

Design and Construction Standards

Division 26 – Electrical

Section 26 00 03 Provisions

1. Information for Design of System: During the initial planning conference, consult the University and Facilities Design and Construction and Principal Electrical Engineer, regarding the choice of primary service voltage to be used, its location, and the capacity available.
 - a. Equipment and Installation Guidelines:
 - i. An important aspect of power system design and installation involves consideration of service reliability of the proposed system and loads that are to be supplied. System Installation inspection and service reliability will be performed by the Contractor in the presence of the University Representative(s), Facilities Operations and Development, Electrical Utilities Shop when and if the systems are to be connected to University electrical power systems. The system shall not be energized if these requirements are not met or it fails final inspection.
 - ii. Contractor(s) and Associate Engineer(s) are responsible for addressing all the design review comments to the satisfaction of the University in order to assure the continued reliability of the University power distribution system.
 - b. Safety:
 - i. The incorrect application of electricity and unsafe installation can cause both minor and serious accidents. The Designer must remain vigilant to electrical hazards and take appropriate steps in meeting all safety rules and regulations in electrical power and installation distribution design. It is important that the design meet requirements of all appropriate codes including, but not limited to, the following codes and regulations: NEC, NFPA, OSHA and National Electrical Safety Code. It is also important that all the equipment, devices and installations supplied and installed in all University's Facilities meet high level of safety requirements, and the EMU Building Design Standards. It shall also be known that the equipment, devices, and installation that fail to meet these requirements will not be accepted.
2. Short Circuit Study, Arc Flash Study and Overcurrent Protection Study: For all buildings with electrical services where electrical work is being performed a short circuit study, an arc flash study and an overcurrent protection study shall be provided. The start point of each study will be one overcurrent protective device

- “upstream” of the starting point of the scope of work of the project and terminating at the farthest point “downstream” affected by the “upstream” changes.
- a. Each study shall include the elementary diagram of the circuit being analyzed.
 - b. The short circuit study shall depict the available fault currents at critical points in the distribution system. The study shall indicate the fault rating of the equipment being analyzed and designated with a “pass”/“fail” marking. Where available currents exceed the short circuit ratings of the equipment, the equipment shall be revised to a component with a higher short circuit withstand rating.
 - c. The arc flash study shall be performed in accordance with NEC, NFPA and MIOSHA safety standards. Available fault currents shall be shown on the elementary diagram at critical points in the distribution system. The PPE level shall be provided at all switchboards, panels, disconnect switches, starters and similar electrical components with proper labels provided.
 - d. The coordination study shall be provided to assure both overcurrent and short circuit selective coordination occur to provide an orderly shutdown and to minimize extent of outages.
 - e. These studies shall be part of the design services.
3. Coordination of Hardware: All electric panel doors shall be equipped with Corbin Ruswin Access Systems cylinders with removable 7-pin cores. Refer to Division 08 for further details.
 4. Equipment belonging to other University Departments shall not be installed in or stored in Facilities Operations mechanical or electrical rooms, unless permission is given by Facilities Operations in writing.
 5. Building electrical power shall be from the EMU power system, if available.
 6. Prohibited Materials and Construction Practices:
 - a. Door Closers: Refer to Division 08 regarding the prohibition against door closers with integral smoke detectors.
 - b. Extra flexible non-labeled conduit or non UL listed conduit.
 - c. Plastic conduit for interior electrical use, except that PVC conduit may be used for power circuits below basement concrete floors in corrosive environments, and for ground wires in any location, or with approval from the University Facilities Electrical Shop. The transition from PVC to steel shall be made below the floor.

- d. Aluminum wiring shall not be used.
 - i. Use of aluminum plated bus and aluminum wound transformers is prohibited in all EMU projects.
- e. Use of incompatible Materials: Aluminum fittings and boxes shall not be used with steel conduit. All materials in a raceway system shall be compatible.
- f. Multi-use Suspension Systems: Piggyback suspension systems for conduits, fixtures, etc. are prohibited. All suspensions must be hung independently from structure, or in limited cases, from trapeze suspension systems.
- g. Use of wire ties to support conduit.
- h. Use of wood strips and wood screws to support lighting fixtures.
- i. Use of Class J fuses.
- j. Direct burial electrical cable.
- k. Electrical ducts crossing above gas piping.
- l. Ducts within 10 feet of a buried steam line in any direction. If it becomes necessary to cross a steam line, acceptable insulation of the crossing must be approved by the Electric Utilities Division, Facilities Operations and Development.
- m. Hard insulated wire connectors, which have Bakelite, are prohibited.
- n. Dimmable lighting unless permission is obtained in writing from the University Facilities Principal Electrical Engineer. See "Lighting Control" in this Division.
- o. Armored or metallic BX cable.
- p. Non metallic sheathed cable.
- q. Flat conductor cable type FCC, under carpet, etc.
- r. Fluorescent fixtures using other than 4-foot tubes are discouraged. Where 2' x 2' fixtures are needed, use 2' long fluorescent tubes. Fluorescent U tubes are prohibited.
- s. Powder metal die cast connectors, fittings and couplings.
- t. Locating the following equipment less than four feet from a wall: electrical equipment that permits or requires rear cooling, rear access for maintenance or cleaning, rear connection, and main distribution panels and equipment.
- u. Bottom fed switches, breakers or fuses.
- v. Switches in which the blades pivot on the top.
- w. Switches, breakers, etc. that require greater than 75 pounds of force on the operating handle.
- x. .
- y. Use of cable tray with medium voltage conductors.
- z. Use of busway other than as permitted in "Busways" of this Division.
- aa. Use of busway for panel risers without a means of disconnect.
- bb. Drilling, tapping of existing bussing in panelboards, switchboards and motor control center.
- cc. Troffers: Use of radiant ceiling panels.

- dd. Lamps not manufactured by General Electric, Philips and Sylvania.
 - ee. Lamps provided by only one manufacturer.
 - ff. Fixtures that require proprietary lamps.
 - gg. Use of communication cable tray to support power and lighting circuits/raceway.
 - hh. Entrance to an Electrical Closet from other than a hallway or exterior door.
 - ii. Electrical panels located in offices or classrooms.
 - jj. Use of a bushing without one in place of a lock nut.
 - kk. In-ground junction boxes.
 - ll. Outdoor use of EMT.
 - mm. Use of an override switch in parallel with a photo cell.
 - nn. More than two (2) offices on a single circuit. Multiple circuits are allowed for a single office as needed.
 - oo. 15A wiring devices.
 - pp. Use of gray wire on 208Y/120 volt systems. Use of white wire on 480Y/277 volt systems.
 - qq. Use of push-in or WACL connectors on stranded wire.
 - rr. Use of non-locking wiring devices under raised floors.
 - ss. Metal conduit covers supported by a threaded body for outdoor use in corrosive environments.
 - tt. Panel enclosures and junction boxes larger than 4-11/16 that have stamped knock-outs.
 - uu. Use of MC or AC cable in kitchens or laboratories. Other uses of MC or AC cable must be approved by the University Facilities Principal Electrical Engineer.
 - vv. Use of IEC type starters or equipment.
 - ww. Control circuits higher than 120V.
 - xx. Sharing motor circuits with power receptacles.
 - yy. Installation of auditorium, atrium, stairwell or high bay lighting that requires construction of scaffolding for service and maintenance; or installations without also providing the proper means for service and maintenance of said lights. Must have approval of the Facilities Electrical Shop for all high bay lighting.
7. Special Requirements for Manholes or Vaults:
- a. Manholes shall not be installed inside buildings.
 - b. If there are existing manholes (MH) or vaults inside buildings undergoing major renovation that cannot be moved or relocated, then provision must be made for access by a live truck, known as the High Voltage Truck, for emergency repair, maintenance, and cable termination or replacement.
 - c. Tapping existing switchgear, switchboards, panelboards, and motor control centers to provide power for new feeders or equipment is prohibited in all University facilities.

Section 26 05 05 Electrical Materials and Methods

1. UL Listed Equipment and Materials: Specify only Underwriter's Laboratories listed equipment, assemblies, and materials when such items are available. The equipment and materials shall be installed in accordance with its listing.

Section 26 05 15 Wire and Cable

1. Material: Copper conductors of 98 percent conductivity shall be used unless use is restricted by Government Agencies.
 - a. All medium voltage distribution cables shall be UL listed, 1/c, copper, mil Ethylene propylene rubber (EPR) insulated, 15 Kv, 133% rated, shielded, MV 105 degrees C. Feeders shall consist of three (3) primary cables and one (1) 3/0 neutral. Extension or modification of existing 4800 volt or 13,200 volt cables can only be done with prior written approval of the University Facilities Operations Principal Engineer or Electric Utilities Shop.
2. Secondary Conductors:
 - a. Color Coding
 - i. Color coding for 480/277V and 208Y/120V shall be as follows:

<u>Phase</u>	<u>Voltage (208Y/120)</u>	<u>Voltage (480Y/277)</u>
Neutral	White*	Gray*
A	Black	Brown
B	Red	Orange
C	Blue	Yellow
Equipment Ground	Green	Green
Isolated Ground	Green with Yellow Stripe	Green with Yellow Stripe

*Each with identifiable color stripe

- b. Solid and Stranded Wire: No. 14 AWG and smaller may be solid. No. 12 and larger shall be stranded.
- c. Minimum Size for Lighting and Power Branch Circuits: No. 12 AWG.
 - i. Use No. 14 AWG stranded for control wiring and auxiliary system circuits.
- d. Field installed cords to portable equipment shall be Type ST or SO and field installed cords for normal equipment shall be Type SRDT or SPT-3 containing identified equipment.
- e. Circuit wiring through ballast channels of fluorescent fixtures shall be 600-volt, 90-1 degrees C insulation. Fixture must be approved for through wiring, if thus used.
- f. General Use Insulation: NEC, 600-volt type THHN/THWN or XHHW.
- g. Connections in No. 10 and smaller wire shall be made with threaded-on plastic or nylon insulated wire nuts. Crimp connectors, except butt connectors are prohibited. Joints in No. 8 and larger conductors shall be made with pre-insulated mechanical lugs.

Section 26 05 17 Wiring Devices

1. Design: All wiring devices provided shall be 20A specification grade. New building devices will be ivory, white or brown with stainless steel plates for standard and ground fault interrupter use. Isolated ground devices shall be orange with stainless steel coverplates. Existing building designers shall match existing color scheme that is prevalent throughout building.
 - a. Placement of Receptacles:
 - i. In standard size classrooms (49 students or less) provide a double duplex receptacle at the front of the classroom centered under the chalkboard or markerboard. Provide two additional receptacles at the front of the room spaced half way between corners and double duplex receptacles. Back of rooms to be provided with single duplex receptacle at center of wall. Remaining walls to be provided with two duplex receptacles on each wall equally spaced.
 - ii. In classrooms with 50 students or more provide two duplex receptacles for the front wall, centered between the corners and one double duplex receptacle at the center of the wall. Provide two duplex receptacles equally spaced on all remaining walls.
 - iii. Corridors shall be provided with duplex receptacles 35' on center and a maximum of 10' from end of corridor. These receptacles shall have separate circuits from the room circuits. In hallways and corridors adjacent receptacles shall be on alternate circuits.
 - iv. Lecture halls shall be provided with a double duplex receptacle centered on front wall and two additional double duplex receptacles equally spaced between center double duplex and corners. Provide one duplex receptacle in the floor for a podium. Provide additional receptacles throughout for cleaning. These receptacles shall be a maximum of 25' on center. If lecture hall is provided with a lab bench, then provide bench with one double duplex for every eight foot of bench.
 - v. Computer labs shall be provided with at least two general purpose receptacles equally spaced per wall in addition to all receptacles for computers.
 - vi. Mechanical room shall be provided with at least four duplex receptacles (one per wall) and additional duplex receptacles where walls are 25' or longer. At least one receptacle shall be fed from the emergency panel.
 - b. Switches:
 - i. Switches provided for all uses shall be 20A specification grade. Color scheme shall match receptacles.
 - ii. Switches provided at roof hatches or where provided outside of rooms they are serving shall be provided with pilot lights.

- c. Cover plates:
 - i. Generally coverplates for flush-mounted standard devices shall be stainless steel for interior use in new buildings. Where work is being performed in existing buildings, coverplates shall match the majority of the existing devices. In residential buildings covers shall be unbreakable nylon.
 - ii. Coverplates for exterior use shall be a type which allows NEMA 3R rating to remain while in use. Where exterior device could be exposed to vandalism, provide locking type coverplates.

Section 26 05 29 Hangers and Supports

1. Materials for Straps and Hangers: Heavy-duty malleable iron or steel. For installation in locations above grade that are subject to moisture penetration, specify corrosion-resisting steel. Perforated straps are not acceptable.
2. Independent Support Systems: Required for all installations.
 - a. Surface outlet boxes, to which fixtures are attached, and pull boxes shall be fastened to the structure independent of the conduit system supports.
 - b. Conduits above suspended ceiling shall be attached to the structure and shall not be supported by a ceiling suspension system.
 - c. Fixtures mounted on or recessed into suspended ceilings shall not be supported by the ceiling tile or ceiling suspension system.
3. Coordination with General Construction: The Associate shall include the following (or similar) statements in specifications for suspended lay-in ceilings:
 - a. Surface mounted fluorescent lighting fixtures shall be supported from the structure above independent of any ceiling system by use of 3/8-inch all thread rods.
 - b. Flush or recessed fixtures in ceilings of the suspended lay-in type shall be installed so that the long dimension of the fixture is supported on the main support member of the ceiling system. Provide at least two galvanized steel safety hanger wires or safety chains, attached from the fixture housing to the structure independent of the ceiling system. Wire or chain shall withstand a 3-foot, 50-pound drop test. In addition, the Luminaire Support Requirements of NEC shall be strictly followed. Manufacturer supplied grid clips must be utilized and installed per manufacturer instructions.

Section 26 05 33 Raceways

1. Interior Conduit and Fittings: Minimum conduit size for power circuits shall be 3/4-inch. Minimum conduit sized for control wiring shall be 1/2-inch.

2. Rigid galvanized threaded UL labeled conduit shall be specified for use in exterior walls, outdoors, for indoors exposed (surface) applications from floor level to 8-feet above floor, seal penetrations, and all the areas having potential to corrode or eat away by chemical action (corrosive atmosphere) and hazardous locations.
 - a. Threaded couplings shall be used with rigid conduit and IMC.
 - b. IMC may be used in place of rigid galvanized where permitted by code.
3. Steel Electric Metallic Tubing (EMT) (up to the 2-inch size) UL labeled conduit may be used in interior partitions, above ceilings, and for surface application higher than 8-feet above floor, except in corrosive and hazardous locations, where PVC coated rigid galvanized conduit is required to be used.
 - a. Insulating bushings and insulated throat fittings shall be used throughout EMT installation.
 - b. Compression fittings shall be used outdoors. Set screw type fittings may only be used indoors.
4. Plastic jacketed rigid galvanized steel conduit shall be used in corrosive atmosphere.
5. Flexible conduit used for motor make-up shall be liquid tight flexible conduit. Flexible conduit used for lighting fixture connections shall be steel, minimum size of 1/2-inch for lighting fixture whip and 3/4-inch for motor connections. Maximum length shall be 6'-0". Flexible conduit of any type shall not be used in interior partitions or in walls as a substitute for EMT, IMC or rigid steel conduit. A ground wire shall be pulled in all flexible conduits. All flexible conduits shall be supported. Distance between supports as allowed per NEC.
 - a. Liquid tight flexible metal conduit shall be used on flexible conduit applications exposed to outdoor or moist locations.
 - b. Liquid tight flexible metal conduit shall be used in raised floor computer room applications.
6. Rigid galvanized steel conduit shall be used outdoors, above grade, in damp locations.
7. Conduit installed through a building wall shall have internal and external seals. Specify link seal or equivalent.
8. Elbows used for medium voltage cable shall be long radius rigid steel.
9. Grounding: Conduit crossing building expansion joints shall have expansion provision with grounding continuity.

Section 26 05 35 Busways

1. The Associate may use feeder Busways in lieu of conduit and wire where approved by the University Facilities Principal Electrical Engineer.
2. Plug-in bus shall be used in shops where the load density provides an economic advantage over panels and shall not extend into more than one space. Plug-in bus shall be copper. Busway shall be used to serve one room or usable space. It is prohibited for busway to penetrate a fire rated wall.
3. Indoor busway (if used) shall be water resistant per ANSI/IEEE Standard 141-1986.
4. If use of busway is approved by special permission for a project, Contractor shall provide 10% of spare busway and 10% of total spare switches used. This includes when busway is installed in shop areas or specially approved conditions.

Section 26 05 38 Surface Raceways

1. Surface raceway shall not be used in new construction except as approved by the University Facilities Principal Electrical Engineer.
2. Surface metallic raceway with associated coupling, boxes and fitting shall be mounted to the surface of structure for the installation of electrical conductors when approved may be used in the following locations:
 - a. In dry locations.
 - b. In Class I, Division 2 Hazardous (classified) locations and as permitted by National Electric Code (NEC).
3. Surface non-metallic raceway shall not be used.
4. Fittings and Boxes:
 - a. Raceway shall have manufacturer's finish standard prime coating suitable for field painting.
 - b. The acceptable manufacturers for surface raceways shall include:
 - i. The Wiremold Co.

Section 26 05 40 Utility Tunnel Conduit and Fittings

1. Installation requirement for corrosive and external heat generating environment. The conduit must be suitable for the best protection from corrosion in the most demanding environments such as utility tunnels, under bridges, chemical, utility plants, underground pipeline, laboratories, electrical substations, and parking lots.
2. The conduits and the fittings must meet the requirements of UL 1984 that covers conduit type AG for use above ground and/or below ground, and type BG for use below ground applications. The University requires that the manufacturer supply a letter from UL, not a "Certificate of Compliance" for the product to be approved for use in University facilities.
 - a. The preferred conduit and fittings shall be PVC coated rigid galvanized steel conduit that provides maximum protection against corrosion .
 - b. PVC Coating Rigid Galvanized Steel Conduit:
 - i. The PVC coated conduit shall be UL listed. The permitted PVC coating must have been tested and approved by UL as providing the primary corrosion protection for the rigid galvanized steel conduit.
 - ii. Applicable UL standard may include: UL 6 Standard for safety, rigid metal conduit, UL 514B Standard for Safety; Fittings for Conduit and Outlet Boxes.

Section 26 05 45 Underground Raceways

1. General Requirements: All underground cables of any classification shall be installed in raceway systems. All the raceways for medium/high voltage shall be 5” in size and all others for street lighting and other applications shall be sized in accordance with the projected electrical load growth in the vicinity. The conduit requirements for utility tunnels are detailed in Section 26 05 35.33 of this standard. Underground raceway systems for medium/high voltage systems shall be encased in concrete. Provide a yellow marker tape 18” above the conduits indicating “Danger Buried Conduits”.

Section 26 10 00 Secondary/Low Voltage Electrical Distribution

1. Magnetic Interference and Mitigation:
 - a. Magnetic interference can pose major problems in the design and operation of electrical and electronic equipment, instruments, control systems, data processing equipment and communication networks. This equipment frequently indicates aberrations whose sources may not be readily recognized, but which are due to magnetic interference. In general, such interference is classified as internal and external.
 - i. Internal interference, created by operation of components within the system itself, can usually be eliminated or nullified by shielding the individual components and confining the magnetic force they create.
 - ii. External interference is frequently caused by nearby or adjacent equipment such as transformers, medium voltage busway, or switching equipment, which generate magnetic “spikes” affecting apparatus which is not physically attached to the source of interference.
 - b. Special Protective and Preventive Materials: In addition to developing a basic protection design in preventing the penetration of magnetic interference, when it is required by this Standard to Design and specify EMF mitigation plans or strategies that will prevent and solve the magnetic interference problems as described in Section 26 10 00.1.a. The expectation of this standard is to reduce EMF to below one (1) milligauss, even in the most complex field environment.
 - c. Special EMF Shielding Material: There are two means of EMF shielding that may be used to achieve effective prevention of magnetic interference or eliminate the existing problems. See Sections 26 10 00.1.b and 26 10 00.1.d.
 - i. In fields of low intensity, use CO-NETIC AA perfection sheet because of its high initial permeability and corresponding high attenuation characteristics. In fields with high intensity, use NETIC S3-6 sheet because of its high magnetic saturation characteristics. CO-NETIC AA Perfection Annealed Sheet are available in standard gauge .014” through .062” thick, in flat sheet sizes up to 30” x 59” or full sheet of .015” thick and 36” by 120”.

- ii. Installation: For wall or floor coverings designer shall specify that sheets shall be butted at seams, all seams flush and tight.
 - iii. Fasteners: NETIC/CO-NETIC AA sheets shall be mounted to walls by non-magnetic fasteners to penetrate the shielding sheets. Hole in the NETIC/CONETIC AA alloy sheets for fasteners shall be drilled with standard metal drills (cobalt steel drill bits). Special fastening application (masonry, concrete, etc.) shall be consistent with EMF shield manufacturer's recommended attachment procedures and EMU Building Design Standard requirements.
 - iv. Seams: All seams between sheets to be covered by CO-NETIC AA foil, 0.01-inches thick, by 4-inches wide, with factory supplied PST backing. Apply foil centered over the sheet seams and pres down tightly.
 - v. Finishing: The CO-NETIC AA metal has a natural shiny, silver colored finish and will not rust. Gypsum wall board (dry wall) or approved other materials shall be applied over the CO-NETIC AA sheets after seams are covered. No magnetic fasteners are to penetrate the CO-NETIC AA sheets.
 - d. Optional Shield Material: The use of ferrous metal sheet for EMF shielding has been one method the University utilized for correcting EMF problems. But it has unavoidable installation difficulties for inexperienced installers. The sheet metal sheet is too heavy, requires accurate overlapping to achieve minimum EMF reduction, but it is very effective, if correctly installed.
 - i. Installation: All medium voltage transformers and switch gear including motor control centers that are adjacent to or under offices, computer centers/rooms or locations that will have the use of Sensitive Electronic Equipment (SEE) shall be shielded with ferromagnetic material.
 - ii. Use of minimum 10 gauge ferrous steel sheet metal on the side(s) of walls where said offices or rooms are situated, to prevent moving charges that produce Electric Magnetic Field (EMF) penetration that in turn destroys or distorts sensitive electronic equipment.
 - iii. In order to have an effective shielding, the 10 gauge sheet metal shielding shall be overlapped at a minimum of 4-inches at every joint.
 - e. Associate Engineer(s) shall contact the University Engineer's Office for details, if there should be any questions.
2. Transformers (Under 600 Volts):
- a. General purpose distributing transformers shall be single phase and three phase dry type, which are generally used with primaries connected to secondary distribution circuits. They shall be designed for the voltage of 120, 208, 240, 480, and 600 with ratings ranging from 500VA to 5000KVA and frequency of 60 Hz.

- b. The transformers shall be designed for continuous operation at the rated KVA for 24 hours a day, 365 days a year operation with a nominal life expectancy and greater overload capabilities in accordance with the latest ANSI-C57. The temperature rise of these energy efficient transformers shall be 80 degrees C temperature rise and shall be insulated with a UL recognized 220 degree C insulation system. Transformers shall have K factor rating as recommended by ANSI/IEEE C57.110-1986, where required (i.e. computer center, lab, etc.). It shall have a 30 percent overload capability. Because of the growth of computer lab in all building and use of wireless computers throughout the University campus all general purpose transformers in renovations and new construction shall be K-rated transformers.
- c. The transformers shall be designed for a low coil watt loss.
- d. Coil and Core Assemblies:
 - i. Transformer cores shall be constructed with high grade, non-aging, grain-oriented silicon steel with high magnetic permeability, low hysteresis and eddy current losses.
 - ii. Transformer coils shall be wound of electrical grade copper and continuous wound construction. The neutral conductor shall be rated to carry 200% normal phase current, when required.
 - iii. Enclosure shall be ventilated, heavy gauge sheet steel, primed and finished in gray baked enamel. The core and coil assembly of the transformers shall be impregnated with non-hygroscopic, thermosetting varnish and cure to minimize hot spots and seal out moisture. The core of the transformer shall be grounded to the enclosure.
 - iv. The sound levels of the transformer shall be designed in accordance with ANSI/NEMA recommended levels.
 - v. Provide minimum clear working space of 3-1/2 feet about transformers operating at 600 volts, nominal, or less to permit ready and safe operation adjustment, repair and maintenance.
- e. Transformers greater than 25 KVA shall not be mounted on or near the wall adjacent to an office, computer room or laboratory unless the wall is magnetically shielded.
- f. Proper ventilation and cooling shall be provided at locations where transformers are installed to prevent temperature in the room to rise above 75 degrees F.

Section 26 20 00 Low Voltage Electrical Transmission

1. Emergency/Standby Power Systems: Refer to Section 26 30 10.

Section 26 20 03 Low Voltage Switchgear – Service Entrance

1. Protective Devices: Main breakers and feeder breakers or switches shall be equipped with ground fault protection as required by applicable codes. In critical applications provide coordinated ground fault protection on feeder breakers. Provide settings and coordination information with the service manuals.
 - a. All circuit breakers with solid state trip units shall comply with the following standards:
 - i. ANSI/IEEE C37.90.1 – Surge Withstand Capability (SWC).
 - ii. ANSI/IEEE C37.90.2 – Withstand capability of relay systems to radiated electromagnetic interference from transceivers.
2. The maximum operating force required to open or close a switch or breaker shall not be greater than 75 pounds on the operating handle.
3. Vacuum breakers or vacuum switches may be used with the approval of the University Engineer's Office.
 - a. All switches shall be top or horizontal fed to the breakers.
4. Indicator lamps shall be LED or transformer type utilizing low voltage lamps.

Section 2620 04 Metering

1. Metering System: A meter with system display is required for each building, transformer, or service. Approved and acceptable meters and manufacturers for EMU facilities are:
 - a. Power Management Ltd. shall be PML 7200 or PML 7700 with enhanced package #1, RS-485 and 480 volt power supply, if required.
 - b.
 - c. Each individual KWH meter specified must have communications and impulse capability.
 - d. If complete meter setup cannot be done from the front panel, any required software, cables, and keys shall be provided to the Facilities Operations and Development Electric Utilities Shop.
 - e. The height shall be five feet (5'-0") from the finished floor or four and a half feet (4-1/2') from the switch pad to the center of the meter.
 - f. Provide four (4) current transformers and circuit monitor that indicate true RMS current for phase and neutral.
 - g. The monitor shall provide the following information:
 - i. Voltage: phase to neutral and phase-to-phase ABC.
 - ii. Amps: present reading and 15-minute maximum demand ABCN
 - iii. Kilowatt maximum demand based on 15-minute intervals.
 - iv. Power factor, kilo VAR, kilo VAR, hour KVA.

2. A 6-pole GE PK-2 panel-mounted test plug installed flush on switchgear for portable test metering by University Maintenance Personnel. Specify that three (3) left poles be factory wired to the phase current transformer secondaries; wire the right hand pole no. 6 to the phase to neutral potential source. Current transformer poles shall have shorting auxiliary contacts.
 - a. If the meter used for KWHR reading does not have a meter serial number on the front of the display, then an engraved name plate shall be installed below the meter with the meter serial number engraved on its.
 - b. Avoid metering schemes that are only capable of measuring partial loads connected to the distribution system or electrical apparatus being monitored. Specify that the current transformers and the meter shall be installed to measure electrical load from the distribution system including fire pumps. The fire pumps shall be connected ahead of the main overcurrent protective device.

Section 26 20 05 Service Disconnect

1. Secondary main disconnects shall be equipped with electronic trip devices.
 - a. The analysis diagram fault currents shall be shown on a symmetrical basis; and for calculation purposes, the transformer primary available fault supply shall be determined from the University Fault Current Study.
2. Fuses may be used in primary voltage services, secondary voltage main switchgear, distribution panelboards, and motor controls.
 - a. UL classification fuses shall be used as required for time delay and current limitation requirements of the application.
 - b. Class I fuse is prohibited.
 - c. Fuses for feeders and branch circuits up to 600 ampere shall be UL Class RK1 or RK5 with 200,000 AIC.
 - d. Fuses for secondary service mains and feeders over 600 ampere shall be UL Class L with 200,000 AIC.
 - e. Spare Fuses: Specify that a spare fuse complement be stored on existing metal shelves, metal mounting boards, or in a cabinet in the electrical switchgear room and that a typewritten and framed bill of material be mounted nearby. There shall be no combustibles stored or kept near transformers. If there is no existing storage or additional storage space is required, specify that Contractor provide a cabinet equal to Bussman SFC and provide a lock to accept Corbin Ruswin interchangeable cores.
 - i. Spare fuse complement shall include a minimum of three or 10% of the total each (whichever number is greater) spare fuses of each class, ampere, and voltage rating installed, including primary fuses and control circuit fuses in switchgear and any equipment.

Section 26 20 06 Grounding System

1. Drawings and Specifications: Drawings shall show ground systems, protective conduit sizes and relative locations. Specifications and drawings shall include detailed requirements of the grounding system. A reference only to the National Electrical Code, without elaboration, has proven to be insufficient. Specifying requirements only by referencing the code is prohibited. It is required that the Associate shall specify all requirements applicable, instead of referring only to National Electrical Code. This includes specifying the size and requirement of all electrode ground conductors used for connecting to the ground rounds, electrode grounds in the concrete, cold water pipe and between the neutral and the equipment ground. It also includes sizing all equipment ground conductors routed with the phase conductors. All sensitive electronic equipment (computer rooms, etc.) shall have single point grounding system originating at the service entrance ground.
2. All connections to the grounding system shall be exothermic welded, cad weld or equivalent. It is required that the grounding system be tested and have a resistance reading of less than 5 ohms at the ground level. Only copper to copper may be clamped. The Associate shall calculate the system required to obtain 5 ohms. The contractor shall only be required to install the indicated system.
3. Service Ground: Grounding rods shall be a minimum size of 5/8" x 10' copper clad steel and shall not be placed in backfill. It shall meet current NEC requirements and other applicable codes.
 - a. Interconnection of the service ground, system neutral, and equipment ground conductors shall be made within the service equipment.
 - b. Grounding path through feeder conduits must be kept at less than five ohms resistance. The entire feeder conduit shall include a grounding conductor. The equipment enclosure (transformer case, etc.) shall not be used as a grounding path.
 - c. Grounding conductors shall be 600-volt insulated installed in rigid PVC where routed exposed. No metal parts such, as locknuts shall surround the ground conductor. If metal is used, protective conduits for ground conductors shall be bonded at both ends to reduce impedance in the ground path under fault current flow.
 - d. Lightning Protection: It is well documented that insulation levels of overhead lines is considerably higher than insulation levels of terminal apparatus including transformers, switchgears, pothead, etc. which make up or comprise the service entrance to buildings. Such overhead lines are vulnerable to overvoltage, mostly from direct or indirect lightning voltages and switching surges. It is a fundamental characteristic of the traveling voltage waves to increase in voltage when they arrive at equipment having a surge impedance higher than that of incoming line and the magnitude of such incoming waves will approximately double at breaker. Therefore, this standard requires that all equipment connected by cable to overhead circuits shall have lightning/surge arrester protection at each end of the cable to guard

against the possibility of transient over voltages. It is of great importance that protection against direct strokes is provided at outdoor substation installations in the form of grounded masts or overhead ground wires stretched above the installation to intercept lightning strikes, which might otherwise terminate on the lines or apparatus. It is also required that entrance equipment such as transformers, circuit breakers, etc. be protected against direct stroke from traveling waves by installing lightning arresters that possess protective characteristics below the impulse insulation strength of the terminal apparatus.

- i. This standard requires that lightning/surge arresters be installed as close as possible to the HV/MV terminals of the power transformer and all other equipment requiring surge protection be grouped as close as possible to the arresters. Use the station type arrester for the best protective level and highest surge discharge ability for important and critical installations. But the intermediate class type arrester shall be used for less critical installations and mostly for feeder protection.
- ii. Protection of Power Stations and Substations: The protection of power stations (EMU electric stations) and substations (Coral substations) shall include the protection of station equipment by means of surge arresters of the type described in paragraph i of this section. These arresters should be mounted on, or closely connected to, the frames of the principal equipment which is being protected, especially transformers. It is also permissible to mount them on the steel frame work of the station or substation where all components are closely interconnected by means of grounding grid.
- iii. This standard requires the following additional protective measures:
 1. Substation grounding network resistance shall not exceed 5 ohms. Lower values are preferred.
 2. Ground Conductors: The surge arrester grounding conductor shall be connected into the common station ground bus. The grounding conductor shall be run as directly as possible between the arresters and ground and be of low impedance and ample current carrying capacity. These requirements must comply with National Electrical Code.
 3. Indoor Locations: Arresters that are installed inside the buildings shall be enclosed or shall be located well away from passageways and combustible parts.

4. Installation: This standard requires that arresters must be located and installed in such a manner that the expulsion of gales or the arrester disconnect is not directed upon energized parts.
5. All protective lightning rods used for building or facility protection must have a master label pasted on them.
4. Transformer Grounds:
 - a. Building Service Transformers: Secondary neutrals shall be grounded separately from the neutral ground at the service main, unless close coupled in unit substation construction.
 - b. Low Voltage Transformers: Secondary neutrals shall be grounded in the low-voltage service equipment, as required by NEC for services.
5. Equipment Grounds: A wire equipment ground shall be installed within the branch circuit conduit and be grounded to the cabinet of the panelboard to an uninsulated ground bus. The neutral bar of the panel shall not be used for equipment grounds.
 - a. Equipment grounds and the identified neutral shall not be electrically interconnected on the building side of the service ground.
6. Convenience Outlets: Specify that a wired ground be provided for continuity of ground path from the device-grounding pole. Provide ground fault interrupter outlets in wet conditions and where required by NEC and other related codes.
7. Exterior Lighting Pole: For steel-framed structure, provide a concrete-encased reinforcing bar electrode. A steel rod similar to the reinforcing bar shall be used to join, by welding, a main vertical reinforcing bar to an anchor bolt. The bolt shall be permanently connected to the base plate of the steel column supported on that footing. The lightning protection ground system may then be connected by thermite weld or by a bronze bolt tapped into a structural member of that frame. An alternate method is to drive in 5/8" x 12'-0" ground rod adjacent the pole base and connect the ground rod to the base plate via a #2 ANG with all connections being thermite welds. All underground PVC conduits to the light poles shall contain a dedicated equipment ground copper wire. It shall be designed to provide a safe method of protecting electric distribution systems by causing the overcurrent or ground fault protective equipment to disconnect the circuit in case of ground fault.

Section 26 27 03 Distribution

1. Design: If feasible and when unit substations are provided, the secondary main breaker shall be made a part of the building distribution switchgear or switchboard. In no case shall the switchgear or switchboard or panelboard be directly attached to the transformer. A minimum 12-inch transition section with solid barrier is

required to reduce the transfer of transformer heat to the low voltage section.

Reduction of heat transfer may be accomplished with secondary throat or ventilated transition section.

- a. When double-ended substations are provided with tiebreakers, the tiebreaker shall be key interlocked with the main secondary disconnecting means requiring the spare key to parallel sections.
2. Equipment: Metal-enclosed switchgear or distribution boards shall be used in buildings or University Facilities at 600V and below for service entrance power, lighting distribution and as the secondary sections of unit substations. Main service disconnecting devices shall be individually mounted. Feeder devices in the main switchboard or switchgear shall be individually mounted. Feeder devices in distribution panelboards shall be group mounted. The following components shall be specified as required:
- a. Service protectors
 - b. Molded case circuit breakers
 - c. Fusible switches
 - d. Motor starters
 - e. Low voltage AC power circuit breaker (generally limited to main or tie position)
 - f. Bolted pressure switches
 - g. Transfer devices or switches
 - h. Instrumentation, metering and relaying
 - i. Type of Molded Case Circuit Breakers: These devices are available in the following general types:
 1. Thermal magnetic dash pot
 2. Magnetic only
 3. Integrally fused
 4. Current limiting
 5. High interrupting capacity.
 - ii. It is required that all circuit breakers that are equipped with solid state trip unit must comply with low voltage switchgear protective devices of this Division .
 1. Air circuit breakers shall be draw out type, installed in individual compartments.
 - a. Interrupting ratings of air circuit breakers and molded case breakers shall not be applied in “cascade”.
 - iii. The handle operating force on all equipment shall be 75 pounds or less.

3. Provisions for Additional Circuits:
 - a. Size of Switchgear or Switchboard: Select a size that will provide sufficient spare spaces, complete with bus and hardware, for a reasonable forecast of future installation of circuits. A minimum of one fully bussed spare section shall be provided. Provide the following spare switches at the design stage:
 - i. Four (4), 30-amp/3 poles
 - ii. Four (4), 60-amp/3 poles
 - iii. Two (2), 100-amp/3 poles
 - iv. One (1) 200-amp/3 poles
 - b. Additional Section: Provide space in the bus arrangement for the addition of future switchgear or switchboard sections. Switchgear and panelboards shall be accessible with a 4-foot minimum working clearance on all sides regardless of whether the gear is listed as front service or not.
4. Instrumentation shall be per “Metering” section of this Division.
5. Service to Fire Pumps: Fire pumps shall be served and protected as required in NFPA No. 20.
6. Use switchboard instead of panelboard for emergency systems for the purpose of future growth and expansion. The switchboard shall be equipped with metering systems as required in “Metering” section of this standard.
7. When adding switches, circuit breakers, bus plugs or motor starters to existing equipment, the Associate shall include the following in the design documents:
 - a. The manufacturer’s nameplate data including manufacturer and catalog information of the existing equipment.
 - b. If the equipment is no longer manufactured (i.e. Continental, Arrow Hart, Crouse Hinds, etc.) the Associate will contact a company that specializes in obsolete equipment and obtain the bidding information.

Section 26 27 04 Feeder Circuits

1. System Design: Design feeders for a voltage drop of not more than 2 percent between service entrance terminals and branch circuit breakers terminals with a capacity for 30 percent load growth above initial design, unless greater growth is designated by the University in the initial planning conference.
2. Feeders: Feeder ratings shall not be such a large percentage of the main that coordination of time and current and interrupting capacities cannot be achieved.
3. Wiring: Specify that all feeders be installed in galvanized rigid conduit.

Section 26 27 05 General Purpose Power and Lighting Circuits

1. Design branch circuits for a voltage drop of not more than 3 percent between the branch circuit breakers and the load. As a minimum, increase conductors a minimum of one size when 120-volt branch circuit home runs exceed 75 feet.

2. Lighting circuits shall not be loaded to exceed 60 percent of panel breaker rating.
3. Branch Circuit Panels: Panels for lighting, convenience outlets, small motors, and equipment shall be molded case circuit breaker type with thermal-magnetic trip and AC and DC ratings. Maximum number of poles in any panel shall not exceed 42. Provide for spare circuits.
 - a. Breakers shall be 20 ampere, 1 pole breakers, mounted in the panel with bolted bus connections.
 - i. Trip rating of breakers for lighting and general use convenience outlets shall be 20 ampere. Provide other sizes as required for special loads.
 - b. Sub-Feed Breakers: Panels shall not have sub-feed breakers. If multiple panels are supplied from a long feeder, use sub-feed lugs or separate splice box with full size tap to panel mains.
 - c. When installing new branch circuit lighting panels on a project the following shall be considered:
 - i. All new panels shall be 42 pole minimum. Designers shall provide each new panel with a minimum of 15% spare 20 amp single pole circuit breakers and 15% spaces. Designers shall consider an additional panel when these minimums cannot be met.
 - ii. New panels shall be 225 ampere minimum for 208Y/120 volt, 3 phase, 4 wire service and 100 ampere minimum for 480Y/277 volt, 3 phase, 4 wire service. Do not provide 240/120 volt, 3 phase, 4 wire tapped delta systems. Where 240 volts is required use of buck/boost transformers is required.
 - iii. Any new or existing building with 3 phase service shall only have 3 phase panels provided. All exceptions must be approved by the University Engineer's Office.
 - iv. Do not provide panel feeders, fusing or main circuit breakers at less than the panel main device rating.
4. Power panels shall be equipped with molded case circuit breakers of adequate interrupting capacity, or shall be switch and fuse construction using time delay fuses.

Section 26 20 03 Motors and Motor Controls

1. Related Work: Air conditioning chiller starters and fire pump controllers shall be specified with the equipment in Divisions 21 and 23. Wiring from switchgear or switchboard to this equipment shall be specified in Division 26.
2. NEMA and NEC Requirements:
 - a. Motors and motor control equipment shall conform to NEMA voltage ratings. A motor rated for 230 volts may not be used on a 208V system. Associate shall specify a 208V motor or buck/boost type transformer to achieve the required 230V.
 - b. Motor branch circuit protective devices shall meet the requirements of NEC 430.

3. Motor Control Centers: Class I, Type B with terminal strip terminations.
 - a. Locations: Centers shall not be located where ambient temperature could cause derating of overload devices.
 - b. Overload heater charts shall be furnished, mounted inside doors of cabinets or separately framed and mounted outside the equipment.
4. Reduced Voltage Starters: Motors, sizes shall be such that if the inrush current exceeds 40 percent of the building transformer rating. Motors shall be equipped with reduced voltage starters of the closed transition auto transformer or star-delta type, or solid state soft start, or current ramp starters.
5. Operating Protection:
 - a. Certification by the motor manufacturer that motors meet the voltage requirements of NEMA.
 - b. Overload Relays: Polyphase motor controls shall be equipped with three (3) overload relays. Reduced voltage starters shall provide overload protection during the starting step.
 - c. Provide 20% spare starters of each size used and provide 25% spare positions for additional starters. Provide space on floor for one (1) additional section.

Section 26 29 05 Motor Starter Applications

1. Type of Starters: Alternating current (AC) magnetic fused type starters, NEMA Class E2 in accordance with ANSI/NEMA ICS2-1983 (26) shall set current limiting power fuses and magnetic air break contactors. Each starter shall be completely self-contained, pre-wired, and with all components in place. Air break contactors, if employed, shall be current rated based on motor horsepower requirements. It is important to know as a guideline that combination starters will provide an interrupting fault capacity of 260 MVA symmetrical on a 2300V system and 520 MVA symmetrical on a 4160 or 4800V system. This starter must comply with ANSI/NEMA ICS2-1983 (26), Class E-2 controllers NEC 2005-760 and applicable IEEE and current ANSI standards.
 - a. Starters for 600V and Below: The design must conform to ANSI/NEMA ICS2-1983 (26). This is a requirement for magnetic controller ratings of 115-575V. AC motor starters and contactors may be used for controlling the circuit to the motor. This standard requires that starters should be carefully applied on circuits and in combination with joint short circuit protective devices such as circuit breakers, fusible disconnects that will limit the available fault current and let through energy level that starter can safely withstand. This withstand must meet the requirements of ANSI/UL 508/1983 (29) and ANSI/NEMA ICS1-1983 (25), (26) which cover controls, systems and devices. Control circuits shall be 120V or less.
 - b. The starters shall not be used without an adjacent line switch, if unfused disconnect switch is used or installed, it must be close to each motor as much as possible. This standard forbids the installation of a remote switch with lock arrangement, switchgear, switchboard or a unit in a control center.

Section 26 30 10 Emergency/Standby Power Systems

1. Alternate Power Sources: Where the interruption of electric power supply to a building would result in hazard to life or property, major loss of research or equipment, provision shall be made for a standby supply of power to be used in the event of failure of the normal supply. Details of the plans as they apply to the project shall be explained and included in the early design development submittal and conferences. If tie-in on existing circuit or feeder is not practical at present, provision shall be made for future tie-in. Emergency and standby power systems are of two basic types:
 - a. An electric power source set apart from the prime source of power operating in parallel that maintains power to the critical loads should the prime source fail.
 - b. An available reliable power source to which critical loads are rapidly switched automatically when the prime source of power fails (AC source).
2. Automatic Transfer Equipment: Reliable equipment and transfer switch must be specified. Where both emergency systems and standby power systems are provided, separate transfer switches shall be provided for each system. Refer to NEC 700, 701 and 702 for system descriptions.
3. Emergency/Standby Systems: It is required that provision be made by designing an emergency system/standby power source supplied by:
 - a. Engine generator
 - b. Separate emergency source
4. Emergency generator drives shall be natural gas or diesel engines depending on the availability of natural gas the size of the unit.
5. When an emergency lighting system or generator system is available supplying either emergency or standby power, the lights, receptacles, and similar critical loads at the generator, all mechanical equipment spaces, in transformer, switchgear, switchboard or substation spaces should be connected to the emergency/standby system.
6. Electrical lighting and power equipment fed from an emergency/standby generator or any two sources shall have the face painted yellow or a yellow band around it unless in a public area. In both public and non-public areas the equipment shall have a distinctive warning sign and indicate the location of both sources of power.
7. An emergency panelboard shall be provided for:
 - a. Exit lights
 - b. Minimal hallway and stairway lighting and telephone power
 - c. Fire alarms, building security equipment and fire protection systems; this does not eliminate the need for batteries. Batteries shall be tested to indicate amp hour availability. The manufacturer shall provide documentation that indicates conformance with repaired rating to the University.

- d. Elevators and/or elevator rooms when required by the University.
 - e. Emergency Illumination: Emergency illumination shall be part of emergency lighting that shall include illuminating all required means of egress lighting, illuminated exit signs, stairwell lights, and all locations where emergency lighting must provide at least code required minimum illumination to allow easy and safe egress from the area involved.
8. A standby power panelboard shall be provided for:
 - a. Building system equipment which is used to heat the building (to prevent freeze-up in the winter) to include heat pumps, condensate pumps and other equipment as may be designated by the Owner.
 9. Wiring for emergency systems shall be in separate conduits. Specify that all emergency system junction boxes and covers shall be painted yellow.
 - a. Switches for emergency lighting circuits shall not be accessible to the public.
 10. Transfer Switch: Transfer switch is a vital part of the proper operation of the system. In addition to current carrying abilities, transfer switch must be able to withstand voltage surges to meet reliability requirements. Special consideration over normal circuit devices or breakers should be given to transfer switch because of its application requirements. Its design must include normal duty and fault current ratings of the switch. These play an important part of transfer switch application and protection scheme. It shall be capable of closing into high current, of fault currents without damage and withstanding severe duty cycle in switching normal rated load. The design and operation of transfer switch must meet the requirements of this standard and the following codes and standards: NSI/NFPA 70-1987 (12), National Electrical Code (NEC), NFPA 99-2002 and NEC 700-2005. Provide a separate transfer switch for emergency loads such as exit lighting, egress lighting, fire detection, public safety communications, and fire protection pumps from standby or backup power loads. All transfer switches must be connected to a remote control switching device to enable starting the generator and transferring load remotely.

Section 26 37 00 Electrical Provision for Elevators

1. Wiring and Switching: Wiring shall be extended to heavy-duty lockable fused switches located in elevator machine room.
2. Emergency Circuit: An emergency circuit to the elevator machine room shall be provided for the elevator cab light, fan and equipment room.
3. Pit Installations: Refer to Division 14. A light, light switch and GFCI convenience outlet must be provided in the pit of each elevator, each on separate circuits in accordance with the State of Michigan Elevator Code.

Section 26 41 00 Facility Lightning Protection

1. Each building shall be equipped with lightning protection, which shall be designed and specified as an Underwriter's Laboratory Master Label System.
2. Grounding System Requirement: Because of possibility that a breakdown in grounding insulation may accidentally energize all plant or facilities, this standard requires that ground connections shall be made to the electrode by methods providing the required permanence and ampacity, such as:
 - a. Thermite weld.
 - b. All non-current carrying metallic structures or steel frame building are grounded.
3. The main purpose of ground system is as follows:
 - a. To maintain low potential difference between metallic parts, ensuring freedom from electric shocks to personnel in the area.
 - b. To avoid fires from volatile materials and ignition in combustible atmospheres by providing an effective electric conductor system for the flow of ground fault currents and lightning. The connection between the grounding electrode and the earth should have a resistance less than 5 ohms.
 - c. To create a low impedance path to ground to dissipate the energy from a lightning strike to minimize structural failures and to maximize personnel safety.
4. All existing lightning protection system shall be maintained during building renovations and extended to any additions to the building.

Section 26 42 00 Cathodic Protection

1. Underground Piping: Refer to 22 70 30 (15490) for cathodic protection method when such protection is determined to be appropriate.

Section 26 50 00 Lighting

1. Light Levels – General: All new lighting installations at the University shall comply with the latest version of ANSI/ASHRAE/IESNA Standard 90.1 1-2004 except that the lighting power budgets for building area method shall be 21% more efficient than stated. Lighting requirements for the most common University building areas are set forth in this standard. The referenced light levels are understood to be a maintained light level. Light levels are measured at a 30-inch height from the floor or at the actual work surface and represent the average level for the area or workstation. Circulation areas beyond workstations should be lighted to one-third the light level of the workstation, but in no case less than 20-foot candles.
 - a. Specify that contractors shall fuse all indoor and outdoor lighting fixtures when installed.

2. Special lighting applications such as recreational field lighting shall comply with the latest Illuminating Engineering Society (IES) standard or as directed by the University Architect.
3. Student Study Areas and Classrooms: Provide 40 to 60 footcandle light level at workstation. Workstations equipped with video display terminals (VDT's) or computers should be illuminated with 30 to 50 footcandles as recommended by the latest edition of the National Institute for Occupational Safety and Health (NIOSH) standards.
 - a. Switching in classrooms shall provide for switching the fixtures in the front and seating area separately to facilitate the use of overhead projectors, etc.
 - b. Light fixtures at workstations with video display terminals or computers should be located perpendicular to device in order to minimize glare and viewing difficulty.
4. Staff and Faculty Office Workstations: Provide 40 to 50 footcandle light level at workstation.
5. Workstation Where Critical or Fine Work is Performed, as in Laboratories or Drafting Rooms: Provide 50 to 70 footcandle light level.
6. Corridors, Stairwells, Lobbies, Waiting Rooms, Storage and Service Areas: Provide 10 to 20 footcandle light level.
7. Rest Rooms, Lockers and Showers: Provide 20 to 30 footcandle light level.
8. Lecture Hall and Auditorium Lighting: Provide 40 to 60 footcandle light level at all seating locations. For a lecture hall stage area, provide 40 to 60 footcandle light level. For an auditorium stage area, the lighting shall comply with the latest IES standard or as directed by the University Architect. Provide separate switching for stage and seating area.
9. Parking Ramp Interior: Provide 1 to 3 footcandle light level in the traffic lanes, 1 to 3 footcandles in the parking areas, and 1 to 3 footcandle light level at the entrance/exit. All values are average maintained horizontal footcandles. Uniformity shall be 10:1 for the entire area. HPS shall not be used in parking structure.
10. Outside Security, Building Perimeter, Parking Lot and Outside Walkways: Provide 1 to 3 footcandle light level.
11. Outdoor lighting levels shall be designed as follows:
 - a. Primary walkways and problem areas: 1 footcandles average and .5 footcandles minimum.
 - b. Secondary walkways and other areas: .5 footcandle and .10 footcandle minimum.
 - c. Primary streets: 2 footcandles average and .25 footcandle minimum.
 - d. Parking lots: 1 footcandle average and .25 footcandle minimum.
 - e. High activity outdoor parking (i.e. St. John Arena): 2.4 footcandles average and .6 footcandle minimum.

12. Temporary Site Lighting During Construction: Sufficient lighting shall be provided such that Campus Police may observe the entire area. Provide a light level of 1 to 3 footcandles. The Contractor is responsible for providing temporary lighting outside of the project area if the project interrupts the normal lighting to the area.
13. Mechanical Rooms: Provide 50 to 60 footcandle light level. Mechanical room fixtures shall be "turret style" industrial fluorescent fixtures with wire guards. Sockets shall be protected by housing and shall not be exposed. Provide emergency egress lighting.

Section 26 51 00 Interior Lighting

1. Recommended Fixtures: Fluorescent fixtures using 4 foot T5 tubes are generally preferred. Incandescent lighting may be used only with the written permission of the University Architect. Any department requesting approval of incandescent lighting must be willing to accept financial responsibility for the maintenance of the incandescent lighting. Where incandescent lamps are used as part of an equipment system or alarm, provide six (6) spare lamps of each wattage.
 - a. High pressure sodium (HPS) lamps shall not be used indoors. For warehouse large areas and high ceilings T-5 high output reflective fluorescent lighting fixtures shall be used.
 - b. Mercury vapor lights are not to be used for indoor use. Exceptions, for research applications, must be submitted by the Associate for review by Technical Services.
 - c. Metal halide lamps shall only be used in areas where there is assurance that they will be turned off at least once a week; this reduces the possibility of an explosion at end of life. Their use should be limited to areas in which network television coverage is expected, accurate color rendering is required, or gymnasiums.
 - d. Fluorescent Fixtures: All fixtures shall be independently supported from the structure above. Fixtures shall be all metal with hinged shielding louvers. Recessed fixtures with hinged frame open louvers may be used where required for architectural effect. 277-volt fixtures shall be used where this voltage is available. Fixtures shall meet or exceed the requirements of the latest version of ANSI/ASHRAE/IESNA Standard 90.1 2004.
 - e. Quartz lamp fixtures are not recommended; if used they must have lenses to protect against exploding lamps.
 - f. Ballasts: High frequency electronic type, specifically designed to use T5 lamps, instant start, to operate multiple lamps in a parallel configuration. Ballasts shall meet minimum performance standards as established by the Certified Ballast Manufacturers Association. Additional requirements shall include a maximum total harmonic distortion of 20 percent, sound rating of "A", shall comply with applicable standards as set by ETL, FCC, NEC, IEEE, be listed by UL and carry a 5-year replacement warranty. Separate ballasts should be provided for each lighting fixture; exception, tandem or cross ballasting of adjacent fixtures is permitted provided the fixtures are

directly connected to each other. For applications where one ballast is used to light multiple fixtures, the location of other fixture shall be identified.

- i. Ballasts for compact fluorescent lamps shall be electronic type and shall have the following characteristics:
 1. Ballasts to be high power factor type.
 2. Ballasts factor shall be .95 or greater.
 3. Ballasts for multiple lamps shall be parallel wiring type.
 4. Minimum starting temperature shall be 50 degrees F.
 5. Fixtures with multiple ballasts shall have individual fusing for each ballast.
 6. Ballast shall contain end of lamp life fault mode shutdown protection.
2. Line Fuses: A line fuse shall be included in the fixture for each ballast in addition to the internal protection of the class "P" ballasts. Line fuses shall be appropriate for the application and wired in place by the fixture's manufacturer. Fusing for fluorescent lighting fixtures shall be non-time delay type similar to Bussman type GLR with HLR holders.
3. Lenses shall not be specified as an alternative for louvers. If lenses are required for the job, the job shall be engineered for these units. Tempered lenses shall be specified on quartz lamp fixtures.
4. Fluorescent Lamps: 4-foot, 32-watt and 2-foot, 17 watt, T5, instant start lamps with color temperature of 3500K and minimum CRI of 85.
5. Specify the use of exit signs utilizing Light Emitting Diodes (LED) light source with life expectancy greater than ten (10) years.
6. Incandescent Lamps: When approved by the University, specify the 130-volt, inside frosted lamp for general application.
7. Lighting Safety: Stairwells in buildings shall have sufficient fixtures so that the loss of one lamp or ballast will not leave the area dark. The mounting of the fixtures shall not be at the extreme height but must be accessible for maintenance. Position fixtures only on side walls over landings at a maximum height of 8-feet. Fixtures shall have lenses; no bare lamps shall be permitted.
8. Provide the following spare parts with the listed quantities for compact and T5 fluorescent fixtures for each item and size required:
 - a. Fuses: 10%, minimum of 15 per amp rating.
 - b. Fuse Holders: 10%, minimum of 5 per type.
 - c. Ballasts: 5%, minimum of 3 of each type.
 - d. Lamp Sockets: 10%, minimum of 10 of each type.
 - e. Fixture Lenses and Supporting Hardware: 10%, minimum of 2 of each type.
9. All submittal reviews for compact T5 fluorescent fixtures shall include the following:
 - a. Catalog cut sheets.
 - b. Lists of spare parts with quantities to be furnished.

- c. Samples of fixtures along with a sample of each spare part to be supplied.
 - i. Turn spare parts over to the University area shop supervisor and obtain signed receipt.
 - ii. A copy of each approved submittal and a copy of each signed receipt shall be included in the Operation and Maintenance Manuals.
10. Spare lamps should be provided as follows:

Lamp Type	Quantity Installed	No. of Spares
HID	1-10	1
	11-20	6
	21 or more	12
Fluorescent	1-10	1
	11-20	6
	21-50	12
	51-200	16
	201 or more	72

Quantity of lamps installed and not fixtures should be calculated for each lamp type and wattage.

11. Incandescent lighting is permitted in dedicated telephone equipment rooms.

Section 26 56 00 Exterior Lighting

1. Lighting for the entire site, including driveways, walks, parking areas and the building perimeter shall be included in the contract documents.
2. Fixtures: High intensity discharge (high pressure sodium lamps) fixtures mounted on the building or on suitable standards are required for all exterior site lighting. These fixtures shall be automatically controlled by photocell(s) and/or the automated building management system.
 - a. Light control shall be provided on all exterior lighting fixtures. The fixture shall be insect proof. Vandal proof fixtures shall be used if the fixtures are mounted 10 feet or less off the ground.
3. Fixture Location: Fixtures shall be located in such a manner that dark voids and excessive glare in windows are eliminated. Accessibility for servicing must be considered in locating fixtures. Consideration must also be given to light spillage onto adjacent facilities (existing or planned) such as greenhouses, which are light sensitive. Use directional or shielded lighting as necessary. Check with the University Engineer for the type of lights. Grounding rods shall be installed in all lighting poles.
 - a. .
4. Design outdoor lighting to be fed from 100 amp switch, which in turn feeds 100 amp contactor with coil controlled by a photocell. Run all 3-phase legs and neutrals to lighting standards and fuse each pole individually. Alternate each pole to different

phase legs and balance phases. Use twist lock type photo controls to control contactors.

5. The University has no secure storage. Any existing poles, luminaires, concrete collars or screw-in bases removed for relocation at a later date must be stored off campus at the project's expense or in the staging area. Luminaires must be removed prior to pole removal and stored indoors. Any items, except for luminaires, being turned over to the University may go to the University designated storage location. Luminaires shall be taken to the M/E Shop at 2560 Kenny Road.

Section 26 58 00 Lighting Control

1. Multiple Switching: The use of multiple switching shall be evaluated for each space and condition. Where possible, switching shall be circuited to effectively use natural lighting from windows; to permit light reduction during partial occupancy; and to permit reduced lighting for custodial activity.
2. Occupancy sensors shall not be used as the sole means of switching. Manual switches will be provided in all areas with occupancy sensors. Occupancy sensors shall not be used in mechanical rooms or rest rooms. At installation, set all sensors to maximum sensitivity and maximum time delay.
3. Remote switching by means of a central control should be evaluated for new construction and for large renovation projects.
4. Dimming Control:
 - a. Where dimming is required it shall be used to control incandescent lighting and may be used for Hi-Lume and approved solid state dimming ballast fluorescent fixtures for low lighting levels. The control panel/panels required for the dimming system shall have the UL label. Each dimming module shall be UL tested and tested specifically for the type of load it is controlling. Each dimmer module shall possess a means of easily disconnecting power on an individual module-by-module basis.
 - b. Dimming panels shall be cooled without the use of cooling fans with no exception and shall be capable of operating as such in an environment of 0 degrees to 40 degrees centigrade. Satisfactory independent laboratory test results shall be required, that a +40 degree centigrade and at full load, the maximum temperatures of both filter chokes and SCRs/Triacs are not exceeded.

- c. There shall be one air gap positive off relay for dimmer, either integral to the dimmer or mounted elsewhere in the same panel. Other advanced technological approaches that give the same or better operational result is highly recommended by this standard.
 - d. All controls shall have the capabilities of reverting back to their previous status after any duration of power outage (power failure memory), without the use of any type of rechargeable or trickle-charge type of battery.
 - e. Lutron dimming systems with ten (10) year warranty meet University standards. Other systems must be submitted to the University Facilities Principal Electrical Engineer for approval.
 - i. Special Requirements for Fluorescent Dimming Systems: Before specifying fluorescent dimming systems, the Associate shall consider the following:
 - 1. 100 hour “burn-in” time is required for the fluorescent lamps when using the dimming ballasts.
 - 2. The cost of replacing the ballast and lamps when needed is 200-300% more than replacing standard systems.
 - ii. This standard requires the Associate to review the application of dimming devices and submit recommendations to Facilities Design and Construction before incorporating into specifications.
5. Parking ramp interior lighting shall be circuited to permit lighting of dark interior areas during the day without lighting those areas which receive sufficient natural light. Automatic control of ramp lighting by photocell is required.
6. All exterior area and security lighting shall be dusk on and dawn off, powered from one location in the building and controlled from the photo control, with provisions for manual override. Time clock control may be used on exterior or security lighting with approval of the Facilities Design and Construction Department.

End of Division 26 – Electrical