



DIVISION 26 ELECTRICAL

GENERAL

American University's utilities on Campus are owned, operated and maintained by the University. Electrical service to each facility is by connection to the University's electrical distribution system that is managed by Facilities Management (FM). All electrical designs must be reviewed and approved by the FM Director Energy and Engineering and/or a designated representative.

All electrical designs shall comply with national, state and local codes. The Consultant shall incorporate into the design, as a minimum, the industry standards and design criteria in the following references:

- a. National Fire Protection Association (NFPA) Standard 70 National Electrical Code
- b. American National Standards Institute (ANSI) Standard C2 National Electrical Safety Code
- c. Standard Handbook for Electrical Engineers
- d. American Electricians Handbook
- e. NFPA 20 Installation of Centrifugal Fire Pumps
- f. NFPA 30 Flammable and Liquid Combustible Code
- g. NFPA 37 Stationary Combustion Engines and Gas Turbines
- h. NFPA 72 Fire Alarm Systems
- i. NFPA 78 Lightning Protection Code
- j. NFPA 101 Life Safety Code
- k. NFPA 110 Emergency and Backup Power System
- l. National Electrical Manufacturers Association (NEMA) standards for Materials and Products
- m. ANSI standards
- n. Underwriters Laboratories (UL) Fire Resistive Directory
- o. D.C. Building Code
- p. D.C. Division of Facility Service Guidelines



The Consultant shall provide a written description of how the entire system is designed to operate. This Basis of Design (BOD) narrative also shall describe how project objectives are being met. It shall be provided in a format that can be easily understood by a layperson, the end user. The narrative identifies items that specifically meet the Owners Project Requirements (OPR) and the most recent Facilities Management (FM) or department System Master Plan(s) and articulate a rationale for any variance.

For renovations, the systems selected shall be compatible with the existing building's electrical systems. The integrity of the basic existing building system shall not be compromised, except where agreed to by the Owner. Work shall be designed and sequenced to minimize impact and interruptions in occupied buildings.

For site work, the Consultant shall indicate all existing underground work such as piping, valves, manholes, electric wiring and telephone, whether new connections are being made or not. Profiles of all piping need to be shown to facilitate coordination with the crossing of other utilities.

The Consultant shall incorporate any requirements from the University insurance carrier or Risk Management into the design and specifications.

Projects using BIM modeling shall detail all manufacturer's requirements for equipment service clearances.

Life cycle cost/present worth analyses that assess total costs of certain electrical components over their useful life may be required on selected projects.

ELECTRICAL SYSTEMS DESIGN CRITERIA

The Consultant shall be guided by the following principles when creating the design and when specifying equipment, methods and materials:

- design shall meet all Owner objectives
- equipment and materials specified shall be well-suited for the specific application



- equipment and materials shall be high-quality products from approved manufacturers, selected for ease of installation, durability, low maintenance and high reliability
- electrical systems shall be sized to accommodate future loads
- electrical system components shall be energy efficient when compared to standard products by the same manufacturer
- all conductors are to be copper

LABELING

Label electric circuits using proper AU identification format using the following electrical labeling color scheme:

- White letters on black for normal power. This is the standard identification for building systems and equipment.
- White letters on orange for critical power. This is for building systems and equipment (legally required) critical and optional emergency power.
- White letters on red. This is for life safety systems or emergency powered equipment only.

Submit panel directories in electronic form title by panel number. Install a printed copy of the panel schedule upon completion of the work. Include existing and new work. Handwritten panel schedules are not allowed.

ENERGY CONSERVATION

American University is committed to energy efficiency and conservation. Conformance with IECC requirements, NEMA premium motors, University efficiency initiatives and the minimum standards for energy conservation as set forth by the District of Columbia shall be exceeded, wherever possible.

DC Green Code 2013 requirements should be incorporated into the design. This includes switched receptacles symbol designation on the plate cover and utilize green colored receptacles and switches where available for classrooms, conference rooms, auditoriums, and common areas.

Metering, compatible with and integrated into the existing university collection and



software systems is required for new buildings. Sub-metering may be required for high load, billable or efficiency monitoring.

CALCULATIONS

All circuits shall be sized for the load to be served. Panel board schedules shall show the load on each circuit, as well as sizing calculations (including connected load, spare capacity and demand factors) used to calculate panel or switchboard size.

All power riser and one-line diagrams shall show the available short circuit currents at the service and each distribution point in the system. Switchboard and panel schedules shall indicate the available short circuit at the equipment.

On large projects where continuity of service is a critical issue, the Consultant shall provide the Owner with a selective coordination study. The study will show (using time current curves) the coordination among all main, feeder and branch circuit over current protection equipment.

The addition of equipment or circuits to a building emergency generator may require a load test to determine if capacity exists. Designer to submit power requirements to FM Master Electrician for review.

PRODUCT STANDARDS

All equipment and materials shall be certified as conforming to industry standards by a third-party laboratory service approved by the District of Columbia. These shall include but not be limited to the following:

- Underwriters Laboratories
- Electric Testing Laboratory
- National Electrical Manufacturers Association



- American National Standards Institute
- Certified Ballast Manufacturers
- Institute of Electrical and Electronic Engineers

All equipment and material shall bear the mark of the respective third-party laboratory service. Generally, provide NEMA 1 enclosures indoors and NEMA 3R enclosures outdoors.

ELECTRICAL DESIGN CRITERIA

GENERAL

All Electrical Work performed on campus must be permitted in accordance with DCRA requirements and under a DCRA provided Electrical Permit.

All projects on campus involving electrical work (regardless of voltage) shall be coordinated with the University's Master Electrician and AU's Commissioning Coordinator.

Projects performed under the Master Electrician's Operations and Maintenance permit shall not proceed from engineering to procurement and construction without the approval of AU's Master Electrician and Director of Energy and Engineering.

The Consultant shall coordinate with AU's Project Manager for specific information concerning those items and work to be provided under the Contract Documents.

Sources, Connections and Outages for Temporary Lighting and Power shall be coordinated with the AU's Master Electrician. Refer to Section 01 51 00 Temporary Utilities and sub-sections for Temporary Power and Temporary Lighting requirements.

Planning and Project Management (PPM) Division must pre-approve the placement of any equipment that will be visible from outside the facility.



The primary system is rated at 13, 200 volts, 3-phase wire. Additions to the system are installed and maintained by Facilities Management.

INSTALLATION OF ELECTRICAL SYSTEMS

Install wires and cables according to the NECA's "Standard of Installing" requirements.

Remove existing wire from raceway before pulling in new wire and cable.

Wiring at Outlets: Install at least 12 inches (300 mm) of slack conductor at each outlet.

Remove existing abandoned wiring & conduit designated as obsolete by AU authorities.

Firestop all penetrations through floors, walls and ceilings according to rating.

Outdoors Wiring Methods shall be as follows:

- Exposed: Rigid steel or intermediate metal conduit.
- Concealed: Rigid steel or Intermediate metal conduit or EMT
- Underground, Single Run: Rigid nonmetallic conduit.
- Underground, Grouped: Rigid nonmetallic conduit, concrete encased.
- Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid or Motor-Driven Equipment): Liquid-tight flexible metal conduit, not exceeding 24" length.

Indoors Wiring Methods (e.g. raceways) shall be as follows:

- Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid or Motor-Driven Equipment): Flexible metal conduit, except in wet or damp locations use liquid tight flexible metal conduit, not exceeding 24" length. Use conduit, tubing, or MC cable in applications allowed by NEC.
- Damp or Wet Locations: Rigid steel, PVC, or Intermediate metal conduit.
- Exposed (including unfinished interior spaces): Electrical metallic tubing, or Rigid



metallic conduit.

- Concealed: Electrical metallic tubing, rigid metallic conduit or MC cable except as otherwise indicated.
- Concealed Connections from JBox in Ceiling Space to Light Fixtures Not exceeding 6 feet length: MC cable, or flexible metal conduit.

Conceal wiring, unless otherwise indicated, within finished walls, ceilings, and floors.

Boxes and Enclosures: In damp or wet locations, use NEMA 250, Type 3, Type 4, stainless steel.

Use raceway fittings compatible with raceway and suitable for use and location. For intermediate steel conduit, use threaded rigid steel conduit fittings, unless otherwise indicated.

Raceways Embedded in Slabs: Install in middle third of the slab thickness where practical and leave at least 1-inch (25-mm) concrete cover.

Install exposed raceways parallel to and at right angles to nearby surfaces or structural members and follow the surface contours as much as practical.

Join raceways with fittings designed and approved for the purpose and make joints tight. Use bonding bushings or wedges at connections subject to vibration. Use insulating bushings to protect conductors.

Install pull wires in empty raceways. Use No. 14 AWG zinc-coated steel or monofilament plastic line having not less than 200-lb (90-kg) tensile strength. Leave not less than 12 inches (300 mm) of slack at each end of the pull wire.

Install raceway sealing fittings where required by the NEC and at wiring entrances to refrigerated spaces. Locate at suitable, approved, accessible locations and fill them with UL-listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces.



Stub-up Connections for Equipment: Extend conductors to equipment with [rigid steel] [intermediate metal] conduit; flexible metal conduit may be used 6 inches (150 mm) above the floor.

Install a separate green ground conductor in all raceways and conduits.

LOW VOLTAGE ELECTRICAL POWER AND CONDUCTORS - 26 05 19

All circuits abandoned or not used are to be located, identified, disconnected, and taken back to the source.

WIRES AND CABLES

Conductors: Copper.

Building Wires: Type THHN/THWN or XHHW, minimum conductor size #12 for branch circuits.

Armored Cable up to No.2 AWG: Type MC with green insulated copper ground conductor.

Cable No. 1 AWG and Larger: In conduit or EMT with green insulated copper ground conductor.

Connectors and Splices: Wiring connectors of size, ampacity rating, material, and type and class for application and for service indicated.

Single Conductor Plenum Coaxial: 75-ohm characteristic impedance, solid bare copper central conductor, foamed PTFE dielectric, 100 percent coverage copper, double-braid shield, PTFE jacket, suitable for installation in air-handling spaces.

Twisted-Pair Plenum: No. 24 AWG, 7-strand, copper conductors; PTF insulation; overall aluminum/polyester shield and No. 22 AWG copper drain wire; PTFE jacket; suitable for use in air-handling spaces.

GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS - 26 05 26

All electrical equipment, devices and raceways shall form a continuously grounded system. Neutral and ground shall be bonded only at the service entrance or at the secondary side of a separately derived system.



Every feeder and branch circuit raceway shall contain a green insulated copper equipment grounding conductor.

All emergency power systems shall be configured and grounded as separately derived systems.

Electrical boxes and enclosures shall be bonded to ground double locknuts and ground bushings.

Each wiring device shall be grounded by means of a separate code-size copper conductor connecting the device ground terminal to the branch circuit panel board ground bus. The conduit system shall not be relied upon for grounding.

HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS - 26 05 29

Lighting fixtures shall be tied (with tie wire) to deck above ceiling, supported at diagonal, opposing corners.

MINERALLAC STRAPS

Minerallac straps **ARE NOT ACCEPTABLE**; one-hole straps are acceptable

RACEWAYS AND BOXES FOR ELECTRICAL WORK - 26 05 33

RACEWAYS

Wire ways: Screwed cover type, with manufacturer's standard finish

Surface Metal Raceway Galvanized steel with Snap-On covers. Finish with manufacturer's standard prime coating suitable for painting.

Surface Nonmetallic Raceway: Two-piece construction, manufactured of rigid PVC compound with matte texture and manufacturer's standard color.

Outlet and Device Boxes: Sheet metal boxes, except use cast-metal boxes at exterior, interior exposed, and interior damp locations.



BOXES

Floor Boxes: Cast metal or Sheet metal, fully adjustable, rectangular

Pull and Junction Boxes: Sheet metal boxes, except use nonmetallic, cast aluminum or cast steel boxes with gasketed covers at exterior and interior damp locations.

UNDERGROUND DUCTS AND RACEWAYS - 26 05 43

AU does not permit Medium Voltage electrical distribution overhead or exposed on campus. All Medium Voltage electrical distribution systems shall be installed underground in duct banks.

All other electrical distribution shall be concealed in conduit or as otherwise approved.

No cabling shall be directly buried. The FM Project Manager shall coordinate actual routing and installation outside the buildings with AU's Master Electrician and Director of Energy & Engineering.

LOW VOLTAGE TRANSMISSION AND SERVICE - 26 21 00

Provide only one service entrance per building, except where otherwise specifically permitted by the Owner. Service entrance equipment shall be switchboard, panel board.

Overcurrent protection for the entire building shall be by single main device.

Service entrance switchboards shall have at least 20% spare breaker spaces, each fully provisioned and sized for estimated future loads.

Service entrance panel boards shall have at least 20% spare 3-pole spare breaker spaces, each fully provisioned and sized for one-half of estimated future loads.

If ground fault protection is provided on the main over current protection device, ground fault also shall be provided on devices in the same switchboard or panel board. All ground fault equipment shall be adjustable. (Initial settings shall be 20% of device rating, with 6-cycle time separation between main and feeder devices.)

Overcurrent protection, devices with ground fault will be circuit breaker only.



LOW-VOLTAGE TRANSFORMERS, DISTRIBUTION TRANSFORMERS 26 22XX

Transformers shall be the standard product of an approved transformer manufacturer. They shall be of live front, loop-feed configuration and pad-mounted design with voltage taps and a 4-position switch conforming to the Owner's standard specification.

DRY-TYPE TRANSFORMERS

Insulation shall be NEMA ST20 Standard for 220 degrees C. UL component recognized insulation system. For transformers rated 112.5 KVA and below, the insulation shall be rated 115 degrees C. rise above 40 degrees C. ambient. For transformers rated over 112.5 KVA, the insulation shall be rated 80 degrees C. rise above 40 degrees C. ambient.

Transformer enclosures shall be indoor-type, completely enclosed with drip-proof ventilated openings, steel with factory standard finish. Transformers less than 30 KVA three-phase or 25 KVA single-phase may have non-ventilated enclosures. Provide a concrete housekeeping pad, minimum 4" thick.

PRODUCTS

MANUFACTURED UNITS

General-Purpose, Dry-Type Transformers, 600 V or less:

- Comply with NEMA ST 20 and list and label as complying with UL 1561.
- Two winding type, three-phase units using one coil per phase in primary and secondary.
- Enclosure: Indoor, ventilated, Outdoor, ventilated, rain tight, NEMA 250, Type 3R.
- Wall-Mounting Brackets: Manufacturers standard for units up to 75 kVA.
- Taps: Standard; for transformers 25 kVA and smaller, provide 2 taps 5 percent below rated high voltage.

EXECUTION

INSTALLATION

Arrange equipment to provide adequate spacing for access and for cooling air
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circulation. Mount transformers larger than 75 kVA on concrete bases or 6" steel channels.

All wiring terminations are to be high-pressed type.

TESTING AND ADJUSTING

Perform visual and mechanical inspections and electrical tests stated in NETA ATS.

Adjust taps after installation to obtain indicated secondary voltage.

SWITCHBOARDS - 26 24 13

Motor branch circuits shall be 480-volt, three-phase, wherever possible. Provide disconnect switches near the motor and motor controller. Individual combination starters are not permitted. Motor control centers shall have combination starters.

All motor circuits shall be dedicated circuits, except for small fractional horsepower exhaust fans that can be easily served and controlled from local lighting and power circuits.

PANEL BOARDS - 26 24 16

REQUIREMENTS

Manufactures: Cutler-Hammer, General Electric, or Square-D
Flush and/or Surface mounted.

Load Capacity: Main breaker capacity and number of circuit breakers that panel will accommodate shall be made clear on Drawings.

Front: Shall be secured to box with concealed trim clamps or hinged to box with standard door within hinged cover.

Doors: Shall have concealed hinges, flush catches, and tumbler locks, all keyed alike.

Bus: Shall be hard drawn copper of 98 percent conductivity.



Molded-Case Circuit Breakers: NEMA AB 1, bolt-in, full module type. Single handle for multipole circuit breakers.

Fusible Switches: NEMA KS 1, Type HD, with [rejection] clips to accommodate indicated fuses, handle lockable.

Motor Controllers: NEMA ICS 2, Class A combination controllers.
Contactors: NEMA ICS 2, Class A combination contactors.

INSTALLATION

Install panel boards and accessory items according to NEMA PB 1.1. Indicate installed circuit locations on typed directory.

Mounting Heights: Top of trim 74 inches (1880 mm) above finished floor, unless otherwise indicated. Revise or delete paragraph below to suit Project.

Future Circuit Provisions at Flush Panel boards: Stub four empty 3/4-inch (19-mm) conduits from panel board into accessible or designated ceiling space and four empty conduits into raised floor or space below floor.

Wiring in Panel Board Gutters: Arrange conductors into groups bundle and wrap with wire ties.

Tighten electrical connectors and terminals, including grounding connections, according to manufacturer's published torque-tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A and UL486B.

Perform visual and mechanical inspections and electrical tests stated in NETA ATS.

MOTOR CONTROL CENTERS - 26 24 19

SECTION REQUIREMENTS

Submittals: Product Data.

Coordinate features of controllers and accessory devices with pilot devices and control circuits to which they connect.

Coordinate features, accessories, and functions of each motor controller with the
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ratings and characteristics of the supply circuit, the motor, the required control sequence, and the duty cycle of the motor and load.

PRODUCTS

CONTROLLERS AND ACCESSORIES

Manual Motor Controllers: NEMA ICS 2, general purpose, Class A with toggle action and overload element, in each phase. Hand-off-automatic switch and "on" pilot light in cover.

Magnetic Motor Controllers: NEMA ICS 2, Class A, full voltage, non-reversing, across the line, unless otherwise indicated; with integral control transformer. Hand-off-automatic switch and "on" pilot light in cover. Combination Controller: Factory-assembled combination controller and fusible disconnect switch.

Overload Relay: Ambient-compensated type with inverse-time-current characteristic. Provide heaters or sensors in each phase matched to nameplate full-load current of specific motor to which they connect, adjusted for duty cycle.

Multispeed-Motor Controller: Match controller to motor type, application, and number of speeds. Provide speed selector switch.

Reduced-Voltage Motor Controllers: Matching type of motor and load with appropriate (e.g. star-delta, part winding, other) type controller.

Pilot Lights and Selector Switches: NEMA ICS 2, heavy-duty typ.

All Motor Control Centers to have an electronic power meter.

Manufacturer: Electro Industries (Shark, or Nexus), factory installed and fully integrated with existing American University electricity collection equipment and software.

EXECUTION INSTALLATION

Use manual controllers for fractional-horsepower single-phase motors, unless otherwise indicated. Install independently mounted motor-control devices.



Install indicated fuses in each fusible switch.

Connect selector switches to bypass only the manual and automatic control devices that have no safety functions when switch is in the hand position.

Connect selector switches with motor-control circuit in both hand and automatic positions for safety-type control

Devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor overload protectors.

TESTING

Perform visual and mechanical inspections, and electrical tests stated in NETA ATS.

LOW-VOLTAGE DISTRIBUTION EQUIPMENT – 26 27 00

For new buildings, the power distribution system shall have separate life safety and emergency lighting. Power and mechanical loads shall have dedicated panel boards originating from the service entrance equipment.

WIRING DEVICES – 26 27 26

GENERAL SECTION

REQUIREMENTS

- Submittals: Product Data
- Comply with NEMA WD 1
- Comply with NEC

DEVICES

General: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction.

Color: Ivory unless otherwise indicated.

Receptacles: Heavy Duty grade, NEMA WD6, Configuration 5-20R unless otherwise
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indicated.

Ground-Fault Circuit Interrupter Receptacles: Feed-through type, with integral duplex receptacle; for installation in a 2-3/4-inch- (70-nuu-) deep outlet box without an adapter, Configuration 5-20R.

Transient Voltage Surge Suppressor Receptacles: Duplex type, with integral TVSS in line to ground, line to neutral, and neutral to ground; meets IEEE C62.41 Category B test with nominal transient-suppression clamp level of 500 V and minimum single transient pulse energy dissipation of 140 J line to neutral, and 70 J line to ground and neutral to ground.

Snap Switches: Heavy-duty, quiet type, 277 Volts rated.

Incandescent Lamp Dimmers: Modular, 120 V, 60Hz with audible and electromagnetic noise filters and continuously adjustable slide, single pole with soft tap or other quiet switch, min. 600 Volts rated.

Fluorescent Lamp Dimmers: Modular, compatible with dimmer ballasts, with audible and electromagnetic noise filters and capable of consistent dimming to a maximum of 10 percent full brightness. Include trim potentiometer.

Dimming System: Factory assembled dimming/relay panel, NEMA 1 grade, and low voltage control stations and interface panel. Dimmers to provide a smooth and continuous "square law" dimming curve throughout the entire dimming range. Dimming ballasts will be provided with the fixtures.

Wall Plates, Finished Areas: Satin-finish stainless steel, fastened with metal screws having heads matching plate color. Provide standard-size Type 304 stainless steel wall plates that are compatible with the switches. Provide Stainless steel screws for securing the devices to the wall plates.

Wall Plates, Unfinished Areas: Satin-finish stainless steel with metal screws.

Floor Service Fittings: Modular, above-floor, dual-service units suitable for wiring method used.

Multi-outlet Assemblies: Components produced by a single manufacturer designed for use as a complete, matching assembly of raceways and receptacles. Metallic



raceway with No. 12 AWG wire. One receptacle per 12 inches (300 mm).

AUTOMATIC WALL SWITCH shall:

- be Manufactured by Novitas or Watt Stopper
- be Ivory-colored, decorator-style, low profile, UL-listed automatic light switch which replaces and fits into a single-gang wall switch outlet box.
- have the following features:
 - 277-volt AC, manual-on, 60 to 1200 watt (ballast load), single level lighting control with 180- degree coverage for 900 (maximum) square feet.
 - Digital time-delay adjustable covering at least the interval from 90-seconds to 30-minutes.
 - Adjustable unit sensitivity from 20-percent to 100-percent.
 - Integrated Light Level Sensor.
 - LED for sensitivity calibration.
 - Compatible with electronic ballasts.

CEILING-MOUNTED ULTRA-SONIC DETECTORS shall:

- White-colored, 24-volt, AC, 20-milliampere, UL-listed sensor for use with companion relay/power supply.
- Configured where the ultrasonic signals of one sensor can interfere with the operation of an adjacent unit; provide detector units with different operating frequencies.
- Have the following features:
 - 360-degree single-directional, 1000 square-foot coverage.
 - Temperature and humidity resistant solid-state, crystal-controlled 25-kilo-hertz detector.
 - Logic Key/On by-pass.
 - Adjustable time delay covering at least 30-seconds to 12-minutes.
 - Adjustable sensitivity

DUAL TECHNOLOGY OCCUPANCY SENSORS shall:

- White-colored, 24 VDC, 28-milliampere, UL and CUL listed for use with power pack.
- Have the following features:
 - PIR and Ultrasonic technologies



- Integrated light level sensor 2.5 to 430 foot coverage
- Single pole, double-throw isolated relay
- 40kHz +/- 0.006% frequency ultrasonic
- Adjustable time-delay of 15 sec. to 15 min.
- LED indicator for both technologies
- Adjustable sensitivity

COMBINATION RELAY/POWER SUPPLY shall:

- Junction box mounted, UL-listed, 277-volt primary, 24-volt DC secondary, 100-milliampere secondary, Self-contained transformer/relay unit.
- Have relay contacts rated 277-volts, shall open when the room is unoccupied, and close when the room is occupied.

WALL PLATES

- a. Where unit sensor and manual wall switch are located side-by-side, provide common wall plate and barrier switchbox.
- b. Where wall plate cover is not specifically listed, cover to be stainless.

INSTALLATION

- Install devices and assemblies' plumb and secure.
- Mount devices flush, with long dimension vertical, and grounding terminal of receptacles on top unless otherwise indicated. Group adjacent devices under single, multigang wall plates.
- Protect devices and assemblies during painting.
- Install wall plates when painting is complete.
- Install wall-mounted devices vertically and in accordance with NEC and recognized industry practices. Mounting heights shall be as noted on the contract Drawings for switches. Ceiling-mount sensors to back plates secured to ceilings.
- Where automatic wall switches are shown adjacent to wall switches, the automatic switch (indicated as OS) shall be connected to control all of the lighting in the room. The manual switch shall be connected between the output leg of the occupancy sensor switch and the switched leg to the outside-lamp ballasts and act as an override-to-off switch. The inside lamp ballasts shall be connected directly to the output of the occupancy sensor.
- In rooms with ceiling-mounted occupancy sensors (indicated as OSI) and sus-



pendent ceilings, surface mount the occupancy sensors to the center of ceiling tiles. Connect the power supply/relay unit to the normal power source and connect the relay contacts in series with the line side of both wall switches for the in- side and outside lamp ballasts. The switches shall act as "override-to-off."

- Wiring from ceiling-mounted sensors to relay/power supplies shall be with plenum-rated, limited-energy, three-conductor, and #18 through #22 copper conductors. Coordinate with other work, including ceiling installation, painting, wiring and box installation. Notify the Owner's Representative of location discrepancies before roughing-in device and then obtain a new location as necessary.
- Wall-mounted devices shall be installed after wiring is complete.
- Install cover-plates and devices after painting is complete.
- Install wall-mounted devices and combination relay/power supplies to electrical boxes which are clean and free of building material, dirt and debris
- Provide electrically continuous, tight ground connections for the automatic switches.
- Ground the hex green grounding screw of the switching device to the ground wire of the branch circuit.

TESTING

- Test all automatic switches and all sensors for proper operation. Adjust sensitivity and time-delay of all sensors and demonstrate adjustment and operating procedures to Owner.

LOW-VOLTAGE CIRCUIT PROTECTIVE DEVICES – 26 28 00

ENCLOSURES

- a. Hinged-Cover Enclosures: NEMA 250, steel enclosure with continuous hinge cover and flush latch. Finish inside and out with manufacturer's standard enamel.
- b. Cabinets: NEMA 250, Type 1, unless otherwise indicated.

CIRCUIT BREAKERS - 26 28 16

- Manufacturer: Cutler-Hammer, General Electric, or Square-D
- Enclosed, Molded-Case Circuit Breaker: NEMA AB 1, with lockable handle and thermal-magnetic trip unless otherwise indicated.
 - Characteristics: Frame size, trip rating, number of poles, and auxiliary de-



vices as indicated.

- Interrupting Rating: Exceeds available fault current.
- Thermal-Magnetic Circuit Breakers, 225 A and Larger: Trip units [interchangeable within frame size] [with adjustable magnetic trip].
- Electronic Trip Unit Circuit Breakers, 400A and Larger: Field-adjustable, short time and continuous-current [and ground-fault trip] settings.
- Current-Limiting Trips: Let-through ratings less than NEMA FU 1, Class RK-5.
- Enclosure: NEMA AB 1, Type 1, unless otherwise specified or required to meet environmental conditions of installed location.
- Circuit breaker to be bolt-in type.
- Perform visual and mechanical inspections and electrical tests stated in NETA ATS.

ENCLOSED SWITCHES - 26 28 16.16

Enclosed, Non-fusible Switch: NEMA KS 1, Type HD, with lockable handle.
Enclosed, Fusible Switch, 800 A and Smaller: NEMA KS 1, Type HD, clips to accommodate specified fuses, enclosure consistent with environment where located, handle lockable with 2 padlocks, and interlocked with cover in closed position.

LIGHTING – 26 50 00

Refer to the detailed recommendation standard develop by AU to meet efficiency goals and maintenance standards for LED Lighting 26 5522.

LIGHTING BRANCH CIRCUITS

- Wherever possible, lighting branch circuits shall be 277-volt, single-phase. When 120/208 voltages are used, provide separate circuits for lighting loads only.
- Lighting branch circuits may be arranged as three-phase conductors, one neutral conductor and one grounding conductor for each home run.

INSTALLATION

- Set units, level, plumb, and square with ceiling and walls, and secure.
- Support for Recessed and Semi-recessed Grid-Type Fluorescent Fixtures: Install ceiling support system rods or wires at a minimum of 2 rods or wires for



each fixture, located not more than 6 inches (150 mm) from fixture corners.

- Support for Suspended Fixtures: Brace pendants and rods over 48 inches (1220 mm) long to limit swinging. Support stem-mounted, single-unit, suspended fluorescent fixtures with twin-stem hangers. For continuous rows, use tubing or stem for wiring at one point and tubing or rod for suspension for each unit length of chassis, including one at each end.
- Lamping: Where specific lamp designations are not indicated, lamp units according to manufacturer's written instructions.
- Air Handling Fixtures: Install with dampers closed.

INTERIOR LIGHTING - 26 51 00

The Designer shall match existing fixtures and luminaires currently in use on campus where possible. This assists in repair and response time.

MER's shall be well lit with LED lighting and be switched at each exit. All mechanical equipment rooms shall be equipped with duplex convenience outlets suitable for operating small tools and drop-cord trouble lights.

INTERIOR FIXTURES, LAMPS AND BALLASTS - 26 51 13

Submittals: Product Data for each luminaire, including lamps.

- Fixtures, Emergency Lighting Units, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction.
- Coordinate ceiling-mounted luminaires with ceiling construction, mechanical work, and security and fire-prevention features mounted in ceiling space and on ceiling.

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- Metal Parts: Free from burrs, sharp corners, and edges. Steel, unless otherwise indicated. Form and support to prevent warping and sagging.
- Doors, Frames, and Other Internal Access: Smooth operating, free from light leakage under operating conditions, and arranged to permit re-lamping without use of tools. Arrange doors, frames, lenses, diffusers, and other pieces to prevent accidental falling during re-lamping and when secured in operating position.



- Lenses, Diffusers, Covers, and Globes: 100 percent virgin acrylic plastic or annealed crystal glass, unless otherwise indicated.
- Lighting fixtures shall be selected and designed to meet requirements of ASHRAE Standard 90.1-2010 for lighting power densities (in watts per square foot) and in accordance with the recommendations of the Illuminating Engineering Society of North America (IESNA). Lighting design levels should not exceed power density or IES standards. These standards are readily available and take into account the type of visual activity in a space, and the age range of the users of the space.
- Incandescent lamps are prohibited unless explicitly approved by the university. Suitable replacements can usually be found among the many varieties of compact fluorescent lamps. Varieties are now available which approach the color of incandescent light.
- Use electronic ballasts and T8 lamps in fluorescent light fixtures. They combine the best quality of light with the most energy savings.
- Not all electronic ballasts, light fixtures and controls are created equal. Compare manufacturer's warranties and include required information for Owner to maximize warranty.
- Occupancy sensors should be considered where spaces are occupied intermittently. They can be inexpensively installed in individual offices, classrooms, and small to moderate size conference rooms.
- Lighting design shall emphasize accessibility for re-lamping, cleaning and maintenance. The location of fixtures over hazardous chemicals, mechanical equipment and laboratory benches shall be avoided. Special provisions shall be made for lamps located in high ceiling areas for lowering or otherwise solving the maintenance problem.

LUMINAIRES

Fixture Type: Designer shall provide a fixture schedule with a description of manufacturers and model numbers.

Life safety exit and night lighting fixtures shall not be equipped with switches. All other light fixtures shall be switched or controlled. Office, conference and other administrative or presentation spaces shall have dual-level switching.

Source low-mercury lamps for indoor and outdoor fixtures as well as both hard-wired and portable fixtures. Mercury-containing lamps shall contain no more than 90 picograms per lumen hour, with a target of 70 picograms per lumen hour or less where available. Where less than 90 picograms per lumen hours is unavoidable, using an



across the building or project calculation may be acceptable, code permitting.

CFLs should comply with the voluntary industry guidelines for maximum mercury content published by the National Electrical Manufacturers Association (NEMA).

EMERGENCY LIGHTING – 26 52 00

- Life safety power circuits shall include fire alarm, warning systems and emergency communication systems.
- Life safety lighting circuits shall include emergency exit lighting and exit signs. An emergency generator shall provide backup power.
- In facilities with emergency generators, provide separate dedicated wiring circuits.
- Light fixtures with in-fixture battery/inverter packages shall be prominently marked.
- Life safety exit and night lighting fixtures shall not be equipped with switches.

EXIT SIGNS – 26 53 00

- Exit signs are LED.
- General Requirements – Comply with UL 924 and the following:
- Self-Powered Exit Signs (Battery Type): Integral automatic charger in a self-contained power pack. Sealed, maintenance-free, nickel-cadmium battery and fully automatic, solid-state charger with sealed transfer relay.
- Manufacturer: Lithonia Lighting
- Model: LX W 3 R EL N
- Sign material: Steel
- Sign colors: White single stencil, red lettering
- Lettering Size: $\frac{3}{4}$ " stroke X 6" high.

EXTERIOR LIGHTING - 26 56 00

- Reference the AU Lighting Master Plan,
- New construction may include some outside area lighting for landscape and security. All street and parking lot lighting, including fixture selection, and placement will be approved by the Project Manager, AU's Master Electrician and a representative from University Safety and Security Services. Designer should match existing parking lot light, emergency phone poles, and exterior building lighting to current campus fixtures.



- To make utility connections, the Project Manager will schedule all interruptions of services.
- Walkway lights are Spring City “Washington Standard” LED. Color Temperature shall be 5,000 Kelvin.
- Site lighting circuits shall be served by PVC conduit with THHN/THWN copper wire.
- Circuits shall be buried a minimum of 18 inches deep.
- Poles and fixtures shall be grounded.
- Building entrances, walkways and parking areas shall be properly illuminated for safety and security. Exterior lighting fixtures shall utilize the American University standard fixture to the extent possible on the Campus grounds. Small exterior auxiliary or service spaces may be illuminated with fluorescent fixtures equipped with cold weather ballasts.
- Exterior light fixtures shall be selected to avoid light pollution, including shielded and low wattage fixtures as per LEED and code requirements
- Separate circuits controlled by a photocell shall serve exterior and site lighting fixtures. Parking lot and other area lighting fixtures shall be circuited separately from stairway, porch or canopy lights; however, the same photocell may control both kinds of lighting.

DIVISION 26 ELECTRICAL PRODUCTS AND MANUFACTURERS

Subject to compliance with project requirements, basis-of-design manufacturer(s) (and model number if applicable) shall be:

Concrete Vaults – Electrical

1. S&C Electric Trenwa

Emergency Generator

2. Cummins w/ matching AFS

Imbiber Beads

3. Inhibitive Technologies

Metering Device – Main Distribution

4. Nexus 1500

Metering Device - Sub meter

5. Nexus Shark

Transfer Switch

6. Cummings Power Transformer – Medium Voltage

Howard Underground Switchgear

7. S&C Electric Vistas



Subject to compliance with project requirements, acceptable manufacture(s) include, but are not limited to the following:

Automatic Wall Switch

1. Wattstopper

Circuit Breakers

1. Cutler Hammer

General Electric

1. Square D

Dimmer Controls

1. Lutron
2. N-Light

Dimmer Switch

1. Bryant
2. Pass & Seymour

Electric Service Switch

1. Cutler Hammer
2. Siemens
3. Square D

Electric Panels

1. Cutler Hammer
2. Siemens
3. Square D
4. Westinghouse

Motor Control Center

1. General Electric
2. Siemens
3. Westinghouse

Panel Boards

1. Cutler Hammer
2. General Electric
3. Square D

Transformer

1. Siemens
2. Square D
3. Westinghouse

26 32 1x GENERATORS

PART 1 - GENERAL

SCOPE

- A. Provide complete factory assembled generator set equipment with digital (microprocessor-based) electronic generator set controls, digital governor, digital voltage regulator, and all auxiliary systems required for automatic operation.
- B. Provide factory testing, on-site startup and on-site testing of the system by a supplier authorized by the equipment manufacturer.
- C. The generator set manufacturer shall warrant all equipment provided under this section, so that there is one source for warranty and product service. Technicians specifically trained and certified by the manufacturer to support the product and employed by the generator set supplier shall service the generator set.

CODES AND STANDARDS

The generator set installation and on-site testing shall conform to the requirements of the following codes and standards, as applicable.

- A. The generator set shall include necessary features to meet the requirements of these standards.
 - i. IEEE 446 - recommended practice for emergency and standby power systems for commercial and industrial applications.
 - ii. NFPA 37 standard for the installation and use of stationary combustion engines and gas turbines.
 - iii. NFPA 70 - national electrical code. Equipment shall be suitable for use in systems in compliance to articles 700, 701, and 702.
 - iv. NFPA 110 emergency and standby power systems. The generator set shall meet all requirements for level 1 systems. Level 1 prototype tests required by this standard shall have been performed on a complete and functional unit. Component level type tests will not be allowed to substitute for this requirement.
- B. The generator set and supplied accessories shall meet the requirements of the following standards:
 - i. NEMA publication mg1, part 32 - the alternator shall comply with the requirements of this standard.
 - ii. UL1236 - battery charger.
 - iii. UL 2200 - the generator set shall be listed under UL 2200 or submit evidence of an independent third party certification process to verify compliance as furnished.
 - iv. Diesel and gas engines shall be EPA tier 3 certified all engines diesel or gas shall include a valid EPA engine certificate of compliance.

- C. The control system for the generator set shall comply with the following requirements:
- i. En 50082-2, electromagnetic compatibility generic immunity requirements, part 2: industrial.
 - ii. En 55011 limits and methods of measurement of radio interference characteristics of industrial, scientific and medical equipment
 - iii. FCC part 15, subpart b.
 - iv. IEC 8528, part 4 - control systems for generator sets.
 - v. IEC std 801.2, 801.3, and 801.5 for susceptibility, conducted, and radiated electromagnetic emissions.
 - vi. UL 508 - the entire control system of the generator set shall be UL 508 listed and labeled.
 - vii. UL 1236 - battery chargers.
- D. The generator set manufacturer shall be certified to iso 9001 international quality standard and shall have third party certification VERIFYING QUALITY ASSURANCE IN design/development, production, installation, and service, in accordance with iso 9001.

ACCEPTABLE MANUFACTURER

- A. Manufacturer shall be Cummins power generation, no substitutes.

SUBMITTALS

Submittals shall be clear and legible and shall include the following

A. Design Review

- i. Submit three copies of each shop drawing.
- ii. A maximum of two marked copies will be returned to the manufacturer, or one additional reproducible copy may be submitted to be marked and returned for manufacturer's use.
- iii. Identify each item submitted using applicable specification section number and paragraph reference.
- iv. Manufacturer's product literature and performance data, sufficient to verify compliance to specification requirements.
- v. Maintenance requirements.
- vi. Warranty with copy of manufacturer and/or component requirements.
- vii. Manufacturer's certification of prototype testing.
- viii. Manufacturer's installation instructions.

B. O&M Submission.

- C. Manufacturer's emergency power system operating and maintenance instruction manuals.

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- D. Operating and maintenance instruction manuals covering the entire emergency power system including the transfer scheme.
- E. Framed operating instructions shall be mounted on or near the unit.
- F. Executed warranty documents.
- G. Shop drawings showing plan and elevation views with certified overall dimensions, as well as wiring interconnection details.
- H. Interconnection wiring diagrams showing all external connections required, with field wiring terminals marked in a consistent point-to-point manner.

SERVICE AND SUPPORT

- A. The manufacturer of the generator set shall maintain service parts inventory at a central location that is accessible to the service location 24 hours per day, 365 days per year.
- B. The generator set shall be serviced by a local service organization that is trained and factory certified in generator set service. The supplier shall maintain an inventory of critical replacement parts at the local service organization, and in service vehicles. The service organization shall be on call 24 hours per day, 365 days per year.
- C. The manufacturer shall maintain model and serial number records of generator set provided for at least 20 years.

WARRANTY

- A. The generator set and associated equipment shall be warranted for a period of not less than 5 years or 1500 hours from the date of commissioning against defects in materials and workmanship.
- B. The warranty shall be comprehensive. No deductibles will be allowed for travel time, service hours, repair parts cost, etc.

TRAINING:

- A. The equipment supplier shall provide training for the facility operating personnel covering operation and maintenance of the equipment provided.
- B. The training program shall be not less than 4 hours in duration, the class size shall be limited to 5 persons, and the training shall occur at the owner's site.
- C. The training shall be videotaped.
- D. Training date shall be coordinated with the facility owner through commissioning.

PART 2 - PRODUCT REQUIREMENTS

GENERATOR SET

A. RATINGS

- i. The generator set shall operate at project design voltage at 1800 rpm and shall be three phase, 4 wire and 60 hertz.
- ii. The generator set shall be sized for project load (kwh), operating at 0.8 pf, standby rated, based on site conditions of: altitude 1000 ft., and ambient temperatures up to 104 degrees F. These ratings shall be increased if necessary, to carry full continuous and motor starting loads of the actual equipment provided. Any other changes necessitated by a change in generator capacity shall also be made.
- iii. The generator set rating shall be based on emergency service.

B. PERFORMANCE

- i. Voltage regulation shall be plus or minus 0.5 percent for any constant load between no load and rated load. Random voltage variation with any steady load from no load to full load shall not exceed plus or minus 0.5 percent.
- ii. Frequency regulation shall be isochronous from steady state no load to steady state rated load. Random frequency variation with any steady load from no load to full load shall not exceed plus or minus 0.5 percent.
- iii. The diesel engine-generator set shall accept a single step load of 100 percent nameplate kW and power factor, less applicable derating factors, with the engine-generator set at operating temperature.
- iv. Motor starting capability shall be a minimum of 105% of design load.
- v. The generator set shall be capable of recovering to a minimum of 90 percent of rated no load voltage following the application of the specified kva load at near zero power factor applied to the generator set. Maximum voltage dip on application of this load, considering both alternator performance and engine speed changes shall not exceed 15 percent.
- vi. The alternator shall produce a clean ac voltage waveform, with not more than 5 percent total harmonic distortion at full linear load, when measured from line to neutral, and with not more than 3 percent in any single harmonic, and no third order harmonics or their multiples. Telephone influence factor shall be less than 40.
- vii. The generator set manufacturer to be shall be certified by the engine suitable for use at the installed location and rating and shall meet all applicable exhaust emission requirements at the time of commissioning.

C. CONSTRUCTION

- i. The engine-generator set shall be mounted on a heavy-duty steel base to maintain alignment between components. The base shall incorporate a battery tray with hold-down clamps within the rails.
- ii. All switches, lamps, and meters in the control system shall be oil-tight and

dust tight. All active control components shall be installed within a UL/NEMA 3r enclosure. There shall be no exposed points in the control enclosure (with the door open) that operate in excess of 50 volts.

D. CONNECTIONS

- i. The generator set load connections shall be composed of silver or tin plated copper bus bars, drilled to accept mechanical terminations. Sufficient lug space shall be provided for use with cables of the number and size as shown in the drawings.
- ii. Power connections to auxiliary devices shall be made at the devices, with required protection located at a wall-mounted common distribution panel.
- iii. Generator set control interfaces to other system components shall be assembly. Made on a permanently labeled labels describing connection terminal block point functions shall be provided.

ENGINE AND ENGINE EQUIPMENT

- A. The engine shall be diesel, 4 cycle, radiator and fan cooled. Minimum displacement shall be 661 cubic inches (10.8 liters), with 6 cylinders. The horsepower rating of the engine at its minimum tolerance level shall be sufficient to drive the alternator and all connected accessories. Two cycle engines are not acceptable.
- B. Generator exhaust should be ducted to discharge above the roof at a location remote from any air intakes. In special applications, exhaust discharge can be located at ground level in a protected manhole away from pedestrian traffic.
- C. Fuel oil tanks for emergency generators shall be mounted above ground.
- D. Engine accessories and features shall include:
 - i. An electronic governor system shall provide automatic isochronous frequency regulation.
 - ii. The control system shall actively control the fuel rate and excitation as appropriate to the state of the generator set. Fuel rate shall be regulated as a function of starting, accelerating to start disconnect speed, and accelerating to rated speed.
 - iii. The governing system shall include a programmable warm up at idle and cool down at idle function. While operating in an idle state, the control system shall disable the alternator excitation system.
 - iv. Skid-mounted radiator and cooling system rated for full load operation in 122 degrees f ambient as measured at the alternator air inlet.
 - v. Radiator fan shall be suitable for use in a system with 0.5-inch h₂O static restriction. Radiator shall be sized based on a core temperature that is 20 degrees f higher than the rated operation temperature, or prototype tested to verify cooling performance of the engine/radiator/ fan operation in a controlled environment.
 - vi. The radiator shall be provided with a duct adapter flange. The equipment manufacturer shall fill the cooling system with a 50/50 ethylene glycol/water

- mixture prior to shipping. Rotating parts shall be guarded against accidental contact.
- vii. The electric starter shall be capable of three complete cranking cycles without overheating.
 - viii. Lubrication oil pump shall be positive displacement, mechanical, full pressure type.
 - ix. Lubrication oil filters shall be full flow type with replaceable spin-on canister elements and dipstick oil level indicator.
 - x. Fuel pump shall be an engine driven, mechanical, positive displacement type.
 - xi. Fuel filter shall include a replaceable spin-on canister element.
 - xii. A fuel cooler, suitable for operation of the generator set at full rated load in the ambient temperature specified, shall be provided if required for operation due to the design of the engine and the installation.
 - xiii. Air filter shall be replaceable dry element type with restriction indicator.
 - xiv. Supply and return fuel lines shall be flexible type.
 - xv. The engine mounted battery charging alternator shall be 40-ampere minimum, with solid-state voltage regulator.
 - xvi. Coolant heater
 - xvii. Provide engine mounted thermostatically controlled, coolant heater for engine. The heater voltage shall be 208 volts, single phase.
 - xviii. The coolant heater shall be ul 499 listed and labeled.
 - xix. The coolant heater shall be installed on the engine with silicone hose connections. Steel tubing shall be used for connections into the engine coolant system wherever the length of pipe run exceeds 12 inches. The coolant heater installation shall be specifically designed to provide proper venting of the system. The coolant heaters shall include provisions to isolate the heater for replacement of the heater element without draining the coolant from the generator set. Quick disconnect/automatic sealing couplers shall allow the heater element to be replaced without draining the engine cooling system or significant coolant loss.
 - xx. The coolant heater shall be provided with a dc thermostat, installed at the engine thermostat housing. An ac power connection box shall be provided for a single ac power connection to the coolant heater system.
 - xxi. The coolant heater(s) shall be sized as recommended by the engine manufacturer to warm the engine to a minimum of 104 degrees f in a 40 degrees f ambient, in compliance with NFPA 110 requirements, or the temperature required for starting and load pickup requirements of this specification.
 - xxii. Provide vibration isolators as recommended by the generator set manufacturer. Isolators shall include seismic restraints if required by site location.
 - xxiii. Starting and control batteries shall be lead acid type, 24-volt dc, sized as recommended by the engine manufacturer, complete with battery cables and connectors. The batteries shall be capable of a minimum of three complete 15-second cranking cycles at 40 degrees f ambient temperature when fully charged.
 - xxiv. Provide critical grade exhaust silencer for engine of size and type as recommended by the generator set manufacturer and approved by the engine

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- xxv. manufacturer. The exhaust system shall be installed inside the genset enclosure according to the engine manufacturer's recommendations and applicable codes and standards.
- xxvi. Exhaust system shall include a minimum 18 inch long flexible steel exhaust connection for each
- xxvii. Exhaust outlet to silencer.
 - a. Exhaust silencer shall reduce noise 25-35 decibels as compared to the generator's open exhaust.
 - b. Provide a threaded drain hole.
- xxviii. Provide an ul listed 10-amp voltage regulated battery charger. The charger may be located in the automatic transfer switch, or may be wall mounted, at the discretion of the installer. Input ac voltage and dc output voltage shall be as required. The charger shall be equipped with float, taper and equalize charge settings. Operational monitors shall provide visual output along with individual form c contacts rated at 4 amps, 120 volts ac, 30 volts dc for remote indication of:
 - a. Loss of ac power - red light.
 - b. Low battery voltage - red light.
 - c. High battery voltage - red light.
 - d. Power on - green light (no relay contact).
- xxix. Charger shall include an analog dc voltmeter and ammeter, 12 hour equalize charge timer, and ac and dc fuses.

AC GENERATOR

- A. The ac generator shall be: synchronous, four pole, 2/3-pitch, revolving field, drip-proof construction, single pre-lubricated sealed bearing, air cooled by a direct drive centrifugal blower fan, and directly connected to the engine with flexible drive disc. All insulation system components shall meet NEMA mg1 temperature limits for class h insulation system and shall be ul 1446 listed. The actual temperature rise measured by resistance method at full load shall not exceed 105 degrees centigrade.
- B. The generator shall be capable of delivering rated output (kva) at rated frequency and power factor, at any voltage not more than 5 percent above or below rated voltage.
- C. A permanent magnet generator (pmg) shall be included to provide a reliable source of excitation power for optimum motor starting and short circuit performance. The pmg and controls shall be capable of sustaining and regulating current supplied to a single phase or three phase fault at approximately 300 percent of rated current for not more than 10 seconds.
- D. The sub transient reactance of the alternator shall not exceed 12 percent, based on the standby rating of the generator set.

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GENERATOR SET CONTROL

- A. The generator set shall be provided with a microprocessor-based control system that is designed to provide automatic starting, monitoring, and control functions for the generator set. The control system shall also be designed to allow local monitoring and control of the generator set, and remote monitoring and control as described in this specification.
- B. The control shall be mounted on the generator set. The control shall be vibration isolated and prototype tested to verify the durability of all components in the system under the vibration conditions encountered.
- C. The generator set mounted control shall include the following features and functions:
- a. Control switches
 - i. Mode select switch: the mode select switch shall initiate the following control modes. When in the run or manual position the generator set shall start and accelerate to rated speed and voltage as directed by the operator. A separate push-button to initiate starting is acceptable. In the off position the generator set shall immediately stop, bypassing all time delays. In the auto position, the generator set shall be ready to accept a signal from a remote device to start and accelerate to rated speed and voltage.
 - ii. Emergency stop switch: switch shall be red "mushroom-head" push-button. Depressing the emergency stop switch shall cause the generator set to immediately shut down and be locked out from automatic restarting.
 - iii. Reset switch: the reset switch shall be used to clear a fault and allow restarting the generator set after it has shut down for any fault condition.
 - iv. Panel lamp switch: depressing the panel lamp switch shall cause the entire panel to be lighted with dc control power. The panel lamps shall automatically be switched off 10 minutes after the switch is depressed, or after the switch is depressed a second time.
 - b. Generator set ac output metering: the generator set shall be provided with a metering set including the following features and functions:
 - i. Digital metering set, 1 percent accuracy, to indicate generator rms voltage and current, frequency, output current, output kw, kwh, and power factor. The generator output voltage shall be available in line-to-line and line- to-neutral voltages and shall display all three-phase voltages (line to neutral or line-to-line) simultaneously.
 - ii. The control system shall monitor the total load on the generator set and maintain data logs of total operating hours at specific load levels ranging from 0 to 100 percent of rated load, in 10 percent increments. The control shall display hours of operation at less than 30 percent load and total hours of operation at more than 90 percent of rated load.
 - iii. The control system shall log the total number of operating hours, total kWh, and total control on hours, as well as total values since reset.

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- c. Generator set alarm and status display
 - i. The generator set control shall include led alarm and status indication lamps. The lamps shall be high intensity led type. The lamp condition shall be clearly apparent under bright room lighting conditions. Functions indicated by the lamps shall include:
 - i. The control shall include five configurable alarm-indicating lamps. The lamps shall be field adjustable for any status, warning, or shutdown function monitored by the genset. They shall also be configurable for color, and control action (status, warning, or shutdown).
 - ii. The control shall include green lamps to indicate that the generator set is running at rated frequency and voltage, and that a remote start signal has been received at the generator set. The running signal shall be based on actual sensed voltage and frequency on the output terminals of the generator set.
 - iv. The control shall include a flashing red lamp to indicate that the control is not in automatic state, and red common shutdown lamp.
 - v. The control shall include an amber common warning indication lamp.
- d. The generator set control
 - i. Shall indicate the existence of the warning and shutdown conditions on the control panel. All conditions indicated below for warning shall be field-configurable for shutdown. Conditions required to be annunciated shall include:
 - 1. Low oil pressure (warning)
 - 2. Low oil pressure (shutdown)
 - 3. Oil pressure sender failure (warning)
 - 4. Low coolant temperature (warning)
 - 5. High coolant temperature (warning)
 - 6. High coolant temperature (shutdown)
 - 7. High oil temperature (warning)
 - 8. Engine temperature sender failure (warning)
 - 9. Low coolant level (warning)
 - 10. Fail to crank (shutdown)
 - 11. Fail to start/over crank (shutdown)
 - 12. Over speed (shutdown)
 - 13. Low dc voltage (warning)
 - 14. High dc voltage (warning)
 - 15. Weak battery (warning)
 - 16. Low fuel (warning)
 - 17. High ac voltage (shutdown)
 - 18. Low ac voltage (shutdown)
 - 19. Under frequency (shutdown)
 - 20. Over current (warning)
 - 21. Over current (shutdown)
 - 22. Short circuit (shutdown)
 - 23. Overload (warning)
 - 24. Emergency stop (shutdown)
- e. Four (4) configurable conditions

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- f. Provisions shall be made for indication of 4 customer-specified alarm or shutdown conditions. Labeling of the customer-specified alarm or shutdown conditions shall be of the same type and quality as the above-specified conditions. The non-automatic indicating lamp shall be red and shall flash to indicate that the generator set is not able to automatically respond to a command to start from a remote location.

ENGINE STATUS MONITORING

- A. The following information shall be available from a digital status panel on the generator set control:
 - i. Engine oil pressure (psi)
 - ii. Engine coolant temperature (degrees f)
 - iii. Engine oil temperature (degrees f)
 - iv. Engine speed (rpm)
 - v. Number of hours of operation (hours)
 - vi. Number of start attempts
 - vii. Battery voltage (dc volts)
 - viii. The control system shall also incorporate a data logging and display provision to allow logging of the last 10 warning or shutdown indications on the generator set, as well as total time of operation at various loads, as a percent of the standby rating of the generator set.

Engine control functions

- A. The control system provided shall include a cycle cranking system, which allows for user selected crank time, rest time, and number of cycles. Initial settings shall be for cranking periods of 15 seconds each, with 15-second rest period between cranking periods.
- B. The control system shall include an idle mode control, which allows the engine to run in idle mode in the run position only. In this mode, the alternator excitation system shall be disabled.
- C. The control system shall include an engine governor control, which functions to provide steady state frequency regulation as noted elsewhere in this specification. The governor control shall include adjustments for gain, damping, and a ramping function to control engine speed and limit exhaust smoke while the unit is starting.
- D. The control system shall include time delay start (adjustable 0-300 seconds) and time delay stop (adjustable 0-600 seconds) functions.
- E. The control system shall include sender failure monitoring logic for speed sensing, oil pressure, and engine temperature which is capable of discriminating between failed sender or wiring components, and an actual failure condition.
- F. The control system shall be equipped with dry contacts that receive power from the battery system and that are controlled to provide 24-volt output to a solenoid valve in

the fuel oil supply line from the fuel oil tank. Contacts shall provide power to energize and open the solenoid valve and allow fuel oil flow when generator receives start signal and remove power to de-energize the solenoid valve to stop fuel oil flow when generator shuts down.

ALTERNATOR CONTROL FUNCTIONS

- A. The generator set shall include an automatic digital voltage regulation system that is matched and prototype tested by the engine manufacturer with the governing system provided. It shall be immune from disoperation due to load-induced voltage waveform distortion and provide a pulse width modulated output to the alternator exciter. The voltage regulation system shall be equipped with three- phase rms sensing and shall control buildup of ac generator voltage to provide a linear rise and limit overshoot.
- B. The system shall include a torque-matching characteristic, which shall reduce output voltage in proportion to frequency below an adjustable frequency threshold. Torque matching characteristic shall be adjustable for roll-off frequency and rate and be capable of being curve-matched to the engine torque curve with adjustments in the field. The voltage regulator shall include adjustments for gain, damping, and frequency roll-off. Adjustments shall be broad range, and made via digital raise-lower switches, with an alphanumeric led readout to indicate setting level.
- C. Controls shall be provided to monitor the output current of the generator set and initiate an alarm (over current warning) when load current exceeds 110 percent of the rated current of the generator set on any phase for more than 60 seconds. The controls shall shut down and lock out the generator set when output current level approaches the thermal damage point of the alternator (over current shutdown). The protective functions provided shall comply to the requirements of NFPA 70, article 445.
- D. Controls shall be provided to individually monitor all three phases of the output current for short circuit conditions. The control/protection system shall monitor the current level and voltage. The controls shall shut down and lock out the generator set when output current level approaches the thermal damage point of the alternator (short circuit shutdown). The protective functions provided shall be in compliance to the requirements of NFPA 70, article 445.
- E. Controls shall be provided to monitor the kw load on the generator set and initiate an alarm condition (overload) when total load on the generator set exceeds the generator set rating for in excess of 5 seconds. Controls shall include a load-shed control, to operate a set of dry contacts (for use in shedding customer load devices) when the generator set is overloaded.
- F. An ac over/under voltage monitoring system that responds only to true rms voltage conditions shall be provided. The system shall initiate shutdown of the generator set when alternator output voltage exceeds 110 percent of the operator-set voltage level for more than 10 seconds, or with no intentional delay when voltage exceeds 130

percent. Under voltage shutdown shall occur when the output voltage of the alternator is less than 85 percent for more than 10 seconds.

OTHER CONTROL FUNCTIONS

- A. A battery monitoring system shall be provided which initiates alarms when the dc control and starting voltage is less than 25 volts dc or more than 32 volts dc. During engine cranking (starter engaged), the low voltage limit shall be disabled, and dc voltage shall be monitored as load is applied to the battery, to detect impending battery failure or deteriorated battery condition.

CONTROL INTERFACES FOR REMOTE MONITORING

- A. The control system shall provide 4 programmable output relays. These relay outputs shall be configurable for any alarm, shutdown, or status condition monitored by the control. The relays shall be configured to indicate: (1) generator set operating at rated voltage and frequency, (2) common warning, (3) common shutdown, (4) load shed command.
- B. A fused 10 amp switched 24 volt dc power supply circuit shall be provided for customer use. Dc power shall be available from this circuit whenever the generator set is running. (3) A fused 10-amp 24-volt dc power supply circuit shall be provided for customer use. Dc power shall be available from this circuit at all times from the engine starting/control batteries.

OTHER EQUIPMENT TO BE PROVIDED WITH THE GENERATOR SET

- A. The generator set shall be provided with a connection box for free conductors to three individually mounted circuit breakers outside of generator enclosure, no generator mounted circuit breaker is required.
- B. Outdoor weather-protective sound attenuated enclosure:
 - i. The generator set shall be provided with an outdoor sound attenuated enclosure, with the entire package listed under ul 2200. Sound rating not to exceed 75.8 dba at 7 meters. The package shall comply with the requirements of the national electrical code for all wiring materials and component spacing. The total assembly of generator set, including the enclosure shall be designed to be lifted into place using spreader bars. Housing shall provide ample airflow for generator set operation at rated load in an exterior ambient temperature of 100 degrees f. The housing shall have hinged access doors as required to maintain easy access for all operating and service functions. All doors shall be lockable and include retainers to hold the door open during service. Enclosure roof shall be cambered to prevent rainwater accumulation. To limit access of rodent's openings shall be screened into the enclosure. All electrical power and control interconnections shall be made within the perimeter of the enclosure.

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- i. All sheet metal shall be primed for corrosion protection and finished painted with the manufacturer's standard color using a two-step electro coating paint process, or equal meeting the performance requirements specified below. All surfaces of all metal parts shall be primed and painted. The painting process shall result in a coating that meets the following requirements:
 - a. Primer thickness, 0.5 to 2.0 mils
 - b. Topcoat thickness, 0.8 to 1.2 mils
 - c. Glossy per astm 0523-89i 80 percent plus or minus 5 percent
 - d. Gloss retention after one year shall exceed 50 percent
 - e. Crosshatch adhesion, per astm 03359-93, 4b-5b
 - f. Impact resistance, per astm 02794-93, 120-160 inch- pounds
 - g. Salt spray, per astm b117-90, 1000 plus hours
 - h. Humidity, per astm 02247-92, 1000 plus hours
 - i. Water soak, per astm 02247-92, 1000 plus hours
- ii. Painting hoses, clamps, wiring harnesses, and other non-metallic service parts will not be acceptable. The fasteners used shall be corrosion resistant and designed to minimize marring of the painted surface when removed for normal installation or service work.
- iv. Enclosure shall be constructed of minimum 12-gauge steel for framework and 14-gauge steel for panels. All hardware and hinges shall be stainless steel.
- v. A factory-mounted exhaust silencer shall be installed inside the enclosure. The exhaust shall exit the enclosure through a rain collar and terminate with a rain cap. Exhaust connection to the generator set shall be through seamless flexible connections.
- vi. The enclosure shall include the following maintenance provisions:
 - a. Flexible coolant and lubricating oil drain lines, that extend to the exterior of the enclosure, with internal drain valves
 - b. External radiator fill provision

Sequence of operation

- A. Generator set shall start on receipt of a start signal from remote equipment. The start signal shall be via hardwired connection to the generator set control.
- B. The generator set shall complete a time delay start period as programmed into the control.
- C. The generator set control shall initiate the starting sequence for the generator set. The starting sequence shall include the following functions:
 - i. The control system shall verify that the engine is rotating when the starter is signaled to operate. If the engine does not rotate after two attempts, the control system shall shut down and lock out the generator set and indicate "fail to crank" shutdown.

- i. The engine shall fire and accelerate as quickly as practical to start disconnecting speed. If the engine does not start, it shall complete a cycle cranking process as described elsewhere in this specification. If the engine has not started by the completion of the cycle cranking sequence, it shall be shut down and locked out, and the control system shall indicate, "Fail to start."
- ii. The engine shall accelerate to rated speed and the alternator to rated voltage. Excitation shall be disabled until the engine has exceeded programmed idle speed and regulated to prevent over voltage conditions and oscillation as the engine accelerates and the alternator builds to rated voltage.
- iii. On reaching rated speed and voltage, the generator set shall operate as dictated by the control system in isochronous state.
- iv. When all start signals have been removed from the generator set, it shall complete a time delay stop sequence. The duration of the time delay stop period shall be adjustable by the operator.
- v. On completion of the time delay stop period, the generator set control shall switch off the excitation system and shall shut down.
- vi. Any start signal received after the time stop sequence has begun shall immediately terminate the stopping sequence and return the generator set to isochronous operation.

PART 3 – EXECUTION

FACTORY TESTING

- A. The generator set manufacturer shall perform a complete operational test on the generator set prior to shipping from the factory. A certified test report shall be provided and reviewed as described in the project documents. Equipment supplied shall be fully tested at the factory for function and performance.
- B. Factory testing may be witnessed by the owner and/or the owner's representative. Costs for travel expenses will be the responsibility of the owner and/or representative or as described in the project documents. The manufacturer shall provide two weeks' notice prior to factory testing.
- C. The generator set factory tests on the equipment shall be performed at 100 percent rated load and rated power factor for four hours. Generator sets that have not been factory tested at rated power factor will not be acceptable. Tests shall include: running at full load, maximum power, voltage regulation, transient and steady-state governing, single step load pickup, and function of safety shutdowns.

End of Section 26 23 1.x



SECTION 26 55 22 LED LIGHTING

This document is provided as a reference for the design professionals working for American University. This document should not be used directly as written for project specifications. This document does not define products for maintenance replacement purposes, but rather should be used for renovation and new construction projects.

PART 1 – GENERAL

1.0 Summary

- A. This Section includes lighting design criteria, interior, exterior and emergency luminaires, as well as related installation guidelines.

2.0 Regulatory Agencies

- A. Lighting design should conform to the applicable requirements of the following agencies' most current edition of regulations and standards, unless otherwise stated:
 - 1. American National Standards Institute (ANSI)
 - 2. American Society for Testing Materials (ASTM)
 - 3. Environmental Protection Agency (EPA)
 - 4. Federal Communications Commission (FCC)
 - 5. Illuminating Engineering Society of North America (IESNA)
 - 6. National Electrical Manufacturers Association (NEMA)
 - 7. National Fire Protection Association (NFPA)
 - 8. Underwriter's Laboratories (UL)
 - 9. U.S. Green Building Council (USGBC)
 - 10. American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE)
 - 11. International Building Code (IBC)
 - 12. International Energy Conservation Code (IECC)

3.0 Record Drawings

- A. Lighting fixture record drawings shall be provided to the University in the form of standard catalog cuts and/or factory assembly drawings, and shall indicate the following:
 - 1. Luminaire type correlated to lighting plans



2. Luminaire and LED wattage and voltage
3. Complete photometric data
4. Manufacturer's name and catalog number including all fixture options
5. LED and driver types and manufacturer's name
6. LED/driver and fixture
7. Warranty information for fixtures/LEDs and drivers
8. LED equivalent or correlated color temperature (CCT), color rendering index (CRI), and beam spread when applicable
9. LED and Ballast Rated Life

B. Lighting control record drawings shall include the following:

1. Single line diagram showing all control components and associated wiring
2. Load schedule indicating circuit and zone number, light fixture types, LED source, and load per circuit or zone
3. Catalog cut sheets of control system components
4. Lighting control narrative describing control intent for programmable lighting system

C. Full size manufacturer's drawings should be provided for custom designed light fixtures.

4.0 Submittals

- A. Product Data: Arrange in order of luminaire designation. The submittals shall include data on features, ratings, listings, certifications, accessories, finishes, dimensions, emergency components, photometric data, and luminaire efficiency data.
- B. Installation, Operation, and Maintenance Manuals.

5.0 Substitutions

- A. Substitutions for light fixtures not specified in the Contract Documents shall be coordinated with the University's project manager and Facilities Management stakeholders.
- B. All fixture substitutions must be requested via a product substitution request in accordance with the Universities Design and Construction Standards and Division 1 requirements of the contract. If substitutions



are requested, the University is under no obligation to accept them.

PART 2 DESIGN CRITERIA

1.0 Illuminance Levels

Academic Building Areas	Illuminance Level (Foot-candles)
Computer Lab	30 fc
Conference Rooms	30 – 40 fc ³
Environmental Rooms- Workspace	50 - 60 fc ⁴
Environmental Rooms - Storage	15 fc
File/Mail	30 - 50 fc
Laboratories	50 - 60 fc ⁴
Libraries - General/Stacks	30 fc
Libraries - Reading Rooms	50 fc
Mechanical/Electrical rooms	20 fc
Offices	35 - 50 fc ⁴
Restrooms	15 fc
Storage areas	15 fc
Theaters ⁵	30 fc
Museums ⁶	20 fc

Residential Building Areas	Illuminance Level (Foot-candles)
Hallways	10 fc
Dining Areas	20 fc
Dormitory Rooms - General	10 fc
Dormitory Rooms - Desk	30-50 fc ⁵
Kitchens	50 fc



Laundry Rooms	30 fc
Lounges	30 c

Athletic Facilities	Minimum Horizontal Illuminance Level (Foot-candles)	Maximum Ratio (Minimum)	Uniformity (Maximum: Minimum)
Baseball			
Infield	100	2.5:1	
Outfield	70	2.5:1	
Basketball (Indoor)	125 fc	1.7:1	
Football ⁷	100 fc	1.7:1	
Locker rooms	20 fc	N/A	
Soccer	150 fc	2.5:1	
Tennis	100 fc	2.5:1	
Track & Field	50 fc	2.5:1	
Training Facilities	50 fc	N/A	

- Higher values may be required if the space is used for videoconferencing.
- On work plane, including task lighting.
- On aisle, entrance and exit corridors as well as general work levels on stage. Theatrical lighting will be evaluated separately.
- On aisles, entrance and exit corridors. Exhibit lighting should be evaluated and located based on the needs and type of installation and be designed to meet IESNA recommendations based on the specific use and function of the exhibit.
- Includes task lighting.
- Reading taken at 36" above ground unless otherwise noted.
- Readings taken at grade.



If sports and athletic facilities are required to be used for televised events, the lighting designed in these facilities must meet IESNA and NCAA guidelines based on the type of facility and the broadcast category. Consideration must be given to both horizontal and vertical illumination for all areas intended to be included in the televised event.

Special and High Risk Use Areas such as wood shops, machine shops, workshops should be designed to allow for both general lighting levels and elevated lighting levels where tasks are performed. Lighting positions should be coordinated with the location of equipment and levels should meet IESNA standards for the specific tasks performed in each area.

3.0 Energy Efficiency & Conservation

- A. Lighting Power Density – All interior spaces should comply with the Lighting Power Density (LPD) defined by the most current edition of ASHRAE 90.1. LPD is expressed in terms of watts/square foot. Standards can be evaluated based on the “building method” or the “space method.”
- B. Building designs and fenestration shall be configured to provide the maximum advantage to daylight harvesting control schemes. Daylight harvesting control schemes shall be employed in all instances where the fenestration area of the room is equal to or exceeds 250 sq. ft.

4.0 Sustainable Design & Energy Conservation

- A. The USGBC Leadership in Energy and Environmental Design (LEED) Building Rating System should be used as a guideline for project lighting design. The Rating System (New Construction, Commercial Interiors, Core & Shell, etc.) most appropriate to the project type should be followed.
 - 1. If the New Construction (NC) rating system is deemed most appropriate, reference in particular the following credit sections; however additional sections may apply.
 - a. Sustainable Sites Credit 8 - Light Pollution
 - b. Energy & Atmosphere Credit 1 - Optimize Energy Performance
 - c. Indoor Air Quality Credit 6.1 - Controllability of Systems – Lighting
 - d. Indoor Air Quality Credit 8.1,2 - Daylighting & Views



- B. Projects shall meet energy and control requirements outlined in the most current version of ASHRAE 90.1 or referenced in the LEED guidelines as described above.
- C. The application of natural light is encouraged to minimize electric lighting requirements.
 - 1. Appropriate glare control must be provided on all windows and skylights. Automatic daylight harvesting (reducing electric lighting load when available daylight is sufficient for lighting requirements) is encouraged.
 - 2. Daylight harvesting utilizing continuous (i.e. not stepped) dimming should always be used in regularly occupied spaces, such as offices and classrooms, to prevent disruption to occupants. Daylight harvesting utilizing on/off switching is acceptable in transient spaces, such as lobbies, atriums, etc.
- D. A lower general light level is recommended in the office or other spaces where under cabinet or desk mounted adjustable task lighting is installed. Such that the net illumination level (as per above tables) is achieved as a result of combined room and task light sources.
- E. High reflectance finishes are recommended for all ceiling and wall surfaces to minimize required energy usage.
- F. Lighting systems should be designed to achieve the above recommended illuminance levels while minimizing energy consumption.
- G. Locate interior and exterior luminaires to minimize light trespass and glare to adjoining properties.
- H. Lighting levels in unoccupied public spaces such as lobbies with exterior views or dorm room corridors must at a minimum meet emergency access and egress levels. Consideration should be given to include the illumination of selected walls and vertical surfaces to provide the appearance of occupancy while maintaining the reduced energy levels.

5.0 Controls

- A. American University requires that interior spaces meet the control requirements defined by the currently recognized version of ASHRAE 90.1.



- B. Ceiling mounted occupancy sensors are preferred and should be used as a default approach to lighting control. Ceiling mounted sensor(s) should be placed in a space such that detection area(s) cover the entire space. When a corner or wall mounted sensor(s) is used it should be located on the “door wall” in the corner farthest from the door. Wall switch sensors will be considered for small spaces with the approval of the Facilities Management department.
- C. When available, occupancy sensors should be specified with isolated relays for future use by non-lighting systems (i.e. local HVAC VAV).
- D. Occupancy sensors shall be specified as the control method in all private offices, restrooms, classrooms, conference rooms, storage rooms and other enclosed areas of intermittent use.
 - 1. Override switches or dimmers should be incorporated in offices, conference rooms, and classrooms.
 - 2. Dual Technology (infrared and ultrasonic/microphonic) sensors should be used in private offices, conference rooms, and classrooms.
 - 3. Ultrasonic sensors are acceptable in restrooms without floor to ceiling partitions.
 - 4. Follow manufacturer's recommendations for coverage specification and sensor placement.
 - 5. Wireless sensors are allowed when battery life meets or exceeds a 10-year rated life and provide a low battery indicator.
 - 6. No lighting controls should be used in mechanical spaces with electrical distribution equipment, motors, pumps, shop equipment or other devices that without appropriate light levels would create a safety hazard.
- E. Where rooms are used for a variety of functions, provide multi-level switching, fixture zoning, or dimming to accommodate light level flexibility for occupants
- F. Where rooms are used for a variety of functions, provide multi-level switching, fixture zoning, or dimming to accommodate light level flexibility for occupants.



- G. Digital time switches with adjustable time setting should be provided for utility spaces containing large equipment.
- H. Consider the design of load shedding for lighting controls in larger new construction to provide feedback to central monitoring system at OCC.
- I. Lighting control systems should be tested and calibrated by the Contractor and should be sample tested by the Commissioning Agent for all projects.
- J. Interior lighting controlled by relay panels for code required automatic shut-off shall have local override switches.
- K. Programming of preset lighting control systems shall be coordinated with the University's project manager and building occupants. A record of the settings shall be provided to building occupants.
- L. Acceptable manufacturers shall be by the following manufactures or equal approved by the A/E of record and Facilities Management:
 - 1. Sensor Switch/Light
 - 2. Hubbell
 - 3. Lutron
 - 4. Wattstopper
 - 5. Cooper Controls
 - 6. Leviton

PART 3 – PRODUCTS

1.0 Drivers

- A. LED drivers shall be electronic type, labeled as compliant with radio frequency interference (RFI) requirements of FCC Title 47 Part 15, and comply with NEMA SSL 1 "Electronic Drivers for LED Devices, Arrays, or Systems". LED drivers shall have a sound rating of "A", have a minimum efficiency of 85%, and be rated for a THD of less than 20 percent at all input voltages.
- B. Dimmable LED drivers shall be 0-10V type. Dimmable LED drivers shall be capable of dimming without LED strobing or flicker across their full dimming range.



2.0 Luminaires

- A. Luminaires should be constructed and installed to allow easy access for luminaire maintenance. Lenses, reflectors, and connectors should be captive to fixture where practical.
- B. Lighting fixtures shall be of specification grade and listed or labeled by Underwriters Laboratories (UL) or an approved Nationally Recognized Testing Laboratory (NRTL).
- C. LED fixtures shall comply with the following: UL Standard 8750 "Light Emitting Diode Equipment for Use in Lighting Products", IES Standard LM-79 "Electrical and Photometric Measurements of Solid-State Lighting Products", IES Standard LM-80 "Measuring Lumen Maintenance of LED Light Sources", and IES Standard TM-21 "Projecting Long Term Lumen Maintenance of LED Light Sources".
- D. ANSI C78.377 "Specifications for the Chromaticity of Solid State Lighting Products" with LEDs binned within a maximum three-step Mac Adam Ellipse to ensure color consistency amongst luminaires of the same type.
- E. Provide lighting fixtures in accordance with the Fixture Schedule.
- F. Provide only LED fixtures with a Design Lights Consortium (DLC) listing, a U.S. Department of Energy (DOE) "LED Lighting Facts" label or a U.S. Environmental Protection Agency (EPA) ENERGY STAR label, which have demonstrated third-party testing verification.
- G. Recessed lighting fixtures shall be thermally protected.
- H. LED fixtures shall be modular and allow for separate replacement of LED lamps and drivers. User serviceable LED lamps and drivers shall be replaceable from the room side.
- I. Dimmable LED fixtures shall have either a 0-10 volt, 3-wire dimming driver, or a two-step (50%-100%) line voltage, two switch
- J. Interior Lighting
 - 1. Fixture types previously typically specified with incandescent or compact fluorescent lamp sources (i.e. recessed downlights) should use dimmable LED technology. American University prefers fixtures manufactured with replaceable LED "lamps" when possible, to avoid potential fixture mismatching upon failure. The design



professional must ensure that the specified dimming control is proven to work with the specific LED utilized for a given switch circuit and for typical replacement LED's and drivers likely to be used.

2. The University will consider acceptance of fixtures manufactured for incandescent lamps paired with LED replacement lamps meeting University Insurer's Certification standards (e.g. UL, FM, etc.). In these instances, the design professional must insure that the specified dimming control is proven to work with the specific LED lamp utilized and for the quantity designed for a given switch circuit.
3. Acceptable dimming protocols include 0-10V and Lutron standards. DALI, DMX or other dimming protocols must be specifically requested or approved by AU's Facility Management.
4. Mounting of luminaires above stairs and in locations that are higher than single floor ceiling heights shall be identified and actively coordinate with the University's Facility Management to confirm access to the fixtures is possible with available maintenance equipment.
5. Luminaires must be hard-wired. Flexible cord (SJO) connectors are not acceptable. MC cable is permitted.
6. Where luminaires from manufacturer's standard product lines do not meet the requirements of the project or application, custom designed fixtures are acceptable with approval by the University provided they meet the following criteria:
 - a. The fixture shall utilize commonly available LED, driver & lens types, preferably those used elsewhere on the project.
 - b. The entire fixture assembly must be listed by U.L. or other Nationally Recognized Testing Laboratory standards.
 - c. The lamp and ballast must be easily accessible for maintenance without major disassembly of the fixture.
7. Where required, luminaires should have low iridescent reflectors, baffles, and louvers.
8. Adjustable luminaires shall be capable of being locked into



position with a legible aiming angle for consistency between fixtures. These luminaires should have the ability to maintain focus position during lamp changes.

9. Luminaires shall bear U.L. label or other Nationally Recognized Testing Laboratory (NRTL) tested to U.L. standards.
10. Where luminaires utilize flat lenses, 100% UV stabilized virgin acrylic with minimum 0.125" thickness shall be specified. When lensed fixtures are specified in areas where the fixtures are subject to damage, polycarbonate lenses shall be specified in lieu of acrylic.
11. Luminaires with painted components should be painted after fabrication.
12. Fixtures using linear fluorescent lamps and electronic ballasts should use lamps and ballasts specified in the lamps and ballasts section of this document.
13. LED technology luminaires should have the following performance specifications:
 - a. Consider LED sources based on durability, energy efficiency, and reduced maintenance. The use should be approved by Planning and Project Management and Facilities Management prior to specification.
 - b. LED fixtures are to be provided by manufacturers with a minimum (8) years' experience and provide minimum (5) years warranty on all electrical parts.
 - c. LED components and fixtures shall comply with ANSI chromaticity standards, LM79 and IES LM-80 lumen maintenance testing standards.
 - d. Dimmable LEDs will utilize Constant Current Reduction or Pulse Width Modulation controls. The design professional is responsible for ensuring performance compatibility between specific LED fixtures and controls.
 - e. LED lighting systems with unmatched drivers and power supplies will not be considered.
 - f. Lumen packages sufficient to meet space design



requirements including: maximum watts/square foot allowed by current energy code uniformity ratios no greater than 5:1 (excluding non-critical lighting locations) and minimum IESNA light levels for the applicable space type. The assumed Driver mA rating should be indicated when reporting initial delivered lumens of a specified fixture.

- h. Lumen/Watt performance greater than 80, assuming Lumens are measured as delivered lumens @ 35-degree Celsius multiplied by a 90% Light Loss Depreciation Factor and Watts are the total system watts of the fixture. Lumen/Watt performance meeting or exceeding 100 is the University's goal.
- i. Rated life of 50,000 when lumens depreciated to 90% of initial rating using IESNA TM-21 testing methodology and data extrapolation. This is commonly referred to L90 rated life.
- j. DLC certification recommended and preferred.
- k. Color Rendering Index equal or greater than 80.
- l. Correlated Color Temperature of 3,500. Color changing LED luminaires shall provide full spectrum color changing capability through the use of red, blue, green and white (amber) LED's.
- m. Design professionals are required to provide LED fixtures that are compatible with existing or newly specified dimming controls.
- n. Facilities Management must approve any exceptions to the above specifications.

K. Exterior Lighting

- 1. Mission Statement: The University's primary mission for exterior lighting of the campus is to enhance safety. In the process, lighting should improve the appearance of the campus, be energy efficient, utilize long life sources to minimize maintenance and minimize light pollution. Lighting must be adaptable for future campus development and changing technologies and be responsive to input from campus users.



2. All measures should consider matching the University's existing campus exterior lighting LED standard. LED luminaires are rapidly evolving as the chosen source for illumination of all new pathway and drive lane lighting on AU's campus.
3. Exterior pathway light poles shall be either of the following existing fixtures. Any deviations must be pre-approved by the Planning and Project Management.
 - a. Washington Gas-Light Standard matching existing in style and specifications.
 - b. Shoebox type, of heavy-duty construction (noting that sheet metal base covers are not acceptable), matching existing in style and specifications.
4. Poles shall be spaced a maximum of thirty (30) feet on center.
5. Luminaires should be either located or specified to prevent possible damage from vandalism.
6. Exterior luminaires and poles shall have the ability to withstand wind speeds of 80 miles per hour.
7. Exterior wall packs, both new and replacement units, shall utilize induction or LED lamping. Fixtures shall have superior glare control with lighting directed downward. Fixtures with light distribution above 90 degrees shall not be acceptable.

D. LED Replacement Lamps

1. Approved Manufacturers: Philips, Osram Sylvania and GE
2. Consider LED sources based on durability, energy efficiency, and reduced maintenance. Planning and Project Management and Facilities Management should approve the use prior to specification.
3. LED lamps are to be provided by manufacturers with a minimum (8) years' experience and provide a minimum (2) years warranty on all electrical parts.
4. LED components and fixtures shall comply with ANSI chromaticity standards, LM79 and IES LM-80 lumen maintenance testing



standards.

5. Dimmable LEDs will utilize Constant Current Reduction or Pulse Width Modulation controls.
6. Design professionals are required to provide LED lamps that are compatible with existing or newly specified dimming controls.
7. LED lighting systems with unmatched drivers and power supplies will not be considered.
8. Lumen packages, beam spreads and main beam candlepower sufficient to meet space design requirements. The assumed Driver mA rating should be indicated when reporting initial delivered lumens of a specified fixture.
9. Lumen/Watt performance greater than 80, assuming Lumens are measured as delivered lumens @ 35-degree Celsius multiplied by a 90% Light Loss Depreciation Factor and Watts are the total system watts of the fixture.
10. Rated life of 25,000 when lumens depreciated to 90% of initial rating using IESNA TM-21 testing methodology and data extrapolation. This is commonly referred to L90 rated life.
11. DLC certification recommended and preferred
12. Color Rendering Index equal or greater than 80
13. Correlated Color Temperature of 3,500. Color changing LED luminaires shall provide full spectrum color changing capability through the use of red, blue, green and white (amber) LED's.
14. Design professionals are required to provide LED fixtures that are compatible with existing or newly specified dimming controls.
15. The Facilities Management department must approve any exceptions to the above specifications.
16. Retrofit LED lamps shall comply with NEMA SSL 4 "SSL Retrofit Lamps: Suggested Minimum Performance Requirements".



E. Emergency Lighting

1. A dedicated Emergency Lighting Inverter System or Emergency Generator shall provide all emergency lighting. The use of Emergency Battery Ballasts installed in lighting fixtures should not be considered.
2. Provide self-contained emergency lighting units in all generator, switchgear, ATS, and UPS rooms, regardless of whether or not generator power is available on the project.
3. All new exit signs shall utilize LED lamping.
4. Self-powered exit signs should be provided with sealed maintenance-free batteries (with at least a 10-year warranty inclusive of battery life) and self-diagnostics.
5. When generator power is unavailable, self-contained emergency battery units are acceptable for code required egress lighting. Coordinate with the Planning and Project Management and Facilities Management.
6. Radioactive self-luminous exit signs are not acceptable. Self-luminous exit signs that are toxin free may be considered on a case-by-case basis.
7. Emergency lighting levels shall meet National Fire Protection Association (NFPA) 101 and International Building Code (IBC) requirements.
8. Identified Egress Paths (i.e. corridors, stairwells & assembly areas) must meet both currently adopted code requirements for minimum illumination levels and sufficient directional signage when normal power is not available.

F. WARRANTY

1. For non-LED lighting fixtures and components, provide a complete warranty for parts and labor for a minimum of one year from the date of Substantial Completion.
2. For LED fixtures, lamps, drivers, and components, provide a complete warranty for parts and labor for a minimum of five years from the date of Substantial Completion.



PART 4 – EXECUTION

- A. All luminaires recessed or suspended from the ceiling shall be supported by the structure above the ceiling at a minimum of two locations for every four feet of fixture length.
- B. The Contractor shall provide a list of Luminaire (fixture, LED and driver) types used on the project with the associated installation locations noted.
- C. All adjustable interior and exterior light fixtures should be aimed by the Contractor to the satisfaction of the A/E and the University.
- D. The contractor will be responsible for the coordination for programming of programmable lighting control systems. This includes providing factory trained technicians for programming and commissioning of the systems as well as training of personnel responsible for the upkeep of the systems as well as arranging a time conducive to both client and design team to meet and provide direction to the programmer.

END OF SECTION 26 52 22

END OF DIVISION 26