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 and implemented. 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. All electrical work shall be performed by a State of Michigan licensed electrician.
7. 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 bus or aluminum plated bus in all distribution, panel boards, disconnects and transformers is prohibited in all EMU projects.
        ii. Use of aluminum raceways.
    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 or medium voltage conduit systems.
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 Physical Plant. See "Lighting Control" in this Division.
o. Armored or metallic BX cable.
p. Nonmetallic 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, components 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. Use of MC cabling for installations other than 6' fixture whips and "fishing" existing wall cavities, use only steel jacketed MC.
y. Daisy chaining of light fixtures is prohibited.
z. Use of cable tray with medium voltage conductors.
aa. Use of busway other than as permitted in "Busways" of this Division.
bb. Use of busway for panel risers without a means of disconnect.
cc. Drilling, tapping of existing bussing in panelboards, switchboards and motor control center.
dd. Troffers: Use of radiant ceiling panels.
ee. Lamps not manufactured by General Electric, Philips and Sylvania.
ff. Lamps provided by only one manufacturer.
gg. Fixtures that require proprietary lamps.
hh. Use of cable tray to support wiring for power and lighting circuits or power and lighting raceways. Cable tray when permitted shall only be used for telecommunications or security systems cabling.
ii. Entrance to an Electrical Closet from other than a hallway or exterior door.

jj. Electrical panels located in offices, corridors, closets or classrooms. Electrical panels shall be installed in designated electrical rooms.
kk. Use of a bushing without one in place of a lock nut.
ll. In-ground junction boxes.
mm. Outdoor use of EMT.
nn. Use of an override switch in parallel with a photo cell.
oo. More than two (2) offices on a single circuit. Multiple circuits are allowed for a single office as needed.
pp. 15A wiring devices.
qq. Use of gray wire on 208Y/120 volt systems. Use of white wire on 480Y/277 volt systems.
rr. Use of push-in or WACL "wago type" connectors.
ss. Use of non-locking wiring devices under raised floors.
tt. Metal conduit covers supported by a threaded body for outdoor use in corrosive environments.
uu. Panel enclosures and junction boxes larger than 4-11/16 that have stamped knock-outs.
vv. Use of IEC type starters or equipment.
ww. Control circuits higher than 120V.
xx. Sharing motor circuits with power receptacles & lighting loads.
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 Physical Plant Electrical Shop for all high bay lighting.
zz. Use of "SO" type cord-and-plug connected light fixtures.
aaa. Use of anything other than panic hardware (NO LEVER HANDLES) installed on all new or existing doors that leave the electrical substation's or closets. Doors shall travel in the correct path of egress.
bbb. Use of exposed raceways unless approved by the Physical Plant Electrical Shop.
ccc. Use of shared neutrals.
ddd. The use of premanufactured receptacle & lighting device boxes and wiring systems. Exception to this is modular office furniture.
eee. Unit substations within buildings.
fff. Use of cord and plug connected lighting.
ggg. Fire alarm not installed in a raceway.
hhh. Ceiling grid power systems.

8. 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.
d. Medium voltage cabling shall not pass thru or under any university building.
e. Refer to Division 33 Utilities for other applicable requirements.

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..
   a. All medium voltage distribution cables shall be UL listed, 1/c, copper, mil Ethylene propylene rubber (EPR) insulated, concentric neutral type,15 Kv, 133% rated, MV 105 degrees C. Feeders shall consist of three (3) primary cables and one (1) 4/0 insulated XHHW green Grounding conductor. 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, all conductors provided shall be manufactured with a continuously colored jacket. Phase tape will not permitted on electrical systems 600 volts and below.
      i. Color coding for 480/277V and 208Y/120V shall be as follows:

Phase	Voltage (208Y/120)	Voltage (480Y/277)
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 SOOW 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. MC Cabling where permitted below shall be steel jacketed and be provided with the correct colored conductors for the system and circuit it is serving.
    i. Light fixture final connections, six foot or less and "fishing" existing wall cavities that will not allow for the use of steel flex. All cables shall be supported when leaving a junction box.
g. General Use Insulation: NEC, 600-volt type THHN/THWN or XHHW. XHHW wiring shall be used for all exterior installations, all interior grade level underground installations or any other damp wet or hash environment.

3. Connections in No. 10 and smaller wire shall be made with high grade threaded-on plastic or nylon insulated wire nuts. Scotch-locks shall not be used. Crimp connectors, except butt connectors are prohibited. Joints of No. 8 and larger conductors shall be made with pre-insulated mechanical lugs. Pre-insulated mechanical lugs shall not be used on motor, feeder or lighting terminations.

Section 26 05 17 Wiring Devices

1. Design: All wiring devices provided shall be 20A specification grade as specified below. New building devices will be ivory, white, brown, black or gray with stainless steel cover plates.. Emergency systems shall be red with a stainless steel cover plate. Isolated ground devices shall be orange with stainless steel cover plates. Existing building designers shall match existing color scheme that is prevalent throughout building. Duplex receptacles shall be Hubbell "HBL5362" or exact approved equal. GFCI receptacles shall be Hubbell "GFR5362TR" or exact approved equal. All devices installed in a wet or damp location need to be listed for use in wet or damp locations. All devices installed in dormitories, apartments or child care facilities need to be tamper resistant.
    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 marker board. 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 one double duplex on the front wall centered between the corners, and one duplex receptacle on both sides of the double duplex centered between the corner and the double duplex. 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 rooms shall be provided with at least four GFCI receptacles (one per wall) and additional GFCI receptacles where walls are 25’ or longer. At least one receptacle shall be fed from the emergency panel.
vii. GFCI’s installed in restrooms, locker rooms, kitchens, mechanical rooms and outdoors shall be weather resistant.
viii. GFCI’s shall not feed devices downstream off of the load terminals.
ix. Devices shall be installed with grounds facing up. In horizontal applications neutrals shall face up. The terminals of all devices shall be fully insulated with tape.

b. Switches:
i. Switches provided for all uses shall be 20A specification grade. Color scheme shall match receptacles. Switches shall be Hubbell “HBL 1221” or exact approved equal.
ii. Switches provided at roof hatches, in mechanical & electrical rooms or where provided outside of rooms they are serving shall be provided with pilot lights. Switches shall be Hubbell “HBL 1221ILC” or exact approved equal.
iii. The terminals of all devices shall be fully insulated with tape.

c. Cover plates:
i. Generally cover plates for flush-mounted standard devices shall be stainless steel for interior use in new buildings. Where work is being performed in existing buildings, cover plates shall match the majority of the existing devices. In residential buildings covers shall be stainless.
ii. Cover plates for exterior use shall be a type which allows NEMA 3R rating to remain while in use, covers shall be steel and contain no plastic components. Where exterior device could be exposed to vandalism, provide locking type cover plates.

d. Finish:

i. All device plaster rings shall be flush with the finished wall surface. Adjustable plaster rings shall be used in cabinet installations and where tile or other materials are installed on the drywall surfaces.

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, spring steel and die-cast components 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. Boxes or 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 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 and Boxes

1. Interior Conduit and Fittings: Minimum conduit size for power circuits & Control wiring shall be 3/4-inch.
2. Raceway color code:
    a. Fire Alarm – Red
    b. Emergency Systems – Yellow
    c. Communications Systems - Blue
3. 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. Thread less fittings will not be accepted.
    b. All electrical feeders shall be installed in a continuous threaded rigid raceway.

   c. A full rigid installation shall be used for branch circuiting in or in areas of electrical or mechanical rooms that are or may be subject to damage from lift/equipment access or potential environmental hazards, such as moving machinery components, steam lines, water lines, hydraulic lines, etc.
   d. All work performed at the EMU Energy Center.
   e. IMC may be used in place of rigid galvanized where permitted by code.
4. Steel Electric Metallic Tubing (EMT) UL labeled conduit may be used in interior partitions, above ceilings, and for surface indoor 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 or set-screw type steel fittings shall be used.
   c. EMT shall be supported every 8 feet.
5. Flexible conduit used for motor make-up shall be liquid tight flexible steel 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. Plastic jacketed rigid galvanized steel conduit shall be used in corrosive atmosphere. See Utility Tunnel Conduit & Fittings of this standard for further requirements.
7. Rigid galvanized steel conduit shall be used outdoors, above grade, in damp locations.
8. Conduit installed through a building wall shall have internal and external seals. Specify link seal or equivalent.
9. Conduit stubbed up through concrete shall be coated.
10. Elbows used for medium voltage cable shall be long radius rigid steel.
11. Grounding: Conduit crossing building expansion joints shall have expansion provision with grounding continuity.
12. 4-11/16" boxes shall be used on all homeruns with the exception of feeders.
13. 1-1/2" shallow boxes, cast bell boxes and handy boxes shall not be used.
14. Boxes shall not be mounted back to back.
15. All branch conduits entering junction boxes larger than 4-11/16" shall have bushings.
16. Oversized condulet bodies with rollers shall be used on all feeders.
17. Junction boxes 2 x 2 and larger shall have hinged covers.
18. Provide pull string and 25% spare capacity in every branch circuit conduit.
19. Exterior hand holes shall be Quazite. All conduits entering underground boxes shall enter thru the bottom opening and not the sides.
20. Communications raceways shall meet the following additional requirements:
   a. LB's are not permitted. C condulets are permitted when oversized and provided with rollers.

b. Conduits shall have no more than two 90 degree bends between pull points or boxes.
c. Conduits shall contain no continuous sections longer than 100 feet without a pull point/box.
d. The bend radius of conduit must be at least 6 times the internal diameter for a conduit 2 inches or less and a radius of 10 times the diameter for a conduit greater than two inches.
e. All conduit ends shall have insulating bushings.

Section 26 05 35 Busways

1. The Associate may use feeder Busways in lieu of conduit and wire where approved by the University Physical Plant & Electrical Shop.
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.
5. Busway used in shop or lab environments that generate dust and debris need to be gasketed, sealed and listed for the intended environment.

Section 26 05 38 Surface Raceways

1. Surface raceway shall not be used in new construction except as approved by the University Physical Plant & Electrical Shop.
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 be one the following if approved by the University Physical Plant & Electrical Shop..
    a. Panduit Co. T-70 series or larger.
    b. Wiremold Co. 4000 Series or larger.
4. Fittings and Boxes:
    a. Raceway shall have manufacturer's finish standard prime coating suitable for field painting.
    b. The acceptable manufacturers for steel surface raceways shall include:
        i. 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. Tunnel installations shall utilize a combination of Robroy Industries Plasti-Bond REDH2OT steel coated rigid and Champion Fiberglass Flame Shield Phenolic conduit systems..
    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.
3. All device boxes shall be malleable iron, cast hub, FS or FD type.
4. All splice boxes shall be NEMA 12, 316 stainless steel.
5. All disconnects and panel boards shall be NEMA 12, 316 stainless steel.
6. All anchors and hardware shall be 316 stainless steel.
7. All wiring shall be XHHW type.
8. GFCI spacing shall be no more than 90 feet and luminaire spacing shall be no more than 30 feet.
9. Luminaire shall be Canlet 02 20W L-LED W F OG 18 or exact approved equal.
10. See other areas of this standard for additional requirements.

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 the Utility Tunnel Conduit & Fittings section of this standard. Underground raceway systems for medium/high voltage systems shall be encased in red concrete. Provide a RED marker tape 18" above the conduits indicating "Danger Buried Conduits" for all underground raceways. Raceways shall not be imbedded in concrete. Conduit shall not be installed directly below building concrete slabs. EMT shall not be used underground. Coated rigid shall be used when transitioning up thru concrete.
2. Provide a #10 green XHHW tracer wire in all underground communications raceways, durably label the wire at each end as a "tracer conductor".

Section 26 05 53 Electrical Identification

1. General Requirements: This covers the identification of all electrical systems and devices within Section 26 Electrical and Section 33 Utilities. These requirements apply to all newly installed equipment as well as all existing equipment within the construction scope or area.
    a. Provide an accurate computer generated directory for all switchgear, distribution panels and panel boards. Provide digital copies of all new directories to the Physical Plant Electrical Shop.
        i. Directories shall be printed on heavy card stock.
        ii. Individual directories shall list their source, voltage, phase arrangement, equipment designation and loads.
    b. All device cover plates within the construction extents new and existing shall be verified and labeled with a Brady or P-Touch type label on the surface of the cover. Install labels on the back of covers in all kitchens, dish rooms, restrooms & outdoors. Label shall identify the panel and circuit number.
    c. All junction boxes shall legibly labeled with an indelible marker. Label shall identify the source, voltage and circuits within.
    d. Identify all feeder raceways with an indelible marker, indicate system or service and voltage.
    e. Conductors shall be neatly identified at all panel boards and junction boxes by means of a Brady label or similar.
    f. Equipment identification labels for systems 600 volts and below shall be installed on all transformers, switches, switchboards, distribution panels, panel boards, MCC's, starters, disconnects and controllers. Labels shall meet the following requirements.
        i. Engraved, laminated self-adhesive Acrylic or Melamine Label. Punched or drilled for rivet mounting. White letters on a black background. Minimum letter height 3/8 inch.
        ii. Label shall identify source, voltage, phase arrangement and equipment designation.
        iii. Outdoor labels shall be UV resistant.
        iv. Submit sample label to the Physical Plant Electrical Shop for approval.
    g. Equipment identification labels for systems 600 volts and above shall at a minimum be installed inside and outside of all transformers, switches, enclosures as required, and on all cables at every junction point or splice. Labels shall meet the following requirements.
        i. Equipment labels shall be engraved, laminated self-adhesive Acrylic or Melamine Label. White letters on an orange background. Minimum letter height 1 inch.
        ii. Conductor labels shall be engraved, laminated Acrylic or Melamine Label. Punched or drilled for cable tie mounting. White letters on a red background. Minimum letter height 2 inch. Affix label to MV cables with a fungus inert, self-extinguishing, 1-piece, self-locking,

nylon cable tie. Cable tie shall be; minimum width 3/16 inch, tensile strength of 50lb minimum, black in color and have a temperature range of minus 40 to plus 185 degrees.

iii. Outdoor labels shall be UV resistant.

iv. Submit sample label to the Physical Plant Electrical Shop for approval.

Section 26 09 99 Testing

1. Testing shall be provided by a recognized corporately independent N.E.T.A. certified testing firm. Refer to division 26 as well as division 33 of these standards for additional requirements. The testing firm shall provide full testing reports and testing of all the following equipment:
    a. All medium voltage equipment including but not limited to transformers, switches and relays.
    b. All medium voltage cabling and terminations.
    c. All low voltage feeders.
    d. All service entrance equipment, busing, relays, breakers, etc.
    e. All distribution equipment busing, breakers, switches, etc.
    f. All Motor Control Centers, complete.
    g. All transformers.
    h. All disconnects.

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 confirming 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 press 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 ferro-magnetic 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) from one of the following manufactures meeting all requirements listed below:
   a. MGM Transformer Co. or Schneider Electric USA, Square D or Jefferson Electric.
   b. 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.
   c. 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.
   d. The transformers shall be designed for a low coil watt loss.
   e. 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 loses.
      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.

f. 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.
g. 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.
h. Provide vibration pads for all transformer supports. Install all transformers on a 4" poured housekeeping pad.

3. All terminations within transformers shall be terminated with 2-hole compression lugs. Modifications to bus shall not be made to accommodate lugs.

Section 26 20 00 Low Voltage Electrical Transmission

4. 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. All installations shall be designed and engineered in a way as to reduce the maximum arc fault potential at the equipment.
4. Vacuum breakers or vacuum switches may be used with the approval of the University Physical Plant & Electrical Shop.
    a. All switches shall be top or horizontal fed to the breakers.
5. Indicator lamps shall be LED or transformer type utilizing low voltage LED lamps.
6. Service entrance equipment shall be Schneider Electric USA, Square D.
    a. Square D type QED series.
7. All freestanding equipment shall be installed on a 4" poured housekeeping pad.
8. All feeders including 400 amps and larder shall be terminated with a 2-hole compression lug.
9. Provide an accurate full "E" size drawing of the one-line diagram of the building electrical system, mounted to the wall of the substation in an enclosed frame.

Section 26 20 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. Schneider Electric USA, Square D. Power Meter PM5563RD.
    b. Each individual KWH meter specified must have communications and impulse capability.
    c. 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.
    d. 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.
    e. Provide four (4) current transformers and circuit monitor that indicate true RMS current for phase and neutral.
    f. 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 or equal 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 & Fusing

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.
    b. Service entrance equipment shall be Schneider Electric USA, Square D.
        i. Square D type QED series.
        ii. Equipment shall have a full arc fault mitigation system.
        iii. Equipment shall have a maintenance service switch.

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. Provide fusing from one of the following companies:
        i. Cooper Bussman, Inc.
        ii. Ferraz Shawmut, Inc.
        iii. Littlefuse, Inc.
    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.
3. All installations shall be designed and engineered in a way as to reduce the maximum arc fault potential at the equipment.
4. All freestanding equipment shall be installed on a 4” poured housekeeping pad.
5. All feeders including 400 amps and larger shall be terminated with a 2-hole compression lug.

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 3/4" 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 schedule 80 PVC or Reinforced Thermosetting Resin Conduit RTRC 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 an insulated green 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.
8. All electrical raceways & equipment shall contain insulated grounding conductors, sized in accordance with all NEC requirements. Raceways or equipment enclosures in no case shall be considered as a substitute for this requirement.

Section 26 27 03 Distribution

1. Distribution equipment shall be Schneider Electric USA, Square D, and type QED series switchboard.
2. Design: When 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 medium voltage transformer without the use of a service rated low voltage main disconnecting means. This connection shall be made within ten foot or less once entering a building.
    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.
3. 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 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. Surge protectors
    b. All current carrying parts shall be 98 percent conductivity copper, the phase buses shall be 100% rated throughout the equipment.
    c. The neutral bus shall be copper and 100% rated throughout and shall have sufficient terminals to accommodate the number of poles or devices that can be installed.
    d. The ground bus shall be copper and rated at 50% of the phase bus minimum throughout and shall have sufficient terminals to accommodate the number of poles or devices that can be installed.

e. For secondary distribution panel boards a full locking cover trim shall be specified, shall be a continuous piano hinge type, provided with a Corbin 15767 lock and three spare keys for each assembly. In addition to the lock assembly each cover shall be provided with a "padlock staple" that accepts a standard padlock.
f. Tub assemblies shall have a solid top and bottom, no pre punched holes.
g. Molded case circuit breakers
h. Fusible switches
i. Motor starters
j. Low voltage AC power circuit breaker (generally limited to main or tie position)
k. Bolted pressure switches
l. Transfer devices or switches
m. 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.

4. 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 and provisions with required busing detail and hardware 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.

5. Instrumentation shall be per "Metering" section of this Division.
6. Service to Fire Pumps: Fire pumps shall be served and protected as required in NFPA No. 20.
7. 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.
8. 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. All freestanding equipment shall be installed on a 4" poured housekeeping pad.
    c. 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.
9. All feeders including 400 amps and larger shall be terminated with a 2-hole compression lug.

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 a threaded galvanized rigid conduit.
4. All XHHW and THHN/THWN feeder wiring installed shall consist of a continuously color coded jacket appropriate for the voltage system it is used on.
5. All feeders shall have threaded bonding bushings.
6. See other applicable sections of this standard.

Section 26 27 05 General Purpose Power and Lighting Circuits, Panelboards and Safety Switches

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 bolt in type circuit breakers equipped with a trip indication window, with thermal-magnetic trip and AC and DC ratings. Maximum number of poles in any panel shall not exceed NEC & manufacture allowable provisions. 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 power & lighting panels on a project the following shall be considered:
   i. Panels shall be Schneider Electric USA, Square D.
   ii. All 208/120 volt branch lighting and power panels shall be Square D type NQO using the appropriate bolt-on breakers, minimum 22 kAic rated.
   iii. All 480/277 volt branch lighting and power panels shall be Square D type NF using the appropriate bolt-on breakers.
   iv. All current carrying parts shall be hard-drawn copper, 98 percent conductivity, the phase buses shall be 100% rated throughout the equipment.
   v. The neutral bus shall be 100% rated throughout and shall have sufficient terminals to accommodate the number of poles or devices that can be installed. In cases where significant neutral currents may be present due to non-linear loads, the panelboard shall be provided with a 200% rated neutral bus bar. In addition to the neutral bus bar the neutral feeder needs to be sized at 200% as well as the source transformer be an appropriate K-rated (harmonic mitigating) transformer. Neutral bars shall be copper.
   vi. The ground bus shall be rated at 50% of the phase bus minimum throughout and shall have sufficient terminals to accommodate the number of poles or devices that can be installed. Ground bars shall be copper.
   vii. The trim shall be a continuous piano hinge trim provided with a Corbin 15767 lock and three spare keys for each assembly.
   viii. Tub assembly's shall have a solid tops and bottom, no pre punched holes
   ix. All new panels shall be 42 pole minimum. Designers shall provide each new panel "at job closeout" with a minimum of 15% spare 20 amp single pole circuit breakers and 15% future bus space. Designers shall consider an additional panel when these minimums cannot be met.
   x. 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.

xi. Any new or existing building with 3 phase service shall only have 3 phase panels provided. All exceptions must be approved by the University Physical Plant Electrical Shop.
xii. Do not provide panel feeders, fusing or main circuit breakers at less than the panel main device rating.
xiii. All feeder conduits shall have threaded bonding bushings. All branch conduits shall have threaded plastic bushings.

4. Provide the following spare conduits turned in a convenient direction to an accessible ceiling space for all new installations. At a minimum 3 – ¾" and 2 – 1", all conduits shall be capped.
5. Power panels shall be equipped with bolt-in molded case circuit breakers of adequate interrupting capacity, or shall be switch and fuse construction using time delay fuses.
6. Indoor panelboards, switchboards and safety switches are to be NEMA 1. In indoor areas where dust, high humidity or water spray may be present use NEMA 4 or 12. In parking structures, cooling towers or other areas subject to high humidity or spray use NEMA 4X, 316 stainless steel if the environment warrants its use. Outdoor applications are typically painted NEMA 3R or 4, 316 stainless steel if the environment warrants its use. All panelboard applications shall have enclosures provided without any openings or pre-punched knockouts.
7. Safety Switches meeting the following requirements.
    a. Schneider Electric USA, Square D.
        i. Safety switches shall be "Heavy Duty" rated.
        ii. Provided with a copper ground bar.
        iii. Provided with a copper Neutral bar as needed
        iv. Copper bus.
        v. Padlock provision for both the door and handle.
        vi. Fused as required.
        vii. Provided without any openings or pre-punched knockouts.
    b. Independent disconnects meeting the above requirements shall be used on all VFD's, roof top exhaust fans, split systems, heat pumps, vrf systems, general pumps and air handling units. Integral equipment disconnects do not satisfy this requirement.
8. All equipment shall be thoroughly cleaned at the completion of all work.
9. All feeders including 400 amps and larger shall be terminated with a 2-hole compression lug.

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. All motor control centers shall be Allen-Bradley or Schneider Electric USA, Square D.
3. 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.

4. 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.
   c. Provide white interiors on all motor control centers.
   d. Provide terminal strips for all terminations at the front of each bucket with spare terminals.
5. 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.
6. 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.
7. A safety switch shall be provided for all motor loads and shall be "heavy duty" rated. Use split bolts on all terminations with No. 8 and larger wire, insulate with a combination of 3M Scotch 130 C, 3M Scotch Temflex friction tape and 3M Scotch Super 33 plus. Pre-insulated Unitap splice blocks shall not be used.
8. All feeders including 400 amps and larger shall be terminated with a 2-hole compression lug.

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. All combination starter units shall be Allen-Bradley or Schneider Electric USA, Square D.

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. Acceptable Manufactures are:
    a. Caterpillar Company; Engine Division (CAT)
    b. Emerson; ASCO Power Technologies, LP.
    c. Kohler Power Systems; Generator Division.
    d. Onan/Cummins Power Generation; Industrial Business Group.
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 and the size of the unit. Acceptable manufactures are:
    a. Caterpillar Company; Engine Division (CAT)

b. Kohler Company; Generator Division
c. Onan/Cummins Power Generation; Industrial Business Group.

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.
    b. 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, specified and certified 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.
5. Systems shall be copper.

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, 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. Internally fused ballasts or drivers will not satisfy this requirement. Fusing shall protect all wiring within individual fixtures.
2. Special lighting applications such as recreational field lighting shall comply with the latest Illuminating Engineering Society (IES) standard, specific MAC or broadcasting requirements 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. Workstations where critical or fine work is performed, as in laboratories, shops 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 lots: 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.
14. Incandescent, quartz, induction or HID Lighting shall not be used.
15. Lighting supplied on all projects shall have local product representation within Southeastern Michigan.
16. The designer shall use manufactures and products currently used and supported on campus. See the EMU Physical Plant Electrical Shop current supported products.
17. Design lighting so the ratio of light levels between adjacent spaces does not exceed 10:1.
18. LED lighting shall conform to the following;
    a. 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.
    b. 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".
    c. 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 90%, and be rated for a THD of less than 20 percent at all input voltages.
    d. LED sources shall be RoHS compliant.
    e. 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.
    f. Dimmable LED fixtures shall be 0-10 volt type. Dimmable LED drivers shall be capable of dimming without LED strobing or flicker across their full dimming range
    g. Recessed lighting fixtures shall be thermally protected.

h. LED sources shall have a color temperature of 4000 degrees kelvin with a minimum CRI of 80 minimum and a lumen maintenance L70 rating of 50,000 hours at a drive case temperature of 149 degrees Fahrenheit minimum. LED sources shall start and operate in 0 degree Fahrenheit to 40 degree Fahrenheit ambient.
i. LED sources shall be binned to a 3 step MacAdam ellipse (SDCM: Standard Deviation Color Matching) of the 4000 kelvin Planckin Locus to ensure color consistency. Supplied with transient voltage protection: Follow ANSI C62.41 to provide Category "A" rating or better.
j. Open circuit protected and short circuit protected.
k. Inrush current less than 2 amps.
l. Nonvolatile memory restores all driver settings after a power failure.
m. LED light panels shall not be used.
n. Specified as USPOM.

19. Lighting that is retrofitted shall conform to all standards within this division, as well as the additional requirements listed below.
    a. All retrofitted fixtures shall be fused.
    b. All retrofitted fixtures shall have their lamp sockets and wiring replaced.
    c. All retrofitted fixtures shall be grounded.
    d. Spare components and fixtures shall be supplied as specified in the interior and exterior lighting sections of this standard.
    e. Lighting that is retrofitted or replaced shall meet or exceed the existing fixtures original design lumen output.
    f. Fixtures shall not be abandoned in place.
    g. Emergency egress lighting shall be addressed.
    h. Direct wired LED's tubes or LED board kits shall not be used.
    i. Instant start ballasts shall be used with LED T5 or LED T8 lamps.
    j. LED T5 & LED T8 lamps shall be from one of the following manufactures;
        i. General Electric, GE
        ii. Osram/Sylvania
        iii. Philips
    k. All components shall be UL or other NRTL Listed.
    l. Photo-metric drawings shall be provided at the request of the EMU Physical Plant.
    m. Lamps, ballasts and drivers being demolished shall be recycled in accordance with the EMU Health and Safety recycling policy.
20. A type LED lamps shall not be used on 277 volt lighting systems.
21. Medium (Edison e26) base sockets shall not be used on 277 volt lighting systems.

Section 26 51 00 Interior Lighting

1. Recommended Fixtures: Light Emitting Diode (LED) fixtures. Color temperature shall be 4000 degree kelvin with a minimum CRI of 80, and life expectancy of ten years or greater. Fluorescent fixtures shall only be used if there is no viable LED option and shall have written approval of the EMU Physical Plant. Incandescent lighting may be

used only with the written permission of the EMU Physical Plant. 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. For warehouse, gymnasiums, large areas and high ceilings high output reflective LED lighting fixtures shall be used.
b. LED Fixtures: All fixtures shall be independently supported from the structure above. Fixtures shall be all metal with hinged volumetric diffusers. 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, exception is under cabinet task lighting, this shall be 120 volt. Fixtures shall meet or exceed the requirements of the latest version of ANSI/ASHRAE/IESNA Standard 90.1. All fixtures shall be end user serviceable from the front side of the fixture.
c. Ballasts: High frequency electronic type, specifically designed to use LED T5 or LED T8 lamps or T8 or T5 fluorescent lamps when approved, 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 LED driver or ballast in addition to the internal protection of the class "P" or similar drivers or ballasts. Line fuses shall be appropriate for the application and wired in place by the fixture's manufacturer. Fusing for lighting fixtures shall be non-time delay type similar to Bussman type GLR with HLR holders.
3. Fluorescent Lamps: When approved, shall be 4-foot, 32-watt and 2-foot, 17 watt, T5 & T8, extended life instant start lamps with color temperature of 4000 degrees kelvin and minimum CRI of 85. Lamps from one of the following manufactures only;

a. General Electric, GE Ecolux
b. Osram/Sylvania Ecologic
c. Philips Alto

4. Specify the use of green illuminated exit signs utilizing Light Emitting Diodes (LED) light source with life expectancy greater than ten (10) years.
5. Incandescent Lamps: When approved by the University, specify the 130-volt, inside frosted lamp for general application.
6. Instant start ballasts shall not be used with occupancy sensors.
7. Provide emergency egress lighting via generator, inverter or battery backup in all electrical rooms, elevator machine rooms and mechanical rooms.
8. 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.
9. Provide the following spare parts with the listed quantities for LED, compact, T5 and T8 fluorescent fixtures for each item and size required:
    a. Fixtures: 1%, minimum of 3 of each type.
    b. Fuses: 10%, minimum of 15 per amp rating.
    c. Fuse Holders: 10%, minimum of 5 per type.
    d. Ballasts/Drivers: 5%, minimum of 3 of each type.
    e. Lamp Sockets: 10%, minimum of 10 of each type.
    f. Fixture Lenses and Supporting Hardware: 10%, minimum of 2 of each type.
10. All submittal reviews for LED, compact T5 and T8 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.
    d. Turn spare parts over to the University area shop supervisor and obtain signed receipt.
    e. A copy of each approved submittal and a copy of each signed receipt shall be included in the Operation and Maintenance Manuals.
11. Spare lamps should be provided as follows:

Lamp Type	**Quantity Installed**	**No. of Spares**
LED Modules	1-10	1
	11-20	6
	21 or more	12
Fluorescent,	1-10	1
LED T5 &	11-20	6
LED T8	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.

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: Light Emitting Diode (LED) fixtures mounted on the building or on suitable standards are required for all exterior site lighting. Color temperature shall be 4000 degree kelvin with a minimum CRI of 80, and life expectancy of ten years or greater. These fixtures shall be automatically controlled by photocell(s) and/or the automated building management system. All Exterior Lighting shall conform to all standards within this division, as well as the additional requirements listed below.
    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.
    b. Building mounted lighting shall be centrally controlled by one source.
    c. All exterior light fixtures shall be non-textured black unless written approval is given from the EMU Physical Plant.
    d. Provide emergency egress lights via generator, invertor or battery backup above all exit egress doors.
    e. The following fixture assemblies shall only be used in parking lots.
        i. Lithonia DSX 1 LED.
        ii. Lithonia or Valmont 30 foot, 6” square steel pole with vibration dampers and large hand hole.
        iii. At parking lot boulevard entrances use the Holophane LED ESL2 fixtures mounted to 20 foot Sitelink NYA pole assemblies with WLC cross arms.
        iv. All Holophane units shall have full black covers.
        v. See the EMU Physical Plant Electrical Shop for cut-sheets.
    f. The following fixture assemblies shall only be used when bordering parking lots/roadways and pedestrian walkways.
        i. Use Holophane GVD2 LED fixtures mounted to 14 foot Sitelink NYA pole assemblies.
        ii. Use a Holophane Twin GVD2 LED assemblies mounted to 13 foot Sitelink NYA poles with ACA cross arms at each side of driveway and roadway entrances and exits.
        iii. All Holophane units shall have full black covers.
        iv. See the EMU Physical Plant Electrical Shop for cut-sheets.
    g. The following fixture assemblies shall only be used along pedestrian walkways.

i. Use Holophane GVD2 LED fixtures mounted to 12 foot Sitelink NYA pole assemblies.
ii. Use a Holophane Twin GVD2 LED assemblies mounted to 11 foot Sitelink NYA poles with ACA cross arms at boulevards, intersecting walkways and building entrances where applicable.
iii. All Holophane units shall have full black covers.
iv. See the EMU Physical Plant Electrical Shop for cut-sheets.

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. Grounding rods shall be installed in all lighting poles.
4. Design outdoor lighting to be fed from 60 amp switch, which in turn feeds a 60 amp Square D type contactor with integral locking disconnect, "H-O-A" override options and pilot lights with the coil controlled by a photocell. If a photo eye is not integral to the lighting system it shall be located on the roof of the building of the system it is served from. Surface raceways on any interior or exterior walls unless it is approved by the EMU Physical Plant will not be accepted. Time clocks shall not be used. 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.
    a. Milbank power pedestal applications are the desired method to establishing a new outdoor lighting network. In general all power pedestals shall be provided with a 200 amp, 208/120 volt, 3 phase, 4 wire electrical service in a 2" or larger RGS raceway. Each pedestal shall be provided with an incoming 2" raceway for data. All raceways entering the pedestal shall be an RGS coated raceway (either approved field installed coating or factory installed coating) transitioned at no less than five feet from the concrete pad to a PVC underground conduit. Each pedestal shall have the following spare conduits turned in a convenient direction for future use at the completion of the project; one 2" and two 1-1/4" for power and one 2" and two 1-1/2" for data. In addition to the spare conduit requirements the contractor is responsible for providing power and data conduits from the pedestals to the new lighting foundations throughout the Mall installation. Note all data runs need to be 300 foot or less from the pedestal to the furthest light foundation it serves. The pedestal shall be installed on a reinforced, poured in place concrete pad minimum 6" thick, shall be large enough to leave 12" around all sides of the pedestal once installed. The contractor shall ensure the surface below the poured pad is properly prepared and compacted with fill and stone to allow for an installation that has no future movement or settling. See the EMU Physical Plant Electrical for cut sheets and additional requirements.
5. The University has no secure storage. Any existing poles or luminaires 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.

6. Additional exterior lighting requirements:
    a. Reference EMU's "cast in place pole base detail" drawing for additional specific base detail requirements. See EMU Physical Plant.
    b. Excavation for light pole foundations shall only be done with the use of an appropriately sized auger.
    c. Trench shall have a minimum width of 6 inches and depth of 30 inches, shall be free of stones or debris before conduits are installed. Clean fill must be used. Install warning ribbon after 12 inches of backfill that states "Warning buried electrical cable".
    d. Plowed in raceways will not be accepted.
    e. For future sleeves install minimum 4 inch Sch. 40 PVC conduit under all walks, roadways, parking lots, and all other hard surfaces, the exception to this is boring. All conduit supplied shall be Sch. 40 or as otherwise specified in this standard and shall be UL listed and NEC compliant. All 90 degree sweeps shall be hand formed and free of defect or damage on site, no factory elbows shall be used. All conduits shall be cut and reamed in a manner that leaves them free of any burrs or sharp edges. Conduits shall be cut off straight and not at an angle. In no case shall the conduit be cut flush with the concrete foundation.
    f. Bases shall be cast-in-place concrete, having 3000 psi minimum 28-day compressive strength, 6-AA limestone concrete mixture. Provide a fine consistent brushed finish on all concrete bases, the finish shall not be an applied topcoat. There shall be no visible spiral on the finished bases. Grind to finish all uneven surfaces so that they are clean, smooth and free of imperfections. Ensure there are no air voids or pockets in the foundation. Pre-Cast bases shall not be used.
    g. Bases shall support the effective projected area of the specified pole, arm(s), luminaire(s), and accessories, such as shields, banner arms, and banners, under wind conditions.
    h. Pole foundations shall not be installed in sidewalks.
    i. Exposed raceways shall not be used.
    j. Anchor bolts shall be in a welded cage or properly positioned by tie-wire to the cage and set according to anchor-bolt templates furnished by the pole manufacturer.
    k. Install poles as necessary to provide a permanent vertical position with the bracket arm in proper position for luminaire location.
    l. Nolax shall be used on the threads of all hand-hole bolts and on all anchor bolt threads, nuts and washers that come in contact with aluminum pole base surfaces.
    m. Typical for all 30 foot poles, install a nut and washer above and below the pole flange.

n. Where copper grounding conductors are connected to a metal other than copper, provide specially-treated or lined connectors suitable and listed for this purpose.
o. Typical for decorative pedestrian or roadway Holophane assemblies: Each base shall contain the following conduits at a minimum (2) 1-1/2" PVC for low voltage data "raceway shall not serve more than six bases or two cameras or emergency phones", (1) 1-1/4" for a spare stubbed out in a convenient direction for future use & (2) 1-1/4" for lighting power "this conduit size may need to be upsized do to voltage drop". Conduit size may be larger depending on the application. Once installed, shimmed, and plumbed, caulk the space between the pole base and the concrete base with non-shrink gray calk appropriate for the environment and installation, install a weep hole on the back side to allow for water drainage.
p. Data raceway lengths shall be minimized to allow for a maximum cable length of 300 feet. Cable shall be a Beldin 7953A Multi-Conductor – Category 6 Data Tuff, 600V AWM Rated Cable or exact equal. A cable shall serve only one camera. Data cabling shall travel point to point without any splicing. All cabling installed throughout the lighting system shall be done in a neat well identified manor so that each end of the cable is identified for future termination.
q. Every effort shall be made to prevent the use of Hand hole(s). In the event a hand hole cannot be avoided, the hand hole shall meet the following minimum requirements; designed and listed for its purpose, approved for the particular installation and be able to sustain any vehicular traffic that may be imposed upon it. Street light pull/junction boxes shall be Quazite or an equal box (approved by the EMU Physical Plant) having a bolted cover embossed with "STREET LIGHT" for lighting installations or "Electrical" for general electrical installations. Low Voltage pull/junction boxes shall be Quazite or an equal box (approved by the EMU Physical Plant) having a bolted cover embossed with "Low Voltage" logo on it, whichever is appropriate for the installation. All box installations shall meet the manufacture installation requirements.
r. For Electrical applications if a splice is required in a pull/junction box and approved by EMU Physical Plant the following shall be used. Thomas & Betts Homac type "or approved equal" (Example part no. RAB 1/0-3(UPC 35042)) use the appropriate combination needed for the installation.
s. Install all conduits so that they enter up through the bottom of the pull/junction box.
t. At a minimum all new lighting conductors shall be #6 copper XHHW with a continuous color coded insulation. All wiring in light poles shall be #12 XHHW minimum.
u. Use split bolts with a combination of 3M Scotch 130 C, 3M Scotch Temflex friction tape and 3M Scotch Super 33 plus tape or appropriately sized wire nuts insulated with 3M Scotch 33 plus. All terminations in pole bases or otherwise shall positioned and sealed in a manner as to prevent water

infiltration. Sealing methods shall be removable. Unitap splice blocks shall not be used.

v. Direct buried conductors shall not be used.

w. Each fixture head shall be independently fused at the hand hole with a Cooper Bussman HEB-AA type fuse holder & Cooper-Bussman 600 volt KTK or FMQ type fuse "or exact approved equal" appropriately sized for the application.

x. CAD as-builds shall be prepared by the contractor and turned over to the EMU Physical Plant after installation of any new or modification of any existing lighting system.

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 electrical rooms, elevator machine rooms, mechanical rooms or shop areas. Dual technology sensors shall be used in 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. Lighting control systems shall operate independently "stand alone" of the building automation systems. Building automation systems can provide input to the lighting control systems but in no case override or prevent a lighting system from operating.
5. Provide all required tools, software and hardware to operate and maintain lighting control systems.
6. Dimming Control:
    a. 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. Acuity Controls nLite & Lutron dimming systems with ten (10) year warranty meet University standards. Other systems must be submitted to the University Physical Plant for approval.
    i. This standard requires the Associate to review the application of dimming devices and submit recommendations to Facilities Design and Construction before incorporating into specifications.
f. Wireless control systems shall not be used.

7. 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.
8. 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.

End of Division 26 – Electrical