SECTION 3 ED: ELECTRICAL DIVISION

Latest Update 11-09-17, See underlined text.

PART II: POWER AND LIGHTING SYSTEMS DESIGN:

1. SCOPE:

1.1. This part outlines the minimum requirements for the design procedures for the power and lighting systems, for new buildings, and repair and alteration projects for existing buildings on the UM campus.

2. PRIMARY SERVICE:

2.1. Four (4) 13.2 kV BGE feeders serve a University of Maryland closed ring bus commonly referred to as the Master Switching Station (MSS) in South Greene Street. The MSS has twenty four (24) circuit breakers to provide a 13.2 kV distribution network throughout the campus. Buildings are typically served by two UM feeders originating from opposite ends of the ring. Smaller facilities may have a secondary (480V or 208V) service from a larger UM building or directly from BGE where UM service is not economical. Conduct an evaluation and provide a report with recommendations at the schematic design phase submission. Where new buildings are added to the University's primary feeders, or a substantial change to an existing structure is made, submit a calculation at the Design Development Phase showing the existing load on the feeder, new load and feeder capacity.

3. GROUNDING REQUIREMENTS:

3.1. **Structural Steel vs. Poured Concrete Structures and Grounding Electrodes:** Per NEC 250.30, the grounded conductor of all separately derived systems must connect to the nearest grounding electrode via a conductor that is separate from the equipment grounding conductor of the primary service. For structural steel buildings, either a common grounding electrode riser or the building's structural steel can be used as the grounding electrode. For poured-concrete buildings, only the common grounding electrode riser can be used. As per NEC 250.52, interior water service piping located more than five (5) feet from the service entrance cannot be used as the grounding electrode. It is UM's preference to always provide a minimum # 3/0 awg grounding electrode riser in the stacked electric closets to ensure a continuous, low-resistance pathway to earth that doesn't rely on building steel or concrete foundations.

3.2. **Ground Grid Considerations:** Incorporate the following in the building's underground ground grid:

a. Provide a minimum of six (6) 3/4 inch x 10 foot long copperweld ground rods spaced a minimum twenty (20) feet a part. Keep in mind that ground resistance decreases with the quantity of ground rods and as their spacing increases (ref. IAEI Soares' Book on Grounding).

b. Interconnect all ground rods using multiple pathways (i.e. not just a single daisy-chain run around the perimeter) with minimum # 4/0 awg copper and only Cad-Weld type welded connections. The available fault current from BGE is around 20kA. At 20kA, mechanical connections do not have the temperature rating for use with the # 4/0 awg wire (ref. IEEE Standard 80).

c. Provide direct, independent connections from the 15kV disconnects' ground bus, 600V switchboard ground bus, substation transformer equipment ground, the building's main substation ground bus, tel/data BDF ground bus, emergency equipment room ground bus (if applicable), structural steel UFER ground (if applicable) to the underground ground grid via XHHW insulated, minimum 250kCM copper in two (2) inch PVC 40 conduit and waterproof sleeves. For the main substation ground, provide parallel connections to separate points in the grid for redundancy.

3.3. Lightning Protection Systems: As per NEC 250.60, the grounding electrodes associated with a lightning protection system cannot be used in lieu of providing the substation grounding electrode system. Although permitted, it is not UM's preference to interconnect the two (2) grounds in earth given the potential for stray voltages to propagate onto sensitive low-voltage systems.

4. RACEWAYS, CABLE TRAYS, UNDERGROUND DUCTS, MANHOLES AND HANDHOLES:

4.1. Galvanized steel electrical metallic tubing (EMT) up to two (2) inches in diameter shall be used for feeders, communication cables and branch circuits unless:

a. The NEC requires intermediate (IMC) or rigid galvanized steel conduits (RGSC) because of voltage class; or,

b. There is a risk of physical damage to the feeder and IMC or RSGC is appropriate.

c. Aluminum conduit shall not be used.

4.2. Intermediate (IMC) or rigid (RGSC) galvanized steel conduit shall be used for raceways over two (2) inches in diameter.

4.3. PVC Schedule 40 conduit, fiberglass strut, and non-metallic NEMA 4X junction and pull boxes and conduits shall be used outside buildings, on roofs, in garages (above eight (8) feet) or underground encased in concrete. PVC shall be used with approved expansion fittings in accordance with the manufacturer's recommendations, with a minimum of one fitting between every two fixed points and one fitting for every building joint that is crossed. All Boxes and raceway supports for PVC runs shall be PVC non-metallic NEMA 4X enclosures and fiberglass strut. PVC shall not be used inside HVAC-conditioned spaces.

4.4. Conduit shall not be exposed on the exterior of buildings. Conduit shall not be installed embedded in floor slabs or under slabs below grade unless required by code or expressly permitted by UM.

4.5. Rigid steel conduit with bonded PVC coating shall be used outdoors, in garages, or in damp/ wet locations where potentially subject to physical damage; i.e. exposed vertical runs below eight (8) feet in garages or any location where it could be struck by a vehicle.

4.6. Size conduits in accordance with the NEC.

4.7. **Branch Circuit Conduit Sizing:** For research building projects, all branch circuit conduits shall be a minimum one (1) inch with no more than six (6) current carrying conductors per conduit. The neutral wire is considered a current-carrying conductor. For office buildings, housing projects, parking garages, and any other non-research space where a high amount of changes are not expected over the life of the space, branch circuit conduit shall be a minimum 3/4 inch.

4.8. Cable tray (center ladder type with nine (9) inch rung spacing) is preferred for vertical and horizontal telecommunications data, and signal cabling. See further requirements see the Telecommunications Wiring Standards latest edition in Section 4: Appendices of these Design Standards.

4.9. The entrance of cable trays into electrical/telephone rooms or through other fire rated construction shall be via approved fittings designed to use removable pillow type fire stops.

4.10. Conduits for the campus standard combination telephone and data communications outlets shall be two (2), one (1) inch EMT conduits extending from one (1), four (4) inch square box to above the lay-in ceiling or to the local distribution backboard if gypsum ceilings are used. Provide bushings at ends of conduits. Where data is run to wire mold 4000 raceway, provide conduit drops every twelve (12) feet along wall space.

4.11. Provide a pull line, with two hundred (200) pound minimum tensile strength, in each data/telephone conduit.

4.12. All branch circuits for power, telephone, communications, fire alarm, etc. shall be distributed from the same floor which they serve. On each floor, provide disconnects from the main power risers to each distribution panel.

a. **Example:** An electrical panel located on the 3rd floor shall serve only the 3rd floor.

4.13. Romex cables shall not be used.

4.14. Manholes and handholes, both on state property and in the city rights-of-way shall be precast concrete to meet all requirements of Baltimore City DPW.

4.15. All new ductbanks shall be minimum five (5) inch PVC 40 encased in concrete with only long-sweep sixty (60) degree bends. Forty five (45) degree short bends are not permitted. The concrete structure shall be continuous with reinforcing. Top of the ductbank shall be minimum of twenty (24) inches below finished grade. The ductbank shall slope to drain to prevent accumulation of water and

shall not have any low points. A utility marker tape shall be buried twelve (12) inches above each ductbank.

4.16. On projects which allow the use of the MC cable for value engineering efforts, MC cable shall be provided with interlocking steel armor for branch circuit wiring.

4.17. MC cable shall not be used within the electrical rooms, mechanical rooms, janitor's closets, any exposed locations or those typical of RGS applications.

4.18. MC cable shall not be used for feeders. All homeruns shall go to a junction box and/or wire trough, located in the corridor ceiling space, immediately outside the electrical closet in EMT.

5. WIRE AND CABLE, BUSDUCT, POWER CABLE:

5.1. All cable shall have copper conductors. All busduct shall have insulated copper conductors. Aluminum conductors are not permitted.

5.2. 15 kV cable for primary distribution shall be EPR insulated, single conductor cable, rated for grounded system application. The size shall be determined by:

a. Load served;

b. Size of existing cables if a tap is to be made;

c. Anticipated extension(s) to serve future loads; and

d. Available duct or conduit size as determined by field survey.

e. In addition, a separate ground cable shall be installed with the three single conductor cables, sized to protect the 15 kV cable shield in the event of a ground fault.

5.3. For 600 volt and under conductors, splices shall be as follows:

a. #12 & #10, solid conductors: wire nuts;

b. #8 and larger conductors shall be by compression type fittings using hydraulic crimpers.

5.4. Not more than one circuit supplied from the same phase shall be installed in the same conduit. No more than six (6) current carrying conductors per branch circuit conduit is permitted. The neutral wire is considered a current carrying conductor.

5.5. Existing 15kV cable which is to be spliced, capped, terminated, or otherwise cut, shall be tested per IEEE 400.2-2004, Table 5, to establish its condition before performing any work and again before energizing. Similarly, new cable shall be tested according to the IEEE 400.2-2004 recommendations before splicing, capping, or terminating and then again before energization. See UM Master Specifications for additional requirements.

6. ELECTRICAL IDENTIFICATION:

6.1. This section defines the general requirements for electrical identification. When working in existing facilities and the existing identification systems are found to vary from the following requirements, bring any differences to the attention of the UM OFM Project Manager for direction.

6.2. Power feeders shall be identified in accordance with a scheme which relates the voltage of the feeder and the source of the feeder as well as number of that feeder.

a. **Example:** 480V-1-5 which would indicate a 480V feeder from switchboard number one (1) which is designated "Number five (5) feeder".

b. The identification scheme should be tailored to the distribution system, and may be simple for a building with one switchboard but must be appropriately sophisticated for a building with emergency and normal systems along with varieties of configurations and numbers of substations.

6.3. Substation and switchboard identification shall match with power feeder identification.

6.4. The panelboard name must identify whether it's on emergency power; what type of load is served; the internal buss voltage; the building floor being served; and a sequential number or address.

a. **Example:** Panel 'ELP232' is an emergency lighting panel serving 208V/120 loads on the 3rd floor.

b. **Legend:** Use the following legend in developing the building's panelboard naming scheme:

(1) **'E':** First letter to be included if on emergency power; leave blank if not on emergency power.

(2) **'LP':** Lighting Panel

(3) **'RP':** Receptacle and small loads panel.

(4) **'LAB':** Emergency panel dedicated to a lab module or suite. Where 'LAB' is used there is no need to include the letter 'E' to identify emergency. These are normally fed from the 'ATS-LAB' emergency power riser in the building.

(5) **'EQ':** Emergency Equipment Panel. Mechanical Division Loads, pumps, fans, ATC, fume hoods, etc. on emergency power that must stay in service during a loss of power. These are normally fed from the 'ATS-EQ' emergency power riser in the building.

(6) **Emergency Distribution Panel (EDP):** Typically used for the I-Line type panel in the floor electric closet that subfeeds the local 'LAB' panels in the research space areas.

(7) **First Number in Series:** '2' designates 208V/120; '4' designates 480V/277.

(8) **Second Number in Series:** Identifies which Floor the Panel is located on.

(9) **Third Number in Series:** Assign a sequential number regardless of whether there is only one type/purpose or more than one.

6.5. Power system identification shall be shown on all risers, plans and substation details and schedules.

6.6. Identify all equipment; low and high-voltage feeders with phenolic tags with White backgrounds and black lettering. Attach tags to switchboards and equipment enclosures via self-tapping screws or rivets; attach to low and high-voltage cabling via weather-resistant plastic tie wraps.

6.7. Data and telecommunications riser cabling and backboards shall be identified using principles similar to those described for power. All cables and backboards shall be identified on each floor and the drawing riser diagrams shall be labeled to match.

6.8. The panel directories of all panels which are affected by this work shall be brought up-to-date with every circuit new and existing, identified correctly. The directory shall be neatly typed.

6.9. Each circuit breaker shall be numbered and marked with proper markers in the spaces made available by the manufacturer of the panelboard.

6.10. Each receptacle shall be neatly marked on the inside of the cover plate with indelible marker identifying the panel and breaker from which it is fed.

6.11. All panels, safety switches, motor controls, switchboards/gear, etc., shall be correctly identified as to the feeder, motor or circuit controlled with black phenolic nameplates with minimum 1/2 inch high etched white letters and beveled white trim.

6.12. Emergency power outlets and their cover plates shall be red in color.

6.13. Color code insulated grounding conductors in accordance with NEC 210-5 (B).

6.14. Color code current carrying conductors (except control and instrumentation conductors) as follows:

a. **208/120 Volt System:**

(1) **Phase A:** Black

(2) Phase B: Red

(3) Phase C: Blue

(4) Neutral: White

(5) Ground: Green

b. 480/277 Volt System:

(1) Phase A: Brown

(2) Phase B: Orange

(3) Phase C: Yellow

(4) Neutral: Grey

(5) Ground: Green

c. No. 12 thru No. 6 conductors shall have continuous insulation color.

d. Color code conductors larger than No. 6 which do not have continuous insulation color by application of at least six inches of colored tape on each conductor at all points of access including junction boxes.

6.15. Number code all control and instrumentation wiring at all points of access including junction boxes.

6.16. Identify all circuits, branch or feeder, at junction boxes. This may be done by labeling the conduits entering the box where exposed.

6.17. Identify systems wiring by painting each junction box using the following schedule:

a. Fire Alarm: Red

b. Emergency: Orange

c. Telecommunications: Green

d. Security: White

7. VARIABLE FREQUENCY DRIVES:

7.1. General: Provide complete variable frequency drive (VFD) units of capacity, quantity and characteristics for fan and pump applications in a single enclosure, and suitable for use with both standard and high efficiency three (3) phase motors as follows:

a. For motors above 175hp, specify twelve (12) pulse or greater units for each motor. Each unit shall be of the same manufacturer. Smaller six (6) pulse not permitted for the larger hp motors.

b. For motors 175 hp and smaller specify six (6) pulse units for each motor. Each unit shall be of the same manufacturer.

c. Coordinate the size of drive with the equipment manufacturer.

7.2. Standards: All VFD's shall comply with the latest applicable standards of ANSI, IEEE and NEMA. As a minimum, the full load output current of the drive shall be equal to the equivalent motor horsepower as listed by NEC Table 430-150.

7.3. VFD Design: All VFD's shall be of the pulse width modulated (PWM) design converting the fixed utility voltage and frequency to a variable voltage and frequency output via a two (2) step operation. VFDs utilizing a 3rd power section are not acceptable. Efficiency shall exceed 96% at 100% speed and load. Line side displacement power factor shall exceed (0.95) regardless of speed and load. The VFD shall be rated for 110% current for one (1) minute for variable torque loads and 150% current for one (1) minute for constant torque loads.

7.4. VFD Enclosure Requirements: Each drive, including it's accessories, shall be mounted in a single cabinet, VFD enclosures shall be suitable for both indoor and outdoor applications as follows:

a. Indoor Applications: Provide single NEMA 12 metal enclosure, including transformer, filters, line reactor, PWM, etc., with manufacturer's optional exhaust fan package. Provide additional cooling and/or exhaust as required to ensure enclosure ambient temperature satisfies manufacturer requirements. Assume a room ambient temperature of 104^0F (40^0C).

b. Out Door Applications: VFD's located outdoors on rooftops, in parking garages, at grade, etc: Provide a single non-metallic NEMA 4X enclosure and an independent heating and cooling system to maintain manufacturer's ambient operating conditions.

7.5. Drawing Requirements: The following information shall be included in the construction documents:

a. Incorporate the University's standard VFD specifications and details into project contract documents.

b. All design work shall be coordinated between electrical, mechanical and UM.

c. Show VFD locations on mechanical plans. Ensure adequate mounting space and floor area including service access. VFD preferred location is adjacent to and within the same room as equipment served.

d. The 50% Contract Document review submission shall include specifications and details for VFD's.

e. The 50% Contract Document review submission shall include harmonic calculations made in accordance with IEEE 519-1992 Standards showing the specified THVD, line notching and the specified THCD limits are met. Calculations shall assume worst case system conditions. The review submission shall include, as a minimum, the following information:

(1) All input data and assumptions.

(2) Explanation of method used to perform the analysis.

(3) All calculations and computer printouts used in the analysis, including input documentation.

(4) A system impedance diagram based on the electrical one-line diagrams.

(5) All calculations shall be in accordance with IEEE 519 with all drives at 100% speed. The point of common coupling shall be the secondary connection of the transformer supplying that group of devices. These calculations shall be done with the transformer loaded to no more than 70% of its nominal capacity. These calculations shall also be done with all twelve (12) pulse or greater drives running as well as the smaller drives running.

8. SERVICE ENTRANCES AND SUBSTATIONS (MEDIUM VOLTAGE):

8.1. Primary electrical service is available from the University 13.2 kV distribution system.

8.2. Available fault current at the master switching station (MSS) bus is 19,200A/432 MVA phase to phase and 18,900A/432 MVA phase to ground at 13.2 kV.

8.3. When deciding whether to use the UM 13.2 kV distribution system or BGE as a source of power, a cost-benefit analysis shall be performed. The analysis shall compare the cost of electricity supplied at BGE Schedule G and Schedule P and the installation of service and distribution equipment.

8.4. Typical primary service is via two feeders, two air load interrupter switches and one fuse compartment. The fuse compartment is key interlocked so that both switches must be open in order to gain access to the fuses.

8.5. 100% spare fuses are required.

8.6. Typically, two transformers with a secondary tie breaker are used, although UM may elect to serve garages and small office or academic buildings with a primary selective (dual feeder) single-ended substation. Automatic transfer may be required as directed by UM depending on the reliability designated

8.7. Voltage surge protection shall be applied in the primary switches.

8.8. B.I.L. rating is 95 kV.

8.9. All bus and coils shall be copper.

8.10. The whole substation assembly shall be on a house-keeping concrete pad at least 3 1/2 inches above the room floor.

8.11. The following items shall be furnished with each substation;

a. Hotstick with voltage tester (glow stick by Biddle or approved equal).

b. Class 2 lineman's rubber insulating gloves rated 17 kV with leather outers and carrying bag;

c. Two sets grounding clamps and associated "welding cable" to permit grounding of primary switches; and

d. One line riser diagram of the complete electrical system framed and covered in plexiglass.

e. A gang box style storage cabinet for tools and equipment.

8.12. Water piping and drain piping shall not be permitted in substations and or electric rooms. The only exception to this requirement will be the piping required for the fire protection system.

9. SWITCHBOARDS AND SWITCHGEAR (LOW VOLTAGE):

9.1. Double-ended substations are to be employed, the mains and ties shall be metal enclosed, draw-out air, or draw-out insulated case circuit breakers with automatic throw over or manual operation, depending on the application.

9.2. Feeder circuit breakers shall be draw out type and shall either be molded case, insulated case or air type depending on application. Microprocessor based trip units shall be used in all switchgear.

9.3. Copper bus is standard.

9.4. Feeder lugs shall be copper and UL approved and meet the temperature rating for the feeder served.

9.5. All spaces in the switchgear or switchboard shall be occupied with a circuit breaker. Circuit breakers not serving a load shall be provided with variable and adjustable rating trip devices.

9.6. All circuit breaker trip devices shall be coordinated.

9.7. All circuit breaker trip devices shall be set, in accordance with the coordination study, by the contractor before placing the feeder in service.

9.8. Circuit breaker trip operation shall be tested and adjusted as required to comply with the coordination study by an independent electrical testing company.

9.9. Computer/laboratory power should be separated from mechanical and lighting systems where possible.

9.10. Service entrance main switchgear shall have transient voltage surge suppression installed.

9.11. All switchgear shall be ANSI/IEEE type 2 arc resistant per C37.20.7.

10. ELECTRICAL METERING:

10.1. Square D metering equipment is the UM standard for the following applications:

a. **Building Service Entrance and/or Switchboard/gear Main Circuit Breakers:** CM4000T meter with min. 32MB memory, vacuum fluorescent display, ride-through module, min. four (4) 0-32V digital inputs, two (2) 4-20mA analog inputs, and 1 kyz output.

b. **Building Sub-metering for Separating Self-support Occupancy Loads:** PM870 with 800kB memory, remote vacuum fluorescent display, ethernet gateway EGX-400, ride-through module, min. two (2) 20-138V digital inputs, min. two (2) 4-20mA analog inputs, and one (1) kyz output.

c. **Transformer Temperature Monitoring:** Provide peak and real time monitoring of dry-type transformers' windings via the Model 98 temperature monitor.

d. **Generator Alarm and Fuel and Auto-Transfer Switch Status Monitoring:** Tie the genset "common alarm," "running," and "low fuel" alarm outputs; Main fuel and genset day tank's "high level," "low level," and digital fuel monitor's 4-20mA analog outputs; and the auto-transfer switch's "emergency mode" and "normal mode" switch status outputs to the UM electrical metering system via the meter's described above. Where it's not possible to use one of the above meters, provide a CM4000 meter with 32MB memory, vacuum fluorescent display, ethernet communications card (ECC21), ride-through module, and I/O card sized as required.

e. **Metering EP Circuit:** Put all electrical metering equipment control power inputs on a dedicated 120V emergency power circuit derived from the 'Live Safety' emergency power riser in the building (i.e. Do not use the 'LAB' or 'EQ' Risers). Do not simply tap the 'A' phase PT input terminal. Backup the 120V emergency power circuit with a 750VA UPS with "low battery" and "replace battery" contact outputs that are tied to a local meter with I/O capability. Provide a shelf for the UPS with a pad lockable strap to keep the UPS secure. Recommended vendor and part information is the APC Smart-UPS 750VA USB & Serial 120V UPS with a relay I/O smart slot card (APC Part # SUA750 with Part #AP9610). In addition to the UPS, provide a Liebert 120V power distribution unit, rack-mountable, and with bypass switch (Liebert part # 2U POD).

f. **3P4W Applications:** For 3P4W applications, provide four (4) CT's and three (3) PT's. For 3P3W applications, provide three (3) CT's and two (2) PT's. Do not provide two (2) CT and three (3) PT installations for 3P3W. Both CT and PT's shall be 0.3% revenue metering class accurate with CT's also having a 133% rating factor.

g. **High Voltage Applications:** For high-voltage applications, do not 'piggy-back' the electrical metering onto the same CT's used for the 50/51 overcurrent relays. Relaying CT's come with a higher rating factor (i.e. to avoid saturation problems during fault conditions) which degrades their accuracy performance to +/- 10% even with a light burden on their secondary circuit. Provide dedicated CT's for the metering that are revenue metering class accurate.

h. **Blocks and Fuses:** Provide CT shorting blocks and PT fuse blocks for each installation.

i. **Technical Support:** Through Square D, provide two (2) years of powerlogic technical support for the UM electrical metering system.

10.2. For each new building project, provide a dedicated ethernet switch (consult UM for latest part number information), backup UPS with battery alarm contact output connected to either the building automation and/or electrical monitoring system, and a bypass switch.

a. **Rack Mount Installations:** For rack mount installations specify an APC smart UPS 750VA USB & serial 120V (part #SUA750RM1U) with an APC smart slot triple chassis (part #AP9604), APC network management card (part #AP9616), and an APC relay I/O smart slot card (part #AP9610). Connect the "replace battery" contact output from the smart slot card to the local building automation system panel and connect the network management card to the local ethernet switch. In addition to the UPS and expansion chassis, provide a Liebert 120V power distribution unit, rack-mountable, and with bypass switch (Liebert part # Micro POD MP2-115A).

b. **Metering Network Switch:** For the metering network switch specify a Cisco switch, part number WS-2960-24PC-L.

10.3. If required, additional metering system modules shall be included with the building construction scope of work to accept the metering input.

11. TRANSFORMERS:

11.1. 13.2 kV primary transformers shall generally be 115^0C temperature rise ventilated dry type with copper coil and of the appropriate voltage secondary. For single-ended substations provide liquid-filled transformer with an insulator that has a high fire-point rating for indoor applications and containment wall/curb for greater reliability and overload capacity.

11.2. Characteristics & Features:

a. Hot spot temperature gauge with output for remote monitoring;

b. 5.75% impedance 7.5% tolerance;

c. 95 kV B.I.L. primary; 10kV B.I.L. secondary

d. NEMA standard sound level; and,

e. Two 2 1/2% taps above rated voltage and two 2 1/2% taps below rated voltage.

f. Provide forced air cooling.

g. Provide Square D Model 98 transformer temperature monitor for remote recording of transformer winding temperatures.

11.3. Primary and distribution transformers shall be grounded to the building's substation grid in addition to any NEC requirements.

11.4. 600V Class Transformers' Energy Efficiency Standards - Per MD COMAR Rule #14.26.03, ".the efficiencies of all low-voltage, dry-type distribution transformers may not be less than the values shown in table 4-2 NEMA Standard TP-1-2002…" This rule applies only to 600V class, 'general purpose' type transformers and, via the NEMA standard, sets efficiency performance standards for transformers when operating at 35% rated load. The design engineer has two (2) possible options for complying with NEMA TP-1:

a. **Energy Efficient Type 'EE' 600V Transformers:** Contains extra "compensation" windings to enable the transformer to be at its' most efficient level when loaded at 35% (i.e. the load level most transformers see when put in service and user diversity is taken into account). Aluminum wound; 10% less coil loss over aluminum wound general purpose transformers but will generate same amount of heat loss as general purpose transformers. Best application is for receptacle and lighting loads in which the transformer is only operated under light and no-load conditions. Price per unit is 10% less than copper-wound general purpose transformers (i.e. UM's previous standard/requirement).

b. **Low Temperature Rise Transformers:** Slightly oversized; also Aluminum wound; much less heat loss and 50% less coil loss (during 35% to 100% load conditions) than general purpose and energy efficient transformers but higher coil loss (70% to 100%) during no-load conditions. Best suited for HVAC equipment loads in which no-load conditions rarely exist. Price per unit is same as copper-wound general purpose transformers.

11.5. Provide the type 'EE' transformers for most receptacle and lighting applications in which there will be at least several hours each day of light to no-load conditions however provide the low temperature rise units for most mechanical and other continuous duty type loads given its' significantly less coil and heat losses during

load conditions (Source: Reference Square D 7400 Series Bulletin - Catalog # 7435CT9901).

12. PANELBOARDS:

12.1. All new panel boards for power distribution, lighting, and branch circuits shall use bolt-on circuit breaker protective devices. Fused switches shall not be used. Plug-in circuit breakers may be used only when connecting to existing panels that accept only plug-in breakers.

12.2. Provide additional spare conduits from flush mounted panels stubbed out above the lay-in ceiling for future use. The number of conduits should be half the number of one-pole spaces left for the future to maximum of six (6).

12.3. All panels installed in electrical rooms and mechanical rooms shall be surface mounted.

12.4. All panels shall be copper bus and breakers and the both the internal and outer doors must be hinged. Providing hinges for the outer cover is typically an optional item so it must be clearly stated.

12.5. All new branch panels shall be either forty two (42) pole or eighty four (84) pole with a min. 225 amp (208V) or 250amp (480V) bus rating. The potential savings by using a thirty (30) pole versus a forty two (42) pole panel is quickly lost after several small renovations and a new branch panel is required because a twenty four (24) pole or thirty (30) pole was previously specified. Also, the bus bars in most 100 amp or 150 amp panels are already 225 amp (i.e. 'NQOD') or 250 amp (i.e. 'NF'). Where special circumstances require the panel to be 100 amp or 150 amp, then require the panel to be "ready to be assembled" in the field instead of "factory assembled." When 100 amp or 150 amp panels are "factory assembled," the nameplate will reflect the engineer's required amperage when they are actually a derated 225 amp or 250 amp panel. In contrast, "ready to be assembled" panels will reflect the actual rating of the bus bars regardless of what the engineer required them to be. In addition, "ready to be assembled" panels have a much shorter lead time (1-2 weeks vs. 4-6 weeks) and are less expensive.

12.6. All new 'I-Line' type distribution panels shall have a minimum ninety nine (99) inches of breaker mounting space (i.e. the combined vertical mounting space on both left and right sides) and with the minimum breaker capacity or prepared spaces for installing 400A and/or 600A branch circuit breakers in the future. Distributors do not size these panels based upon required poles but on the required amount of breaker mounting space. They also may still provide the largest panel possible but then shorten the internal bus bars so the extra mounting space is useless.

13. EMERGENCY AND STANDBY ELECTRICAL POWER SYSTEM:

13.1. **Emergency Generator Permitting:** Per MD COMAR Rule # 26.11.02.10, all new emergency generator installations with an output greater than or equal to 500 brake horsepower or 373 kW must first receive a 'permit to construct' from

the Maryland Department of the Environment (MDE). However, prior to receiving MDE approval, the MD Public Service Commission (PSC) must issue a Certificate of Public Convenience and Necessity (CPCN) Exemption for the generator and, prior to the PSC issuing the CPCN waiver, BGE must provide a CPCN 'Relief Letter.' As soon as the design team is confident the generator size will exceed the MDE 373 kW limit, work with the designated UM Representative to generate the above permit and CPCN waiver applications. For the BGE application, provide a one-line diagram of the building project's proposed emergency power distribution system that confirms the genset will comply with a MD PSC 'Type I' application meaning it will only be used during a loss of utility power and not 'Type II' where it could be used for paralleling with utility power.

13.2. Buildings shall have a source of emergency and/or standby electrical power, typically one or more diesel generator set(s). Where identified in the program, the EPS/SEPS may be used for electrical demand peak shaving or load curtailment. For small loads, UM may elect to use a battery/inverter system. EPS/SEPS would be sized based on the following typical loads:

a. Life safety requirements including all fire alarm and protective (fire pump), emergency, exit and egress lighting loads, and ventilation loads as required by the authority having jurisdiction;

b. Security, access control, telephone and data communications systems;

c. Fume hood exhaust where loss of exhaust could create a hazard;

d. Electrical substation, generator room, Tela/Data BDF and IDF closet(s), and server equipment room(s) lighting and convenience power to facilitate quick restoration of normal power and voice/data communications;

e. Elevators, typically through use of a sequencer so that only a single elevator runs at a time;

f. A generous amount of laboratory convenience and equipment power. In some critic medical research laboratories, up to 100% of convenience receptacles are connected to the SEPS. Equipment load may include freezers, centrifuges, walk-in cold rooms, etc.

g. ATC panels;

h. Other unique loads as required, i.e., data centers, NMR's, some server farms, etc.

i. Reasonable growth and future expansion, typically 20% - 50%, according to facility. However, given the conservative inrush magnitudes and multipliers programmed into most genset vendors' sizing software and the end-user's high diversity factored in during planning there is usually plenty of spare capacity realized with building occupation and use.

13.3. In addition, generators must be sized using as a criteria motor starting with 15% maximum voltage drop at the motor.

13.4. The transfer switches and engine controls shall be isolated from the engine generator by a partition with a glass observation window. A room shall enclose the engine generator set to prevent noise from being present at the transfer switch and engine controls.

13.5. The engine generator day tank shall have a sight glass.

13.6. Where applicable, provide a double-wall, sub-base day tank for each genset. Do not provide day tanks that are located inside the genset enclosure.

13.7. Provide local fuel gauges for both the main fuel tank and genset day tank. In addition, provide digital fuel monitors for both the main fuel tank and genset day tank with a min. of two (2) 4-20mA signal outputs from each fuel monitor. Tie one (1) of the signal outputs from each of the tanks' digital fuel monitors to the UM electrical metering system for remote recording of tank liquid levels. In addition, tie the 'high' and 'low' liquid level digital output alarms from the fuel tanks to the UM electrical metering system. The other signal output will go to the local BAS/ATC monitoring panel.

13.8. All engine generator transfer switches and engine sensing devices for correct system operation shall have contacts for remote monitoring. The contacts shall be for anticipatory high water temperature and low oil pressure. Additional alarm contacts shall be provided for generator called on to start, mode switch not in "Automatic", over speed, over crank, battery alarm, transfer switch in emergency position, transfer switch in normal position, ventilation fan and louver on/off, and closed/open, and fuel pump for day tank malfunction, and engine heater not working.

13.9. The generator set shall be diesel fueled with automatic start and transfer upon loss of normal power. Automatic transfer switches shall have manual by-pass switches to permit maintenance and repair of automatic switches without interrupting the load being served.

13.10. Each engine-generator set shall have a local start/stop switch at each unit.

13.11. Engine generator sets should be located close to the normal power switchboard to permit paralleling with the normal power substation for demand peak-shaving and curtailing load operations. Provide a tie circuit breaker and tie feeder between the emergency power bus and the appropriate substation secondary.

13.12. Engine generator sets and emergency-normal power tie circuit breaker should be equipped with synchronizing and paralleling equipment and instrumentation including wattmeters with pulse output, ammeters, voltmeters and synchroscope, and reverse power and other protective relaying required by BGE.

13.13. The contractor shall fill and 'top off' all fuel tanks within forty eight (48) hours of final acceptance.

13.14. The emergency power system shall have a status monitoring system with annunciation at the building management system. In addition several summary

alarms as well as an analog fuel level indication will be transmitted to the energy management system.

a. Example of parameters are as follows:

(1) Water temperature

(2) Oil pressure

(3) Mode switch in other than automatic

(4) Over speed

(5) Over crank

(6) Battery voltage status

(7) ATS status

(8) L.V. main circuit breaker status

(9) Reverse power

(10) Fail to synchronize

(11) Engine running

(12) Low fuel level

(13) Ground fault

13.15. Bridge Power Distribution Systems: The A/E shall coordinate with the UM OFM Project Manager to determine whether the need exists for providing a bridge power riser and/or distribution system for supporting the following critical systems during the eight (8) to twelve (12) second source transfer from normal power to emergency power:

a. Tela/Data systems including network switches that support VOIP.

b. Building automation system network panels and all low-voltage power supplies.

c. Fire Alarm, access control, intrusion detection system panels.

d. The bridge power riser will consist of a separate distribution system fed off the standby emergency power service that ties into a central UPS via receptacles and/or disconnects. In sizing the UPS, consider 100% spare capacity with a run-time capability of only fifteen (15) minutes (the UPS will only need to run for a maximum of fifteen (15) seconds). Consider dedicating the riser to the stacked tel/data closets with branch circuit taps

to the local floor's electric and/or 'energy management' closets for supporting the building management system loads.

14. INTERIOR LIGHTING:

14.1. General: Lighting levels shall be in accordance with I.E.S standards, IESNA Lighting Handbook Tenth Edition; maintained levels.

14.2. All lighting fixtures shall be of LED light source type that are approved as "Efficient Lighting Systems". Review LED luminaires to evaluate glare control, flicker rates, and color rendering capabilities.

14.3. Building designs shall take maximum advantage of day lighting. Ambient light sensors, dimmers and programmable controllers are to be used where cost effective. The type of photo sensors (open loop or closed loop type) used shall be coordinated with the lighting control system.

14.4. To take the advantage of the day lighting, the lighting fixtures shall be placed perpendicular to the exterior window to achieve maximum control.

14.5. Where sufficient day lighting is achieved and requires to turn-off or reduce the overhead lighting level, task lighting shall be provided for supplemental lighting.

14.6. Automatic Lighting Control: Up to 60% of a building's lighting load is wasted or unused. As UM becomes more aware of the potential energy savings through lighting control and the efficient use of lighting, the proper design of lighting control system(s) for a building becomes ever more important. The design of the lighting control system shall be in accordance with the latest IECC code and ASHRAE standards. In developing lighting control system(s) for a building, please incorporate the following:

a. Occupancy Sensors: Because of their capability to switch lighting in 'real-time', occupancy sensors are the most effective tool for conserving energy through lighting control and, therefore, should always be considered first. At a minimum, provide occupancy sensors for all public spaces, lobby areas, corridors, vending areas, waiting rooms, bathrooms (ceiling-mounted only), etc. Unless impractical, occupancy sensors shall be used in offices, classrooms and conference rooms. The occupancy sensors shall employ passive infrared (PIR) and ultrasonic (US) detection and microphonics for keeping lights on even when there is only sound and no motion.

b. Central Lighting Control Panels: Centralized lighting control panels for interior lighting should only be used for special purpose applications such as auditoriums, theaters, seminar and conference rooms where manual control of the lighting is critical to the successful use of the space. Avoid using centralized lighting control panels for public spaces for general use in lieu of occupancy sensors because the energy savings is not as significant.

c. **Electronic Timer Switches:** Provide electronic timer switches in all utility rooms/spaces with a display that counts down the time remaining (e.g. Tork Digital SSA-200) and with a time frame of up to eight (8) hours.

14.7. **Lighting Calculations:** Perform all lighting calculations in accordance with the latest edition of IESNA Lighting Handbook. Submit hard copies and electronic files of the calculations to UM for review and comment during design phase. Submissions shall include the following:

a. Calculations at a minimum shall include room name, room number, fixture type chosen for the room, number and type of lamps to be used in the room, required illumination level (IESNA), calculated illumination level, calculated illumination level statistics, power density statistics, lighting fixture schedule and all light loss and reflectance assumptions used.

b. Calculations indicated and submitted as part of construction documents are also accepted.

c. Calculations for most interior spaces may be performed using the zonal cavity or point-by-point method. Perform and submit point-by-point calculations for areas of greater architectural or luminous complexity. Perform and submit point-by-point calculations for laboratory designs.

d. Calculations for exterior spaces, including parking structures, shall be point-by-point.

e. Calculations shall include demonstrated compliance with energy conservation measures. Allowed Lighting Power Density (LPD) figures shall follow ASHRAE 90.1.

14.8. **Lighting Fixture Schedule:** Provide a Lighting Fixture Schedule on the drawings, separate from the specifications. The Lighting Fixture Schedule shall state details such as fixture designations used on the plans, lighting fixture description, exact lamp type, lamp quantity, wattage per lamp including ballast, etc. Provide three equal manufacture lists on the Lighting Fixture Schedule.

14.9. **Lighting Design:** Lighting design includes the following:

a. **Laboratory:** See paragraph 16 for requirements.

b. **Non Laboratory Areas**: The A/E shall make recommendations applicable to specific project. UMB standard recommended fixtures for general lighting areas (2x4, 2x2, and 1x4) are as manufactured by H.E.Williams – AT1, Lithonia – BLT and Cooper Lighting.

14.10. **Lighting Schemes:** Provide at least two (2) proposed lighting schemes for special or architecturally unique areas such as, Lobbies, Atriums, Conference Rooms and other special use areas identifies in the project program or as directed by UM. Layouts shall vary in design and materials such as fixture layout, fixture type, lamps, louvers, reflectors, etc. to enable UM to select the best scheme to suit project goals and budget requirements.

14.11. Excluded Fixtures: Do not use fixtures with "wrap-around" lenses.

14.12. LED Lighting:

a. Provide LED luminaire as a complete luminaire consisting of housing, reflector/lens, LED module, driver and dimming driver. LED luminaires from different manufacturers which have similar housing, lumen output, input wattage, and optical system may have different photometric performance. A/E shall review all important performance parameters to assure a minimum of three domestic manufacturers are producing equivalent equipment.

b. Utilize LED luminaires when operating at or below temperatures of 32 degrees F. LED luminaires perform well in cold weather. Do not specify LED luminaires for environments that exceed 122 degrees F, unless LED luminaires are certified, listed and warranted by manufacturer for such environment. Verify with manufacturer that performance and warranty are not altered.

c. LED driver must be determined in conjunction with luminaire, lamp source, and controls. Utilize 0-10V dimmable power supplies as basis of design. LED power supplies must be field accessible.

14.13. Exit Signs: Exit signs shall be LED type with a uniform illumination of RED letters over the entire face. Exit signs in mechanical spaces shall of the photo-illuminance type if adequate lighting is available for proper illumination.

14.14. Battery Backup Fixtures: Battery Backup Fixtures shall be LED type. When battery backup fixtures are required; specify maintenance free type fixtures self-diagnostic test feature.

2. EXTERIOR LIGHTING:

15.1. General: The University goals, for an attractive institutional identity within its urban setting, as well as a high priority for security and safety requires, open spaces and the exterior of buildings be well-lighted. Except in locations where it may be necessary to relocate or remove, and approval of Baltimore City is obtained, the city street lighting grid utilizing a high pressure sodium (hps) source on twenty four (24) foot or thirty (30) foot masts shall remain in place. This lighting shall be supplemented by University projects to raise the overall minimum on pedestrian walks to three (3) foot candles. See Section 3 AD of these Design Standards. Provide LED light source fixtures. Review LED luminaires to evaluate glare control, flicker rates, and color rendering capabilities.

15.2. Building and Site Lighting: Building and site lighting, including steps and ramps, shall be provided by each project. Entrances and service areas, such as loading docks, shall be provided with ten (10) foot candle lighting level. Alleys and incidental spaces such as interior courtyards, etc. shall be provided with a minimum of three (3) foot candles and a uniformity ratio of three (3) to one (1).

Highlighting of architectural features may be recommended for major capital projects which have a significant impact on the campus setting and institutional identity. Landscape lighting has not been employed on campus, but may be proposed for unusual conditions. In general, utilitarian direct source fixtures such as “wallpacks” should not be used on facades or areas facing the public streets.

15.3. Sidewalk Lighting: Sidewalk lighting shall be provided as a private lighting system powered from the project in accordance with the University Center Design Manual, as defined in Section 3 AD of these Design Standards. The standard fixture is:

a. Type 1 Fixture: Pedestrian Walkway

(1) **Model:** Louis Poulsen Model # ALBEERTSLUND-MAX1-LD-GREY FINISH-ALB MAX PT/LED/120 277/GREY/T DRA 5.3”

(2) **Lamp/LED:** CCT - 4000K, WATT- 82, LUMEN – 4996, LIGHT SOURCE 82WLED 4000K, GREY, INSULATION CLASS 1, EFFICACY 61. LED driver in fixture head.

(3) **Mast:** Louis Poulsen #DRA-5”.3”, 10’-BR ALU (BRUSHED ALUMINUM)

(4) **Base:** Cast aluminum cover w/ tamper proof screws

(5) **Pedestal:** Site cast air-entrained concrete, top flush with underside of sidewalk finish (usually brick) with four (4) galvanized anchor bolts, engineered for wind and impact loading.

b. Type 2 Fixture: Surface Parking Lot

(1) Model: Beacon Viper VP-L series

(2) LED Engine Watts – Provide as necessary to provide required illumination for the area/parking lighting

(3) LED Color – 4000K

(4) Voltage – UNV

(5) Optics – Provide Optics to suite illumination requirements.

(6) Provide house side shield options as required.

(7) Provide Bird Deterrent

(8) Provide with rectangular arm for round pole mount.

(9) Fixture Finish – Metallic Titanium Textured

(10) Pole – Round Straight Aluminum Beacon Smooth, 25', Metallic Titanium Textured finish. Pole shaft and thickness shall be determined per ASCE 7-05 wind map EPA Load Rating

c. Type 3 Fixture: Plaza Lighting

(1) **Model:** Selux Saturn Cutoff LED # SACL-1-LG4700 (700Ma/65W)-40-8'-BRUSHED ALUMINUM -120 OR 277-DS-HS(AS REQUIRED)

(2) **Lamp/LED:** CCT - 4000K, LG4700 (700mA/65W)

(3) **Pole:** Round Straight Aluminum A35 -8' -BRA (BRUSHED ALUMINUM FINISH)

(4) **Base:** Two-piece cast aluminum

(5) **Optics:** Provide optics to suite illumination requirements

15.4. Exterior Lighting Control: Control all exterior lighting via the local building automation system through an electrically held lighting contactor with a mechanical override switch.

15.5. Exterior Lighting Calculations: Perform all lighting calculations in accordance with the latest edition of IESNA Lighting Handbook. Submit hard copies and electronic files of the calculations to UM for review and comment during design phase. Submissions shall include the following:

a. Calculations at a minimum shall include site plan, fixture type chosen for the site, number and type of lamps to be used, required illumination level (IESNA), calculated illumination level, calculated illumination level statistics, power density statistics, lighting fixture schedule and all light loss and reflectance assumptions used.

b. Calculations indicated and submitted as part of construction documents are also accepted.

c. Calculations for exterior area lighting, side walk lighting; parking lot lighting and parking structure lighting shall be point-by-point method.

d. Calculations shall include demonstrated compliance with energy conservation measures. Allowed Lighting Power Density (LPD) figures shall follow ASHRAE 90.1.

15.6. Lighting Fixture Schedule: Provide a Lighting Fixture Schedule on the drawings, separate from the specifications. The Lighting Fixture Schedule shall state details such as fixture designations used on the plans, lighting fixture description, exact lamp type, lamp quantity, wattage per lamp including ballast, etc. Provide three (3) equal manufacture lists on the Lighting Fixture Schedule.

16. LABORATORY ELECTRICAL DESIGN FOR NEW AND/OR RENOVATION PROJECTS:

16.1. Design Intent: The intent of the laboratory electrical design is to standardize the use of materials, equipment, and systems for all new laboratory installations and all laboratory renovation projects. The A/E shall discuss with UM the selection of all material and equipment prior to proceeding with the design.

16.2. General Laboratory Requirements: Standard laboratory requirements shall include but not be limited to the following:

a. Electrical Services: Electrical services shall include normal power, and emergency power for laboratory equipment and lighting for each laboratory space.

b. Emergency Power Outlets: Red with red face plates with circuit number indicated on the back of the cover plate and on the face plate.

c. GFI Outlet: GFI and indicator near wet areas.

d. General Lighting: Unless otherwise directed by UM provide 1x4 LED source fixtures in laboratories located over the laboratory benches. Lighting shall be designed in accordance with IES standards, IESNA handbook, Tenth Edition. Wherever feasible, use natural light as the primary daytime light source. Review LED luminaires to evaluate glare control, flicker rates, and color rendering capabilities.

(1) Provide 1- foot x 4-floot recessed LED lighting fixture with acrylic lens, installed above the edge of the lab bench. UM standard laboratory fixtures are:

(a) LED – Lithonia – BLT, H.E.Williams – AT1, Cooper Lighting.

e. Special Receptacles: Coordinate with the UM OFM Project Manager for special type of twist-lock receptacles requirements in the laboratories and equipment spaces.

16.3. Special Laboratory Requirements: Special laboratory requirements shall include but not be limited to the following:

a. Biological Safety Level 2 (BSL-2) Laboratories: Ultra violet lighting shall be provided only as plug-in equipment with integral switch as directed. Provide warning sign. All fixtures shall be vermin proof.

b. Biological Safety Level 3 (BSL-3) Laboratories: A/E design team must coordinate the designs for biological safety level 3 areas with UM Facilities Management.

c. **Animal Biological Safety Level 3 (ABSL-3) Laboratories:** A/E design team must coordinate the designs for animal biological safety level 3 areas with UM Facilities Management.

d. **Surgery Laboratories, Survival:** In laboratories used for survival surgery in addition to standard laboratory requirements provide a ceiling mounted surgery light fixture and explosion proof outlets. Also lighting fixtures shall be watertight and vermin proof, and switches and receptacles shall be watertight.

e. **Surgery Laboratories, Non - Survival:** In laboratories used for non - survival surgery in addition to standard laboratory requirements provide a ceiling mounted or floor mounted surgery light fixture and explosion proof outlets. Also lighting fixtures shall be watertight and vermin proof, and switches and receptacles shall be watertight.

f. **Animal Holding Rooms:** In rooms used to hold animals all lighting fixtures shall be watertight and vermin proof, and switches and receptacles shall be watertight.

g. **Photo Dark Rooms:** In dark rooms provide traditional red filter work lighting with exterior warning light with interlocked switches for alternative general lighting.

h. **Administrative Support Areas:** In administrative support areas include standard power, data and lighting.

i. **Equipment Rooms:** In equipment rooms include standard power, emergency power for equipment, and lighting.

j. **Laboratories with Low Flow Chemical Fume Hoods:** In laboratory areas with low flow chemical fume hoods in addition to standard laboratory requirements provide power for the fume hood and emergency power for incubators and other equipment and data outlets as directed by UM.

k. **Laboratories with Existing Standard Chemical Fume Hoods:** In laboratory areas where the existing standard chemical fume hoods are to be reused from another location in addition to standard laboratory requirements provide power for the fume hood and emergency power for incubators and other equipment and data outlets as directed by UM.

l. **Laboratories without Chemical Fume Hoods:** In laboratories without chemical fume hoods in addition to standard laboratory requirements provide emergency power for incubators and other equipment and data outlets as directed by UM.

m. **Tissue Culture Laboratories:** In tissue culture laboratories in addition to standard laboratory requirements provide emergency power for incubators and other equipment and data outlets as directed by UM.

n. **Prosthetic Dental Laboratories:** In prosthetic dental laboratories provide standard power, emergency power, data and lighting as directed by UM.

END OF SECTION 3 ED - PART II