be changed from one conductor to the other with minimal effort.

Lighting Control Panels for all Street, Path, and Parking Lot lighting shall be located outside of buildings. Pad mount Type 3R Galvanized & Painted Metered Service Enclosure (TESCO preferred, or equal) with a 277/480V 3 Phase 4 wire system. Panel shall include the following:

- 100/3 circuit breaker (MAIN DISCONNECT).
- 1 - 480/120 control voltage step down transformer.
- 1 - 20/1 120 volt circuit breaker (CONTROL VOLTAGE).
- 12 - 20/1 277 volt circuit breakers.
- 9 spare circuit locations for future use.
- 3 - 20 amp 4 Pole lighting contactors with 120 volt coils.
- 1 - Hand / Off / Auto (H.O.A.) test switch.
- 1 - 120 volt service receptacle.
- Photo cell.
- Digital / Astronomical time clock with battery backup (INTERMATIC preferred, or equal).
- Street, Path or Parking Lot Light nameplate locations as required.

Foundations: The hole for the foundation shall be augured or hand dug, any exception shall be pre-approved by the University's Representative. Anchor bolts installed in foundations shall be provided with double nuts and washers. Anchor bolts will be set in place and supported by the use of a template to maintain the true bolt circle before the concrete is poured. The University's Representative shall inspect the work before the concrete is poured and must be contacted 48 hours before the scheduled pouring. The top of the foundation shall be three (3) inches above finished grade, trowel finished and level. Surplus excavation shall be disposed of by the contractor.

Provide emergency exterior egress lighting to adjacent public right-of-way.

APPLICATION CATEGORIES

Table-1 presents the six major lighting categories deployed on the Campus. The physical attributes and performance criteria described for each category are based on commercially available technologies at time of this specification's release. The lamps used in these fixtures include Induction Fluorescent (IF), Metal Halide (MH), High Pressure Sodium (HPS), and LED technology. Examples of source technologies currently in service on the Campus are provided as a reference in Table 1 and the specific fixtures in service establish the minimum acceptable performance criteria. Contact the Campus representative for information on these fixtures (performance and style) to ensure compliance with this standard.

The fixture style attribute is included only as a generic label for the acceptable luminaire in each category. All new fixtures must adhere closely to the aesthetic form factors noted in Table -1. Bollard fixtures shall not be used on any applications.

Unless otherwise noted, the following criteria shall apply to all fixtures:

1. All sources shall have an efficacy of 70 Lumens/Watt.
2. All fixtures shall be designed to minimize light pollution and glare, while meeting the light distribution requirements for a given category. A designation of full cutoff shall be considered one measure of compliance, but not the sole criteria in evaluating a fixture's ability to minimize light pollution and glare.
3. All fixture ballasts shall be electronic and have a minimum electrical efficiency of 80 percent.

EXECUTION

1. A 13 in. wide by 17 in. wide by 12 in. deep pull box shall be located within 3 feet of any street, path or parking lot light foundation. All conduits leaving the control panel to the pull boxes adjacent to each street, path, or parking lot fixture shall be 2 in. P.V.C. Conduits from pull boxes to individual street, path, or parking lot fixture shall be 1 in. P.V.C. unless otherwise specified.
2. All vehicular street lighting electrical circuits shall be multi-staggered circuits. Street lighting systems will be effectively grounded at the source. All conduit runs to contain a grounding conductor. Grounding electrodes shall not be installed at individual streetlights.
3. Parking lot, bicycle/pedestrian pathway, and bicycle parking lights shall have a concrete pull box installed adjacent to each fixture with conduits and wiring termination in pull box.
4. All bicycle/pedestrian pathway and bicycle parking lighting circuits shall be multi-staggered circuits. Lighting controllers shall be on a separate dedicated circuit from lighting branch circuits to minimize disruption.
5. If a raised standard is used, the pole shall be shortened to compensate for standard height.
6. Hinged pole bases shall be used on parking structure decks for servicing without the use for a lift.
7. All lighting fixtures in all categories shall include In-Line fuse holders. Fuse holders shall have a current rating of 30 amps, 600 volts, and accept a 5 amp 13/32 inch diameter by 1-1/2 in. length fuse. Fuse holders shall be located in the hand hole of the pole.

Exterior Lighting Categories [Note 1]	**Fixture Style**	**Mfg. & Model #** [Note 2]	**Lamp Type**	**Pole / Mounting**	**Height (ft)** [Note 3]	**Finish: Pole or Fixture**	**Controls** [Note 4]	**Uniformity Ratio, Maximum to Minimum**	**Color (CRI)**
Vehicular Streets (Non-Restricted)	Cobra	Lumec GLPS 90W49LED 4K	LED	Tapered/ rounded	20-30	Aluminum or Light Gray	Lumewave RF controller / 0-10V dimming power supply	6:1 (avg:min)	4000K (>70)
Parking Lot	Shoebox	Lumec GLPS 90W49LED 4K	LED	Square (4" x 4")	18	Dark Bronze	Lumewave RF controller / 0-10V dimming power supply / Occupancy Sensor	20:1 (max:min)	4000K (>70)
Bike & Pedestrian Pathways, Restricted Vehicular Streets	Shoebox	Lumec GLPS 90W49LED 4K	LED	Square (4" x 4")	16	Dark Bronze	Lumewave RF controller / 0-10V dimming power supply / Occupancy sensor	2:1 (avg:min)	4000K (>70)
Bike Parking & Plaza	Shoebox	Lumec GLPS 90W49LED 4K	LED	Square (4" x 4")	16	Dark Bronze	Lumewave RF controller / 0-10V dimming power supply / Occupancy Sensor	2:1 (avg:min)	4000K (>70)
Parking Structure	Deck Mounted	--	IF LED MH	Deck	Garage height	Dark Bronze	Photosensor/ Stepped Dimming Occupancy	10:1 (max:min)	>70
Building Mounted & Loading Dock [Note 4]	Wallpack (Cut-off)	--	MH IF	Building	14	Dark Bronze	Photosensor/ Stepped Dimming Occupancy	N/A [Note 5]	>70

NOTES:
1. Minimum light levels for all categories shall comply with the latest edition of Illuminating Engineering Society of North America (IESNA).
2. Or Equal.
3. Mounting and pole heights (in feet) to match with adjacent fixtures where applicable.
4. In addition to listed controls, provide an Astronomical Time Clock.
5. Wall-pack fixture to be down type (full-cut-off).
6. If fixture is located near walkway, apply Bike & Pedestrian Pathways minimum light levels.

REFERENCES

CONTROLS:
There are four types of occupancy sensor technologies; passive-infrared, ultrasonic, microwave, and audio based. Audio and ultrasonic technologies are inappropriate for exterior use because they can be triggered unintentionally by small animals, wind, rain, etc. This outline will assist in making an appropriate occupancy sensor selection based on the application and the type of fixture being controlled.

On/Off vs. Stepped-dimming Occupancy Controls

1. On/off occupancy controls consist of a lighting system that operates at full power and light output when occupied, and operates at zero power and light output when

unoccupied. This functionality is appropriate for secondary use areas where occupant traffic is not required to enter at night.

2. Stepped-dimming occupancy controls consist of a lighting system that operates at full power and light output when occupied and operates at a reduced power level and light output (this level can be design or product specific) when unoccupied. This design method balances energy savings and safety. This functionality is appropriate for primary use areas.

Zonal vs. Individual Occupancy Controls

A zonal occupancy control design involves occupancy sensors controlling light fixtures that they are not directly associated with (e.g. – a parking lot with occupancy sensors at the entrance controlling all of the fixtures). Zonal occupancy controls can be cost effective and provide desired performance features but they are prone to "blind" spots (i.e., it is possible to occupy the controlled zone without being detected) and unreliable communication between sensors and fixtures.

1. Individual occupancy control design involves each controlled fixture having an integral occupancy sensor. This increases reliability and minimizes "blind" spots but can increase incremental cost.

Passive-infrared Occupancy Sensor

1. Passive-infrared sensors require a direct line of sight to function properly. This means any obstructions such as buildings, trees, etc. between the sensor and the intended target will keep the sensor from triggering occupancy.

2. Passive-infrared sensors have varied coverage ranges and patterns. An appropriate range and coverage pattern should be determined based on application, traffic patterns, and fixture compliance.

Microwave Occupancy Sensor

Microwave occupancy sensors can detect motion through some (but not all) mediums. These sensors can be useful when fixture penetration is not an option (e.g., wet location listing required). If the sensor is exposed to open air or through a thin acrylic sheet it can reduce blind spots due to unforeseen obstructions. However it is not typical for a microwave sensor to detect reliably through fixture housings. Unless a fixture is offered with an integral microwave sensor and a detailed coverage pattern, beware of specifying a sensor to be integrated into a housing.