University of Pittsburgh	**Facilities Management** **Operations & Maintenance** **Division K – Electrical Design Manual**

SIGNATURE BLOCK

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REVISION HISTORY

Revision No.	Revision Date	Change Scope
000	06/14/2019	Original issue of document
001	03/14/2024	Comprehensive revision. Review full document for changes.

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ELECTRICAL STANDARDS

K.1 GENERAL ELECTRICAL

A. Purpose
   1. Prioritize future maintainability of the electrical system and equipment, reduce energy usage, and reduce cost (both immediate and via future operations and maintenance).

B. Workmanship
   1. The Professional shall specify that Electrical Contractors (EC) shall be responsible for the repair of damages caused by the EC to other Contractors' work and/or existing work area and to repair said damages to original conditions to the satisfaction of the University.
   2. The University's Project Manager reserves the right to direct the removal of any item which does not comply with the contract drawings or specifications, or does not present a neat, orderly, and workmanlike appearance.

K.2 ELECTRICAL DESIGN CRITERIA

A. The Professional shall meet with the University's Project Manager to develop and prepare a Project Program in accordance with the Facilities Management requirements for new buildings and/or renovations.

B. The Professional shall be required to visit the site to verify existing conditions and to survey the area of work.

C. The electrical design criteria shall include but is not limited to the following:
   1. Power distribution systems
   2. Grounding systems
   3. Life safety, legally-required, and optional standby systems
   4. Lightning protection
   5. Lighting systems
   6. Fire alarm systems
   7. Telecommunications systems
   8. Security systems
   9. Instructional equipment.

D. The building under design may only require some of these criteria, and the Professional shall identify with the University's Project Manager the implementation of those systems that apply.

E. Lighting and receptacle systems shall be designed to be energy conserving and in accordance with IBC, IECC, ANSI, and ASHRA/IES Standard 90.1 as adopted by Pennsylvania's Uniform Construction Code (UCC).

F. The University Sustainability Plan has a goal to LEED and/or WELL certify all projects with a value of more than $5 million. For projects pursuing certification, electrical products such as sub-metering, daylight harvesting, light pollution reduction, EV supply equipment, and on-site renewable energy that can garner points shall be considered and options shall be presented to help the University determine the best approaches to reach its goals.

K.3 PRIMARY POWER DISTRIBUTION

A. Research and laboratory buildings shall be provided with a two-source primary, secondary selective unit substation system with transformers furnished with fan-cooling and/or lower

than normal temperature rise such that under emergency conditions they can carry continuously the maximum load of both sides. Classroom/office buildings and other similar structures shall be provided with only a primary selector load break switch, when medium voltage is supplied to the building.

B. Selector switches shall be fused using current-limiting fuses. Large, gasketed, high impact viewing windows shall be provided in the switch enclosure that permit full view of the position of all three switch blades, blown fuse indicators, and cable terminations from outside the enclosure.

C. **Oakland Campus:**

1. Primary power distribution is 4160 volts from one of seven Duquesne Light Company (DLC) substations located on the main campus as follows:

Substation	Xfmr Qty.	Xfmr Ratings	Xfmr Voltage	Temp. Rise
BST	3	10MVA ONAF	23kV-4.16kV	55/65°C
Chevron	1	5MVA (ONAF)	23kV-4.16kV	55/65°C
	1	5MVA (ONAF)	23kV-4.16kV	65°C
Clapp	1	3.75MVA ONAN	23kV-4.16kV	65°C
Panther	2	10MVA (Future ONAF)	23kV-4.16kV	55/65°C
Posvar	3	7.5MVA ONAF	23kV-4.16kV	55/65°C
Scaife	2	10MVA ONAF	23kV-4.16kV	55/65°C
CUB	2	10MVA ONAF	23kV-4.16kV	55/65°C

2. Each of these substations, except Clapp, has main-tie-main auto-throwover control. Each feeder originating from the substation shall be protected by a draw-out vacuum breaker with overcurrent protective relaying fully coordinated with upstream and downstream devices.
3. All new 5 kV distribution equipment with vacuum breakers shall have arc fault protection.
4. Each building's main unit substation shall be provided with two 4160V feeders from two different DLC transformers (i.e., a primary selective system).
5. Minimum 500kCMIL copper conductors shall be used for all primary power distribution medium voltage feeders.
6. All underground medium voltage conduits shall be encased in RED concrete (i.e., mixed).
7. The minimum size medium voltage conduit to be used underground shall be 5".
8. Precast manholes shall be waterproof coated. All wall penetrations shall be core drilled for conduit entrance. They shall also include a sleeve for ground rod, pulling irons, and sump with grate. All hardware for mounting cable racks, ground bars, etc. shall be stainless steel. All penetrations shall be sealed with hydrophilic grout. Manhole covers shall be cast iron, 36" in diameter with cast-in legend as follows and shall include the University-assigned alphanumeric manhole designation:
   a. "UNIVERSITY OF PITTSBURGH ELECTRIC" "MH-XXX) (with XXX being the designated manhole number) for power distribution.
   b. "UNIVERSITY OF PITTSBURGH TELECOMMUNICATIONS" for communications, data, and telephone systems. Refer to Division L CSSD Specifications.
9. Precast manholes shall be by A.C. Miller Concrete Products Inc. or University-approved equal.
10. Minimum size for medium voltage manholes shall be 8'x8'x7'.

D. **Bradford Campus:**

1. Primary power distribution is 12,470 volts from First Energy Corporation, Pennsylvania Electric Company (Penelec).

E. **Greensburg Campus:**
1. Primary power distribution is provided by First Energy Corporation, Allegheny Power at normal service entrance voltage.

F. **Johnstown Campus:**
1. Primary power distribution is provided by First Energy Corporation, Pennsylvania Electric Company (Penelec) via a 480-volt network or normal service entrance voltage.

G. **Titusville Campus:**
1. Primary power distribution is provided by First Energy Corporation, Pennsylvania Electric Company (Penelec) at normal service entrance voltage.

K.4 GROUNDING

A. A grounding system meeting or exceeding the requirements of the NEC and IEEE Standard 142 shall be designed for each University building. The neutral point of all 4160V, 208Y/120V, and 480Y/277V systems shall be single-point, solidly grounded. The neutral (grounded conductor), equipment grounding conductor, and isolated ground conductor, where used, shall be bonded to the grounding electrode conductor at the service equipment only (single-point). All electrical equipment shall be connected to the grounding system. All separately derived electrical systems (e.g., transformers, generators, and UPSs) shall be grounded per code requirements including a separate grounding electrode conductor to a building grounding electrode.

B. The grounding electrode conductor shall be protected by rigid aluminum or fiberglass conduit where exposed. Provide grounding bushing when utilizing rigid aluminum conduit.

C. The grounding electrode system shall have a measured resistance to ground of 5 ohms or less.

D. All metallic raceways, cable trays, and metallic sheaths of MC cable shall be properly grounded and bonded. In addition, separate, code-sized, insulated equipment grounding conductors shall be contained within the same raceway, cable, or otherwise run with the circuit conductors.

E. Bare ground conductors shall not be installed unless approved by the University’s Senior Electrical Engineer.

F. All compression lugs used in the building system shall be rated copper only. All mechanical lugs can be cu-al rated lugs.

G. All raceways used to contain single or multiple branch circuits shall include a green insulated ground conductor. Circuits used for isolated ground outlets shall have, in addition to the green insulated equipment ground conductor, a separate green-with-yellow-stripe insulated ground conductor installed and tagged for identification at all outlet and junction boxes.

H. A 600V ground wire shall be run with all medium voltage feeders in all types of conduit (PVC, Fiberglass, RMC and Aluminum).

I. Feeders
1. All raceways used to contain 480-volt feeders shall include a green insulated ground conductor.

2. All raceways used to contain 208-volt feeders shall include insulated ground conductor(s) as follows:
    a. Common ground: one green insulated equipment ground conductor that is intended to supplement the conduit grounding system shall be installed with all feeders. This conductor shall be connected to the bonded ground bus of the panelboard or switchboard at each end.
    b. Isolated ground: one green-with-yellow-stripe insulated isolated ground conductor that is intended to provide an isolated ground system for sensitive equipment shall be installed with feeders to panelboards serving research areas and telecommunications equipment. Panelboards serving research areas and telecommunications equipment shall include an insulated ground bus. The isolated ground conductor shall be connected to this insulated ground bus.

J. Panelboards and Switchboards
1. All 480 volt and 208 volt panelboards and switchboards shall include a bonded ground bus.
2. All 208 volt panelboards that serve research areas and telecommunications equipment shall include both a bonded ground bus and an insulated ground bus. The insulated ground bus is intended to provide an isolated ground system for sensitive equipment.

K. Manholes
1. Provide one copper ground bus mounted as high as possible in each manhole sized to accommodate all required grounds. Minimum bus size shall be 18" x 2" x 1/4" thick, mounted with standoff brackets to side of manhole.
2. Provide one ¾” x 10’ copper-clad ground rod and connect to ground bus with #2 AWG. Connection to ground rod shall be by exothermic weld. Hydrophilic grout shall be used to seal ground rod penetration.
3. Terminate all equipment ground conductors run with feeders and any ductbank grounds onto ground bus.
4. Terminate all 5kV cable shields from splices and t-taps onto ground bus with #8 AWG. Make ground connections with approved pure-wrought-copper compression connectors, or approved high-strength, high-conductivity, cast-copper-alloy connectors with silicon bronze nuts, lock washers, and bolts.
5. Bond all metal manhole components, including manhole lid rings, ladders, pulling irons, cable racks, sump frames, and door frames, to ground bus with #2 AWG. Provide exothermic welds for all connections.
6. Ground conductors shall be solid copper.

K.5 ELECTRICAL EQUIPMENT ROOMS

A. Electric utility service entrance, generator, and emergency power supply system (EPSS) rooms shall be separate and physically isolated from mechanical, plumbing, and telecommunications rooms.

B. Electrical rooms shall not be adjacent to areas where vibration, noise, and/or electromagnetic fields would be objectionable.

C. Mechanical piping and ductwork shall not be routed through electrical equipment rooms except when servicing the room.

D. Telecommunications, data, and security wiring shall not be routed through or terminated in electrical equipment rooms except when servicing the room.

E. Access shall be provided for replacement of the largest piece of equipment without cutting the equipment or removing walls.

F. Doors for electrical rooms shall open out and have a panic bar opener.

G. The rooms shall be adequately ventilated under automatic control and shall have a floor drain with a trap primer.

H. All floor-mounted equipment shall be installed on 4" tall housekeeping pads unless otherwise directed by the University's Senior Electrical Engineer.

I. Electrical rooms shall be located and designed to minimize the possibility and/or impact of water intrusion and flooding. The Professional shall consider sources of water inside and outside the building and specify protective measures to reduce the likelihood of equipment damage from a burst pipe or flooding event.

J. Electrical room shall not contain automatic shutoff of lighting fixtures. Provide toggle switches.

K.6 SALVAGED ELECTRICAL MATERIALS

A. The Professional shall review salvaged materials and equipment items with the University's Senior Electrical Engineer and define these items in the bid documents.

B. The University shall have the right of first refusal for any existing equipment removed by the Contractor. The Professional shall specify that the Contractor shall be required to return to the University any piece of equipment in operational or "as found" condition as requested by the University. The Contractor shall be responsible for placing this equipment in a location designated by the University. Distribution and other equipment items to be returned include but are not limited to the following:

1. Transformers
2. Medium voltage and low voltage switchgear
3. Switchboards and panelboards
4. Relays (electronic and mechanical)
5. Disconnect switches, circuit breakers, motor starters, and VFDs
6. Bus duct, plug-in breakers and switches
7. Electric meters and components
8. Building management systems
9. Fire alarm systems
10. Generators
11. Luminaires, light poles, and lighting controls, including occupancy and vacancy sensors
12. Automatic Transfer Switches
13. Bussed trough
14. Fuses

C. All electrical equipment not retained by the University shall be recycled or reconditioned. Receipts shall be provided to the University for all recycled/reconditioned materials.

K.7 SHUTDOWNS OF UTILITIES

A. The Professional shall specify that Contractors shall submit for approval from the University, at least twenty-one (21) days in advance, a request for the shutdown of utilities. The University must issue an outage notice at least ten (10) working days in advance unless it is

an emergency. Utility shutdowns must be scheduled so as not to interfere with the University's daily functions.

B. Professionals shall be responsible for identifying major shutdowns that shall occur during nighttime or weekend hours. These shutdowns are to be specifically described in this Division of the Specifications. The Professional shall submit to the University all options regarding shutdown work including time and cost for each option.

C. Where shutdowns are unavoidable because of introducing additional or increased hazards or of infeasibility due to equipment design or operational limitations as permitted per NFPA 70E, a justification for work and energized electrical work permit shall be filed with the University's project manager in accordance with NFPA 70E. The Electrical Contractor shall inform the University about the Contractor's electrical safety program.

K.8 AS-BUILT DRAWINGS, TRAINING AND O&M MANUALS

A. The Professional shall specify that, during the course of work, the Contractor shall record all changes in the work on a set of the contract documents (in electronic format) to include one (1) set of corrected specifications. The Professional shall revise the original documents and provide the "As-Built" information in computer file form (PDF and DWG) to the University. The Professional shall also update the as-built fixture drawings/schedule to reflect actual installed fixtures. This applies to all Trades involved with the work.

B. The Professional shall specify that training sessions for each piece of electrical equipment or each electrical system shall be a minimum of eight hours each. Training shall not be held until the start-up and commissioning of the subject electrical equipment or system is complete.

C. The date of substantial completion of the construction contract takes effect on the date when both the required training and O&M manuals have been fully received.

D. All major electrical equipment (including but not limited to switchgear, switchboards, transformers, generators, ATSs, UPSs, and VFDs) shall have a warranty label placed in a conspicuous place. Label shall indicate start and end date of the warranty period. The start date shall be the date of final acceptance by the University.

K.9 ACCESS PANELS

A. Access panels shall be provided for accessibility to devices and controls requiring service by the University that will not be readily accessible after completion of the project.

B. Where existing mechanical equipment or pipes are located above electrical equipment not covered by the NEC (i.e. VFDs, starters, control panels, etc.), secondary drip pans shall be provided. Drain lines shall be provided and shall be daylighted to a service sink, floor drain or corridor, as approved by the University, where leaks will be noticeable by maintenance personnel.

K.10 REGULATIONS AND PERMITS

A. All electrical work, equipment and materials furnished and installed shall conform to the requirements of the latest editions of the following: the National Electrical Code (NEC), the National Fire Protection Association (NFPA), the Department of Labor and Industry (L&I), Occupational Safety and Health Association (OSHA), United States Department of Health and Human Services (as applicable), Federal Specifications (as applicable), Allegheny County Health Department (as applicable), International Building Code (IBC), International Energy Conservation Code (IECC), American National Standards Institute (ANSI),

Illuminating Engineering Society (IES), American Society of Heating, Refrigerating and Air-Conditioning Engineers (ANSI/ASHRAE/IES Standard 90.1), Institute of Electrical and Electronics Engineers (IEEE), National Electrical Manufacturers' Association (NEMA), Factory Mutual (FM), and any other governmental or local authorities having jurisdiction.

B. The Professional shall procure the necessary permits from the Department of Labor and Industry. The Professional and the University will determine the level of permit required, and the Professional will complete and submit the paperwork for the application on behalf of the University. If applicable, the Contractor will be responsible for maintaining the permit set on the construction site. Notify the inspection agency in sufficient time prior to concealment of work so that a complete rough-in inspection may be made.

C. Any and all standards and regulations listed in this document shall be included in the specifications as applicable, shall take precedent over the specifications, and shall be satisfied by the Contractor at no additional expense to the University.

K.11 EQUIPMENT STANDARDS

A. All material and equipment shall be listed, labeled, or certified by a nationally recognized independent testing laboratory where such standards have been established. Equipment of a class which no nationally recognized testing laboratory accepts, certifies, lists, labels or determines to be safe shall be considered, if inspected or tested in accordance with a national industrial standard, such as the American National Standards Institute (ANSI), National Electrical Manufacturers' Association (NEMA), or Insulated Cable Engineers Association (ICEA).

K.12 CALCULATIONS

A. The Professional shall perform all electrical power calculations required to complete the design in accordance with all applicable codes and standards and industry best practices. Electrical power calculations shall include, but not be limited to: voltage drop, load (connected, demand, and design), phase balancing, power factor correction sizing (for new services or large motor installations), generator sizing and motor starting and submit them to the University's Electrical Engineer for review.

B. The Professional shall submit PDF computer-generated point-by-point lighting calculations of interior and exterior spaces, lighting power density calculations, and ComCHECK results to the University's Electrical Engineer for review. The Professional shall take into account room finishes, surface reflectances, and light loss factors in photometric calculations. All pertinent calculation parameters, including average footcandles and min/max footcandle ratios, shall be indicated; areas where the design is not IES or IECC compliant shall be highlighted.

C. For all medium voltage cable runs and ductbanks, the Professional shall perform all cable pulling tension, sidewall pressure, and jam ratio calculations and submit them to the University's Electrical Engineer for review.

K.13 POWER SYSTEMS STUDIES

A. When new equipment required to be labeled by NFPA 70E is involved or if the short circuit currents or upstream overcurrent protective device characteristics change for existing equipment, the Professional shall provide power system studies, including short circuit (with equipment kAIC evaluation), overcurrent protective device coordination, and arc flash risk assessment.

1. **The Professional shall perform a preliminary study to determine short circuit design criteria and to minimize potential arc flash risks. The preliminary study shall be provided to the University for review during the Design Development Phase. Study shall include worst case incident energy levels for both utility sources and generator source.**
2. Before equipment submittals are approved, studies shall be completed based on the submittals to confirm the equipment ratings and overcurrent protection characteristics.
3. Any equipment location found to be in excess of a 12 cal/cm^2 PPE (Personal Protection Equipment) as defined by NFPA 70E-2016 Table 130.7 (C)(16) shall be identified to the University's Senior Electrical Engineer immediately so that solutions and products that will mitigate the arc flash risk and reduce the PPE Category may be further evaluated before proceeding with full release of equipment on order.
4. Before startup and commissioning, studies shall be finalized using approved equipment data.
5. Labels shall be provided and installed by the Professional for all equipment as required by NFPA 70E. Where applicable, separate labels shall be provided for utility and generator power. Labels shall be die cut 3 x 5, self-adhesive, thermal transfer printed, including the following parameters:
   a. Equipment Name and Date
   b. Flash protection boundary (Arc Flash Boundary)
   c. Incident energy at 18" expressed in cal/cm^2 (for LV equipment) or
   d. Incident energy at 36" expressed in cal/cm^2 (for MV equipment)
   e. Voltage shock hazard
   f. Glove Class
   g. Limited shock approach boundary
   h. Restricted shock approach boundary
6. For short circuit studies at the Oakland campus, the fault current contribution data will be provided by the University's Electrical Engineer at the secondary of the service transformer to the building.
7. For power system studies on the regional campuses, the Professional shall obtain the fault current information from the local electric utility.
8. Adjustable overcurrent protective device settings shall be confirmed by the Professional before installing the labels.
9. SKM Systems Analysis Power*Tools shall be used for all power system studies. The Professional shall have a minimum of five years proven experience performing all required power system studies; otherwise, discuss with the University to identify an approved subcontractor. The manufacturer or supplier of the new electrical equipment being studied shall not be used to perform the power system studies.

K.14 RACEWAYS

A. Unless otherwise specifically approved by the University's Senior Electrical Engineer, all new wiring in existing and new buildings shall be concealed.

B. The minimum conduit size aboveground shall be ¾ inch; underground shall be 1 inch.

C. Aboveground, low-voltage conductors shall be installed indoors in electrical metallic tubing (EMT) and outdoors in rigid aluminum conduit except where otherwise required.
   1. EMT shall not be used outdoors, underground, or in concrete slab.

D. Aboveground, medium-voltage conductors shall be installed indoors in rigid galvanized steel conduit (RGS) and outdoors in rigid aluminum conduit except where otherwise required.

E. Medium-voltage pull and junction box covers shall have white lettering on red background tags reading “Danger Medium Voltage __Volts Keep Out.” Fill in voltage as 4160 for Oakland Campus or 12,470 for Bradford Campus.

F. Underground, low-voltage and medium-voltage conductors shall be run in Schedule 40 PVC conduit except under roadways or driveways where conduit shall be Schedule 80 PVC. Underground conduit for site lighting shall be direct buried; all other applications shall be in concrete encased ductbanks. Provide a minimum of one spare conduit per ductbank, equal to or larger than the largest specified size.

1. PVC installations shall incorporate rigid aluminum or fiberglass elbows/90s to prevent burning or damage during cable pull.

G. Compression fittings shall be used for EMT up to and including two (2) inches. On EMT conduits larger than two (2) inches, compression fittings or steel-sleeve set screw fittings shall be used. Die-cast fittings are not permitted.

H. Rigid conduit fittings shall be of the threaded type only.

I. Ductbank installations shall comply with the following requirements.

1. Concrete-encased ductbanks shall have a minimum 5” envelope.
2. All ductbanks, regardless of voltage, shall be provided with a minimum 36” to top of encasement cover and a permanent, magnetically detectable underground warning tape above the buried conduit 6”-8” below finished grade. The tape shall be not less than 6" wide by 4 mils thick and read “Caution buried electric line below” in black lettering on a red background.
3. Where ductbanks cross roads, 2” diameter round red phenolic tags with white arrows center stamped “ELECTRIC” with the manhole designations stamped above and below shall be permanently embedded into the face of the curbs at each end of the crossing directly above the centerline of the ductbank. Manhole designations shall be oriented in the direction of the manholes. Phenolic tag lettering shall be 3/16” high.
4. Where ductbanks terminate into vaults, junction boxes, manholes, or enter a building, the ductbank shall be properly identified by a durable nonmetallic engraved placard mounted adjacent to the ductbank entry point. Permanent, secure installation methods suitable for the mounting substrate shall be utilized. Double-sided stick tape is prohibited. Placard shall be white with ½” black lettering and shall bear the following information:
    5. Point of termination
    6. Quantity and size of conduits
    7. Length of ductbank
    8. Date of installation

    For example:

    TO MANHOLE L8
    (4) 5”C - 125 FEET
    INSTALLED DEC 2023

J. Manholes shall be installed so that top of manhole is 12”-24” below grade. Provide pre-cast collars to place top of manhole cover at grade.

K. With approval of the University’s Senior Electrical Engineer, low-voltage cable marked “For CT Use” installed in cable tray may be used in electrical rooms or switchyards accessible to qualified personnel only.

L. The use of AC or BX cable is prohibited.

M. MC Cable
   1. All conductors shall be run in conduit from the panelboard to a junction box in the room where “MC” cable can be used (i.e., all home runs to be in conduit).
   2. In existing structures “MC” cable may be used in inaccessible ceiling and wall spaces.
   3. MC can only be run from the junction box to a device, no horizontal MC shall be run.
   4. In new construction, lengths shall be limited to 6’-0” maximum to ceiling-mounted luminaires and wiring devices (i.e., whips) and 20’-0” maximum to wall-mounted 20A and 30A circuits/devices; higher rated circuits shall be all in conduit.
   5. “Luminaire” MC cable with purple and gray wire for dimming control is allowed.
   6. All installations of “MC” cable shall be inspected by the University’s Senior Electrical Engineer prior to covering the work with walls, ceilings, etc. The Professional shall verify all other uses of “MC” cable with the University’s Senior Electrical Engineer.
   7. Install MC cable parallel to building column lines. All MC cable shall be independently supported and organized in a neat and orderly fashion per NEC 330 and NECA 1.

N. As permitted by the NFPA and local codes, plenum-rated, riser-rated, and general purpose cable with 300 volt insulation or less may be installed without raceway or in cable tray when used for telecommunications system wiring only. All other 300 volt and less wiring shall be run in raceway or as “MC” cable as required elsewhere in this standard.

O. The use of electrical non-metallic tubing (ENT) shall not be permitted without the written approval of the University’s Senior Electrical Engineer.

P. Insofar as possible, use existing conduits for wiring. Clearly identify existing conduits to be reused and point of connection between existing and new conduits and conductors. If not reusing conduits, include them in demo scope. The Professional shall indicate that exposed raceways, luminaires, panel boards, and other electrical equipment that are no longer a functioning part of the electrical system shall be de-energized, disconnected and removed and all ceiling, wall or floor openings left by this removal shall be patched (fire sealed, if applicable) and painted to match corner to corner.

Q. In existing, inaccessible, finished areas where concealment is impractical, Wiremold, Hubbell, or University-approved equal surface metal raceway (SMR) or surface non-metal raceway (SNMR) shall be used with approval by the University’s Project Manager. Permanent, secure installation methods suitable for the mounting substrate shall be utilized. Double-sided stick tape and self-tapping masonry screws are prohibited.

R. Raceways installed in spaces containing equipment that generates a magnetic field (e.g., X-Ray, MRI) shall comply with the requirements outlined in the equipment’s site preparation guide and the Environmental Health & Safety Magnet Safety Guide #03-005.

S. All raceways shall be supported on a minimum of 8’-0” centers and within 3’-0” of outlet box. “MC” cable shall be supported on 6’-0” centers and within 1’-0” of outlet box.

T. Junction and pull boxes shall be installed such that covers are readily accessible and adequate working clearance is maintained after completion of the installation.

U. Fiberglass conduits shall be used in corrosive or inhospitable environments, i.e. steam tunnels or chilled water vaults.

V. Steam tunnel installations shall also include the following:
   1. All raceways shall be specified to be RTRC fiberglass.

2. Liquid-tight flexible metal conduit shall be permissible to be installed in locations as identified in the Design Manual, however LFMC in steam tunnels shall be extreme temperature rated and UL listed.
3. Concrete anchors, threaded rods, hangers, and other supports shall be stainless steel.
4. Strut hangers for multiple conduit runs shall be either fiberglass or stainless steel.
5. Pull boxes shall be either fiberglass or stainless steel.
6. Device boxes shall be FD type stainless steel.
7. Wiring shall be type XHHW.
8. Penetrations though concrete walls, where applicable, shall be sealed with interlocking EPDM link seals.
9. GFCI receptacles installed in steam vaults shall have the following features.
    a. Weather-resistant
    b. Extra heavy-duty industrial grade
    c. High-impact polyester housing
    d. Corrosion resistant, including:
        i. Nickel-plated face contacts, mounting strap, line/load terminals and terminal clamps,
        ii. Stainless steel screws.
    e. Hubbell #GF5362SG or approved equal. Equal wiring devices shall meet or exceed this performance specification, no exceptions.

K.15 CONDUCTORS

A. Existing conductors over 25 years old shall be replaced; unless reviewed with, and approved by, the University's Senior Manager of Electrical Engineering.

B. All low-voltage building power wire shall be type THHN/THWN 90°C dry/ 75°C wet, 600 volt, insulated stranded copper. Minimum wire size shall be #12 AWG. Solid wire shall not be used. 300 volt insulation can be used for telecommunications and building management system wiring. Wet locations shall use XHHW 90°C dry/ 75°C wet, 600 volt, insulated stranded copper.

C. All electrical wiring passing through an environmental air plenum space shall be approved for such use or shall be installed in metal conduit.

D. Low-voltage conductor ampacities in aboveground raceway shall be as stated in NEC Table 310.15(B)(16) under the applicable column, 60°C or 75°C and shall be derated as necessary per NEC for ambient temperatures and quantity of current carrying conductors.

E. Low-voltage conductor ampacities in underground electrical ductbanks shall be calculated using NEC Annex B application information.

F. Branch circuit wiring shall be color-coded. Black (phase A), red (phase B), blue (phase C), and white (neutral—grounded conductor) shall be used for 208Y/120V systems. Brown (phase A), orange (phase B), yellow (phase C), and gray (neutral—grounded conductor) shall be used for circuits of 4160Y/2400V and 480Y/277 volts. Green shall be used for equipment grounding conductors only. Green with yellow stripe shall be used for isolated ground conductors. For three-way or four-way switches use a color other than those listed for the traveler circuits.

G. Wire Connectors shall be rated for at least 75°C per UL486C.

H. Push in wire connectors are prohibited (except in luminaire disconnects).

I. Underground low-voltage connectors shall be a bolted type with a gel lubricant, for use under water and prevent rust. Gel-filled waterproof wire nuts are also acceptable**.**

J. All medium-voltage power cable shall be 5kV, UL-listed Type MV-105, 105°C, single-conductor, 133% insulation level, copper-tape shielded with the following:

1. Compact stranded, annealed bare copper conductor with an extruded, semiconducting, ethylene propylene rubber (EPR) compound strand screen
2. EPR insulation with a minimum thickness not less than 90% of that specified in ICEA
3. Helically applied bare copper tape over extruded, semiconducting, EPR layer insulation screen
4. Sunlight resistant, black polyvinyl chloride (PVC) overall jacket.

The cable shall be Okonite Okoguard-Okoseal Type MV-105 or equal by General Cable, Prysmian, Southwire or, American Insulated Wire.

K. All medium voltage separable cable splices shall be Elastimold Series 600 Deadbreak separable connectors or equal by Cooper Power Systems, or Prysmian. In manholes, each set of connectors shall be supported with cable support arms.

L. All 5kV stress cones shall be 3M Company Cold-shrink QT-III or approved equal of Elastimold, Cooper Power Systems, or Prysmian.

M. All medium voltage non-separable cable splices shall be 3M Company Cold-shrink QS-III or approved equal of Elastimold, Cooper Power Systems, or Prysmian.

N. After installation, all medium-voltage cable circuits shall be properly identified by a durable nonmetallic engraved tag at every point of access and at both ingress and egress points of manholes and junction boxes. Tags shall be white with black lettering, ¼" in junction boxes and ½" in manholes. Tags shall bear the following information:

1. Circuit voltage
2. Points of origin and termination
3. Length of conductors, including excess length provided for splices and/or terminations
4. Size and number of conductors, including equipment ground
5. Class of insulation
6. Date of installation

For example:

4160V FROM PANTHER HALL SWITCH #390 TO IRVIS HALL SWITCH #336 760 FEET (3) 500KCMIL CU + #4 CU GRD 5kV, 133% INSULATION INSTALLED DEC 2006

O. All medium voltage cables in pullboxes and manholes shall be arc-proofed and fireproofed using a flexible flame and high electric arc-resistant type of tape manufactured for the purpose applied to cables and splice areas. Tape shall be installed in a ½ lap wrap fashion and securely held in place by a random wrapped silicone cloth adhesive tape.

P. A full loop of spare cable length shall be provided around the perimeter of all manholes for each cable passing through. Heavy duty nonmetallic cable racks with a minimum of four cable support arms on each stanchion shall be installed every 3'-0". Stanchions shall reach from 0'-6" above the manhole floor to within 1'-0" below the ceiling. Stanchions shall be

Underground Devices Inc. Type CR and arms shall be Underground Devices Inc. Type RA, 14” or University-approved equal.

K.16 PANELBOARDS

A. Normal lighting and appliance panelboards shall contain a minimum of 42 poles.

B. Emergency lighting and appliance panelboards shall contain a minimum of 24 poles.

C. Normal lighting and appliance panelboards shall have all of their branch circuits on the same floor as the panelboard location.

D. Emergency lighting and appliance panelboards may be located every third floor, depending on panel loading.

E. The number of overcurrent protective devices in power distribution panelboards shall be restricted only to practical physical limitations such as standard box heights and widths.

F. The operating handles of the topmost-mounted devices in all panelboards shall not exceed 6’-6” above the finished floor.

G. For labs, a separate panelboard shall be located in each lab.
   1. For restricted lab spaces like cleanrooms and vivarium, locate the panelboard exterior to the lab.
   2. Review Division P for specific laboratory design standards.

H. Panelboards shall have panel schedules on the drawings as well as matching, typed directories in each panel, reflecting final as built conditions.

I. Panelboards shall be door-in-door construction with hinged front panels and hinged doors. Provide common keying for all panels.

J. Circuit breakers shall be bolt-on type and for lighting branch circuits shall be rated ‘SWD’.

K. The preferred manufacturers for panelboards are Eaton, Square D, Siemens, and ABB.

L. Panelboards shall have copper bus.

M. All new branch circuit panelboards intended for normal or optional standby/research power circuitry shall not exceed 80% of in-use breakers; a minimum of 20% of the total available single-pole spaces in the panel shall be spares. Spare circuit breaker selections shall represent the circuit breaker ratings utilized in the panel. Provide spare breakers to completely fill in all unused spaces.
   1. Example: A 42-pole panel shall contain at least enough spare breakers to fill 9 single-pole spaces.

N. All new branch circuit panelboards intended for life safety/emergency power circuitry shall contain a quantity of available single-pole spaces equal to the number of circuits utilized in the design plus 20% (rounded to the nearest standard size panel). These panels shall be provided with spare circuit breakers equivalent to 10% of the maximum number of single-pole circuits the panel can accommodate.
   1. Example: If a new life safety panel is designed to utilize 18 single-pole life safety circuits, adding 20% spare capacity yields the need for a 22-pole panel. The nearest standard size panel is a 24-pole panel.
   2. Example: A 36-pole panel shall contain at least enough spare breakers to fill 4 single-pole spaces.

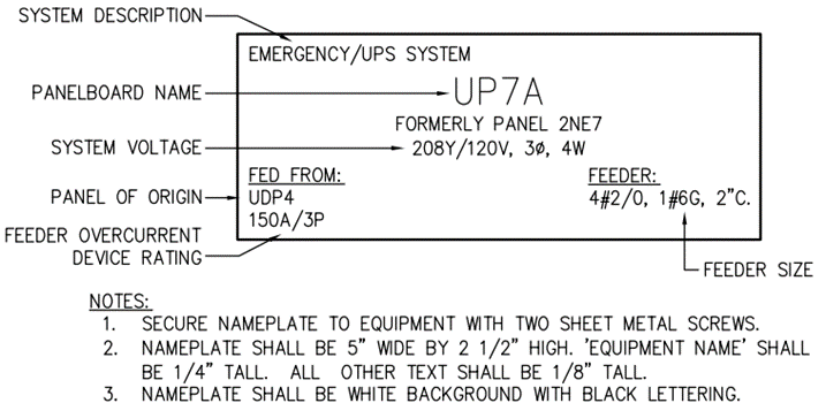
O. All new distribution-type panelboards shall include at least 20% additional bussed space to accommodate spare breakers and provisions (space) for future breakers. The Professional shall provide spare breakers per Section K.24 at their discretion.

P. Any panel over 42 poles shall not utilize the EZ-trim doors unless approved by University's Senior Manager of Electrical Engineering.

Q. Stub a minimum of five empty 1" conduits to an accessible location above the ceiling out of each recessed panelboard.

R. Reference "APPENDIX 1 – ELECTRICAL EQUIPMENT NAMING CONVENTION" for panelboard naming to be used with large renovations and new builds.

S. A permanent, engraved nameplate shall be fastened to all panelboards in accordance with the following detail.



ELECTRICAL EQUIPMENT NAMEPLATE DETAIL

K.17 WIRING DEVICES

A. Manufacturers: Hubbell (Bryant), Eaton (Arrow Hart), Legrand (Pass & Seymour), Leviton or approved equal.

B. Durability: Wiring devices shall be specification grade or better. In locations subject to damage or heavy use, wiring devices shall be heavy-duty type.

C. Convenience receptacles shall be Type 5362, straight blade devices, duplex, 2-pole 3-wire grounding, 20A 125V, NEMA 5-20R.

D. GFCI receptacles shall be Type 5362, straight blade devices, duplex, 2-pole 3-wire grounding, 20A 125V, NEMA 5-20R, UL 943 Listed.

E. Combination USB charger receptacles shall be straight blade devices, duplex, commercial grade, 2-pole 3-wire grounding, 20A, NEMA 5-20R with two USB charging ports (Type A & C) rated at 5 amps and 5 volts DC
   1. Combination USB charger receptacles shall be used in areas with soft seating (e.g. lounges, dorms, etc.).

F. Where used, switches shall be toggle, industrial grade, 20A, 120/277VAC rated, #1221, 1223, and 1224.

G. Cover plates for wiring devices shall be stainless steel finish in unfinished areas, and can be high-impact nylon with color as selected by the Architect in finished areas.

H. Receptacles shall be mounted at 18" A.F.F to centerline. If receptacle is vertical, the grounding pole shall be at the top; if horizontal, the neutral blade shall be at the top.

I. Switches shall be mounted at 46" A.F.F to centerline. Where 3-way switches are used, lights shall be off when all switches are in the down position.

J. Switches shall be installed on the strike side of a door and mounted within 12". Architects/Design Professionals to consider this when designing glass mullions for doorways.

K. All existing device locations which are to be reused shall receive new devices, and new cover plates.
   1. If existing wiring is more than 25 years old, it should be reviewed by the University's Senior Manager of Electrical Engineering before re-use.

L. While-in-use weatherproof receptacle covers shall be used as required by NEC for wet locations, which include but are not limited to outdoor areas and all indoor areas that could be subjected to hose spray.

M. Stranded conductors shall be attached to all wiring device ground terminals with approved crimp-on, insulated fork terminal connectors.

N. Cover-plate-receptacle labels and cover-plate-switch labels shall indicate panel and circuit identification for all receptacles and switches. Durable wire markers or tags shall be used inside wiring device back boxes.

O. Receptacle Colors
   1. Legally-required standby or optional standby receptacles shall be red.
   2. Isolated ground receptacles shall be orange.
   3. UPS-fed receptacles shall be blue.

P. A normal-emergency receptacle shall be provided in any electrical room containing a switchboard, switchgear, or medium-voltage transformer.

Q. Where automatic receptacle control is required by Codes, split duplex receptacles shall be used with the top receptacle controlled and permanently marked "controlled."

K.18 ENGINE-GENERATOR SETS

A. All genset electrical equipment, piping, and ductwork shall be mounted on vibration isolators to minimize transmission of vibration and noise to building structures or spaces.

B. Alarm signals shall be sent to the Campus-wide Building Management System to indicate genset run status, fuel tank low status, and genset trouble alarm. These signals shall be from the generator.

C. Genset design shall include an integral double-walled fuel tank and associated leak detection, venting, piping, and remote filling (if necessary) as well as engine exhaust and cooling/combustion air ventilation systems. Remote fuel fill stations shall be mounted no higher than 4'-0" above finished grade, shall have cam lock couplings to match the University's fuel supplier's hoses, shall include means for locking and have an exterior fill alarm. Fuel gauges shall be provided on all fuel tanks. Readout shall be in gallons. Exhaust

and vent stacks shall terminate a minimum of 12'-0" above finished grade. All indoor mufflers and exhaust piping shall be insulated.

D. Outdoor generators shall have a sound attenuating enclosure that reduces the sound level to not more than 60 dB at the property line. Manufacturers' standard finish paint color shall be specified for new enclosures. When existing enclosures require repainting, the finish paint color shall be Sherwin Williams Lounge Green (SW 6444) card no. 157-C3.

E. The Professional shall provide a listing of all equipment fed by the emergency generator and all calculations used to size the generator and the fuel tank. The fuel tank capacity shall support running the genset at 100% load for 24 hours minimum.

F. A full-load field test shall be performed after the genset installation is 100% complete. Test shall be run by a factory-authorized service company for a minimum of four hours. Provide a load bank as necessary for the testing.

G. Make provisions for the contractor to refill the fuel tank following the load test, before turn over to the University. Also, make provisions for the contractor to refill all generator tanks if existing generators were used to support an extended outage for the contractor.

H. On the Oakland Campus only, the emergency genset fuel shall be diesel only. Natural gas may be used for optional standby gensets.

I. Generators shall be separately excited permanent magnet generator type. The automatic voltage regulator shall be full wave rectified pulse width modulated output type. The governor shall be an electronic isochronous type.

J. Any fuel tanks over 1400 gallons are required to be tested and certified during installation.

K. Life-safety generators shall have a remote annunciator and control panel located in the fire command center per IBC, where applicable.

L. Building generator design shall include one circuit breaker feeding a wireway with emergency distribution disconnects specific to each load type, as needed.

M. Preferred generator manufacturers are Caterpillar and Cummins. Alternates must be approved.

K.19 AUTOMATIC TRANSFER EQUIPMENT

A. The emergency system shall either be 208Y/120 or 480Y/277 volt, three phase, four wire. It shall have one or more open-transition, four-pole, switched-neutral automatic transfer switches (ATSs).

B. A separate ATS shall be provided for legally-required and optional standby loads per NEC. Legally-required and optional standby loads (e.g., research loads, computer labs, server rooms, environmental rooms, fume hood exhaust fans, hot water pumps, building management panels, security panels, elevators, fire pumps, smoke control systems, and telecommunications) shall not be connected to the life-safety emergency system ATS. Closed transition ATSs are permissible for research and laboratory equipment to minimize disruptions during generator testing.

C. The ATS shall have 3-cycle or 30-cycle short circuit withstand ratings that exceed the available system fault current, as determined by the overcurrent protective device coordination study.

D. ATSs shall be contactor type. Circuit breaker type ATSs are not permitted.

E. All ATSs shall have a maintenance bypass isolation switch that allows the transfer switch assembly to be removed for repair or replacement unless written permission by a University Electrical Engineer to omit the maintenance bypass is obtained by the Design Professional.

F. If elevators, motor-generator sets, transformers or other large motors are connected to the generator, the ATS supplying them shall include an in-phase monitor to minimize voltage transients and system stresses and avoid nuisance tripping of the feeder breaker.

G. Alarm signals shall be sent to the Campus-wide Building Management System to indicate ATS is in the emergency position.

H. Loss of normal power, pre-transfer, or other signals required by the elevator controllers for smooth transition between normal and emergency sources shall be provided in the ATS and wired to the elevator controllers.

I. The preferred manufacturers of automatic transfer switches are Russelectric, Cummins, ASCO, and Caterpillar.

K.20 EMERGENCY POWER LOADS

A. New construction projects shall have emergency loads connected to the emergency power system through a dedicated ATS as required by the governing codes. The following equipment in new structures shall also be provided with emergency power whether required or not: fire alarm system, emergency lighting, exit signs, and emergency lighting in electrical and mechanical rooms. A separate ATS shall be provided for the legally-required and optional standby loads.

B. Existing buildings shall only have loads connected to the emergency power system through a dedicated ATS as required by the governing codes or as approved by the University's Senior Electrical Engineer. Load data on existing emergency generators shall be obtained from the University's Electrical Engineer by the Professional. A separate ATS shall be provided for the legally-required and optional standby loads.

C. The following optional-standby loads can only be added with written permission from the University's Senior Manager of Electrical Engineering and must be on a separate ATS if capacity on the generator permits: research loads, computer labs, server rooms, environmental rooms, fume hood exhaust fans, hot water pumps, and telecommunications equipment.

D. The following legally-required and optional-standby loads shall be connected to the generator via a separate ATS even if not required by the governing codes: building management panels, security panels, elevators, smoke control systems, and fire pumps.

K.21 SUBSTATION/SWITCHGEAR

A. Medium-voltage (i.e., 5kV or 15kV) circuit breakers shall be of vacuum draw out type in metal-clad switchgear. AC control with capacitor trip devices shall be used. DC control is not acceptable.

B. Multi-ratio phase current transformers shall be provided in each breaker compartment. In addition, multi-ratio zero sequence current transformers shall be provided in each feeder breaker compartment. All taps shall be wired to a terminal block accessible in the breaker control compartment. Current transformers and voltage transformers shall be wired to separate test switches with shorting blocks and voltage disconnects for each meter.

Protective relays shall be draw out type or have quick disconnect connectors with integral shorting contacts. Cause-of-trip indicators shall be provided on each protective relay.

C. Three potential transformers connected line-to-ground shall be used for voltage sensing on each bus and incoming line. Two voltage transformers connected line-to-line is not acceptable.

D. All breaker statuses shall be hardwired to a terminal strip in a central interface cabinet to be individually wired to the campus-wide Electric Metering system.

E. Each breaker shall have a corresponding electric meter. See section K.23 for meter details. Each meter shall be individually wired to a patch panel in a central interface cabinet for connection to the campus-wide Electric Metering system via Ethernet cable.

F. The preferred manufacturers for medium voltage switchgear are Eaton, Square D, Siemens, and ABB.

G. All protective relays shall be independently powered from an external normal/emergency circuit and a UPS. UPS status shall be hardwired back to the campus-wide Electric Metering system. Relays shall be Schweitzer Engineering Laboratories (SEL) model no. SEL 751.

H. Relay protection shall be designed to meet the requirements of NEC 311.10.

I. Remote racking devices shall be provided to permit the insertion and removal of breakers while the operator is outside the arc flash protection boundary.

K.22 TRANSFORMERS

A. Transformers shall be mounted on isolators to minimize transmission of vibration noise to the building structure.

B. All indoor transformers with a medium-voltage primary shall be dry type, unless there is a space constraint that would dictate a smaller footprint with an oil-filled transformer. All outdoor transformers with a medium-voltage primary shall be oil-filled.

C. All oil-filled transformers shall be FM Approved Code Listed and Labeled, designed in accordance with the requirements of ANSI/IEEE C57.12.00 and labeled by Factory Mutual Research Corporation as meeting the requirements of FMRC Approval Standard Class 3990, insulated with FM Approved less-flammable fluid all in compliance with NEC Sections 110-3 and 450-23, and shall be as follows:

1. Liquid-filled type design
2. Temperature rise of 65°C
3. Primary insulation of 60kV BIL
4. Secondary insulation of 30kV BIL
5. Copper windings
6. Naturally cooled high fire point fluid (KNAN) / Naturally cooled high fire point fluid with future fans (KNAF)
7. Bussed connection to low voltage switchboard where applicable
8. Distribution class lightning arresters
9. Temperature sensors on windings with external alarms tied to the Campus-wide Building Management System
10. Containment pan sized and provided by the manufacturer for indoor transformers. Containment pans cannot be more that 12" from the base surface of the transformer.

11. Pressure sensors with an external alarm tied into the Campus-wide Building Management System

D. The dielectric coolant shall be a listed less-flammable fluid meeting the requirements of NEC 450-23 and the requirements of IEEE C2-1997, Section 15. The fluid shall be non-toxic, non-bioaccumulating, and be readily and completely biodegradable per EPA OPPTS 835.3100. It shall be comprised of edible oils and food grade performance enhancing additives. It shall not require oils derived from genetically altered seeds. It shall be FM Approved and UL Classified, Envirotemp FR3 or University-approved equal. It shall have a minimum open cup flash point of $\geq$ 325°C and a fire point of $\geq$ 350°C per ASTM D92.

E. For all oil filled transformer installations, the Professional and EC shall inspect the transformer connections three months after installation for oil leaks.

F. Medium-voltage dry-type transformers shall be as follows:
1. Ventilated dry-type design
2. Insulation temperature of 220°C
3. Temperature rise of 80°C
4. Primary insulation of 60kV BIL
5. Secondary insulation of 10kV BIL
6. Copper windings
7. Natural air convection (AA) / Future forced air (FFA)
8. Bussed connection to low voltage switchboard where applicable
9. Distribution class lightning arresters
10. Temperature sensors on windings with external alarms connected to Campus-wide Building Management System
11. Infrared thermal inspection windows
12. Minimum impedance:
    a. 750kVA and above: per ANSI/IEEE Standards
    b. Below 750kVA: the Professional shall specify transformer impedance to minimize losses while limiting short-circuit current to 58.5kAIC maximum.

G. Low-voltage dry-type transformers shall be as follows:
1. Ventilated dry-type design
2. Insulation temperature of 220°C
3. Temperature rise of 80°C
4. Primary insulation of 10kV BIL
5. Secondary insulation of 10kV BIL
6. Copper windings

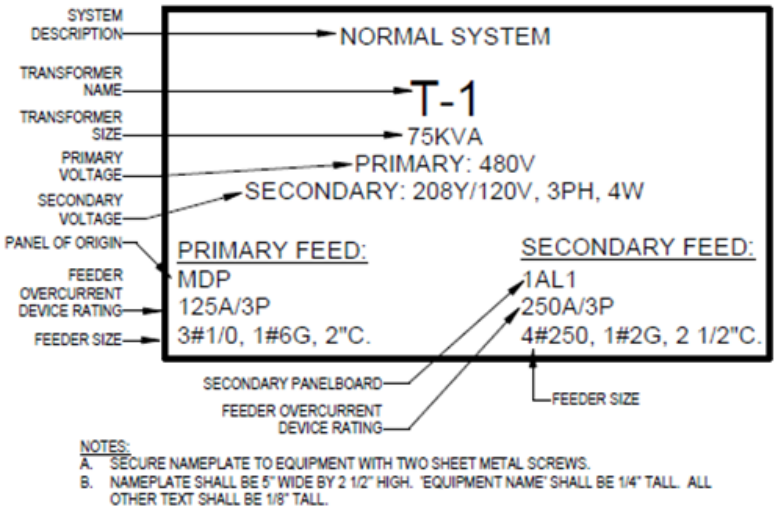
H. Outdoor transformers may be installed only as approved by the University's Senior Electrical Engineer.

I. Transformers shall be furnished with full capacity high-voltage taps. The taps shall be two 2.5% above and below nominal voltage.

J. Fan-assisted convection cooling (NEMA AFA) to achieve base ratings such as that used by GE TransforMore transformers shall not be used.

K. Transformers shall be sized for connected load with demand factors as allowed by NFPA 70 or for existing demand load where trend data is available. Transformer sizing shall also take into consideration planned future loads that may be placed on the transformer. Include 30% spare capacity above the calculated demand load where the possibility for undefined future load addition exists.

L. A permanent, engraved nameplate shall be fastened to all transformers in accordance with the following detail.



TRANSFORMER NAMEPLATE DETAIL

K.23 SERVICE, DISCONNECT, METERING

A. Generally, electrical distribution systems shall be 480Y/277 volt, 3 phase, 4 wire for lighting and mechanical loads and a 208Y/120 V, 3-phase, 4-wire for small power loads.

B. The Main Distribution Panel (MDP) shall have a power meter that monitors the following:
1. Current
2. Voltage
3. Power
4. Energy
5. Frequency
6. Power factor
7. Harmonics (current and voltage)
8. Total harmonic distortion.

C. The MDP meters shall be Square D Powerlogic or equal by Siemens or Eaton, compatible with the campus-wide Electric Metering system and as approved by the University's Senior Electrical Engineer. Each meter shall be individually connected to the campus-wide Electric Metering System via an Ethernet cable.

D. Power meters shall support native BACnet over IP protocol as a standard to communicate across the building automation system. When BACnet is not available, native Modbus may be used only when approved by the University's Senior Electrical Engineer. Media converters and gateways shall not be used to provide a bridge between different protocols and standards.

E. UPS control power shall be provided to all meters on main switchgear/switchboards and shall be fed from an external normal/emergency circuit.

F. A status point from the UPS shall be hardwired to the campus-wide Electric Metering system.

G. Each meter shall have separate shorting blocks for the CT inputs and disconnects for the PT or voltage inputs.

H. Meter types shall be as follows:
1. Utility Mains
   a. Sq D PowerLogic ION 9000
   b. Eaton Power Xpert PXM8000
   c. Siemens 9810.
2. Building Mains
   a. Sq D PowerLogic PM-8240
   b. Eaton Power Xpert PXM4000
   c. Siemens 9410.
3. All Other Applications
   a. Sq D PowerLogic PM-5560
   b. Eaton Power Xpert PXM1000 Series
   c. Siemens 9410.

I. The MDPs shall contain a main circuit breaker and the required branch feeder breakers. Space for future 25% minimum load growth shall be included in all MDPs.

J. The main circuit breaker shall have ground-fault protection only where required by NEC. The main ground-fault protection shall be set at the maximum pickup and time-delay settings permitted by NEC. When main ground-fault protection is required, all feeder breakers shall have ground-fault protection set for proper selective overcurrent protection coordination.

K. All feeder breakers in an MDP shall be metered for kW (kilowatt demand) and kWh (kilowatt-hours) and this data shall be integrated into the campus-wide Electric Metering system.

L. 1600 amperes or greater circuit breaker frame sizes shall be of the metal-enclosed, draw out, low-voltage power circuit breaker type designed to ANSI C37.13, C37.16, and C37.17 and shall incorporate electronic trip units with functions as determined by the coordination study and as required by NEC with cause of trip indicator targets.

M. The main circuit breaker fed from a transformer shall have a separation barrier to protect the rest of the gear from arc flash concerns.

N. The Professional shall submit load calculations for MDPs with demand and diversity factors. All calculations shall be as according to NEC guidelines.

O. The preferred manufacturers for low-voltage switchgear, switchboards, panelboards, busway, transformers, and disconnect switches are Eaton, Square D, Siemens, and ABB.

P. All panelboards, disconnect switches, motor starters, and transformers shall be labeled indicating source of power, voltage, and load.

Q. For buildings with direct utility company service, power factor shall be targeted for 0.95 lagging average minimum without going leading and shall be accomplished with central static or distributed static PF correction capacitors. A harmonic resonance calculation shall be performed and mitigating measures shall be taken if required.

R. No tapered bus shall be used in switchgear, switchboards, distribution boards, etc.

K.24 FEEDER CIRCUIT/BRANCH CIRCUITS

A. Low-voltage distribution overcurrent protection devices shall be molded case circuit breakers. 100 amperes and larger frame sizes shall incorporate full LSI electronic trip units

with adjustable LTPU, LTD, STPU, STD, and INST settings with cause-of trip indicator targets. Electronic trip units shall only be used on smaller frame sizes where indicated by the coordination study for proper selectivity. All trip functions shall be adjustable from the face of the breaker. Trip units that require an external device to program or change are not acceptable.

B. Circuit breakers shall be fully rated; series rating circuit breakers is not permitted.

C. Branch circuit wiring shall include the home run number.

D. Each branch circuit shall have a separate neutral.

E. A separate ground wire shall be provided for every A, B, C phase configuration.

F. Branch/feeder arc-fault circuit interrupters (AFCI), combination type, shall be provided to protect all 120V branch circuits supplying outlets installed in dwelling units except those required to be protected by GFCI.

K.25 MOTORS AND MOTOR CONTROLS

A. Motors ½ through 500 HP shall be NEMA premium efficiency type. Refer to mechanical standards for details.

B. If 480V is available in the building, all motors and mechanical equipment shall be fed from the 480V distribution system.

C. Variable frequency drives (VFDs) shall be used for all fan and pump applications. Refer to mechanical standards for details.
   1. VFD cable (i.e., shielded cable) shall be considered during design to mitigate reflective voltages and other degrading effects of high-speed switching devices that can shorten the lifetime of the motor.

D. Fused switches shall not be utilized for motor overcurrent protection. Instead, circuit breaker combination type motor starters shall be used for motors up to 40 HP (magnetic-only motor circuit protectors on motors 10 HP and above). Motors over 40 HP shall utilize magnetic reduced-voltage autotransformer type starters. All combination motor starters shall include hand/off/auto selector switches. Start/stop momentary pushbuttons shall not be used. Refer to mechanical standards for details.

K.26 SOUND PRESSURE LEVELS

A. The sound pressure levels in electrical equipment rooms (motors, elevators, transformers, etc.) in the equipment spaces shall not exceed 85 DBA on the A scale at any point three (3) feet from the equipment, with all equipment in the room operating in the range of each piece of equipment.

B. Reference the Engine/Generator section for outdoor dB levels.

K.27 SURGE SUPPRESSION

A. Provide a UL 1449, latest edition and revision, “Master Plan” surge-protective and filter system for the protection of AC electrical circuits and equipment from the effects of lightning induced currents, substation switching transients, and internally generated transients resulting from inductive and/or capacitive load switching and other electronic equipment.

B. The surge suppression system shall be comprised of the following:

1. Distribution class arresters at the utility equipment
2. An ANSI/IEEE C62.41 Category "C" surge-protective device (SPD) at the building service entrance
3. ANSI/IEEE C62.41 Category "B" SPDs at critical distribution panels serving sensitive electronic equipment including computer labs, laboratory instrumentation, and optional standby systems;
4. ANSI/IEEE C62.41 Category "A" SPD receptacles in telecommunications MDF and IDF rooms and in areas as directed by the University's Project Manager.

C. SPDs shall be installed in all emergency life-safety power system switchgear, switchboards, and panelboards per NEC 700.8.

D. All SPD devices shall be integral to the switchgear, switchboards, and panelboards to which they are connected.

E. Distribution Class Arresters.
1. Equipment shall comply with ANSI/IEEE C62.11, metal oxide varistor distribution surge arrester requirements.
2. Equipment shall employ metal oxide varistor technology, mounted in polymer housing. Equipment shall be rated 6kV on a 4.16kV distribution system and 15kV on 12.47kV. Equipment shall provide line-to-ground protection. Equipment shall be Cooper Power Systems VariSTAR or University approved equal.
3. Equipment for pad mounted applications shall employ metal oxide varistor technology mounted in pre-molded rubber elbows. Equipment shall be rated 6kV on 4.16kV distribution system and 15kV on 12.47kV. Equipment shall provide line-to-ground protection. Equipment shall be Cooper Power Systems M.O.V.E. Elbow or University-approved equal.
4. Preferred manufacturers are Cooper Power Systems and McGraw-Edison.

F. Category "C" SPD
1. Equipment shall comply with ANSI/IEEE C62.41 (IEEE 587), Category "C" requirements, tested to ANSI C62.45, listed to UL 1449 Second Edition, latest revision, and bear the UL label.
2. Preferred manufacturers are Eaton, Square D, and Siemens.

G. Category "B" SPD
1. Equipment shall comply with ANSI/IEEE C62.41 (IEEE 587), Category "B" requirements, tested to ANSI C62.45, listed to UL 1449 Second Edition, and bear the UL label.
2. Preferred manufacturers are Eaton, Square D, and Siemens.

H. Category "A" SPD
1. Equipment shall comply with ANSI/IEEE C62.41 (IEEE 587), Category "A" requirements, tested to ANSI C62.45, listed to UL 1449 Second Edition, and bear the UL label.
2. Equipment shall be duplex type receptacle, NEMA 5-20R, and shall protect against line-to-line, line-to-neutral, line-to-ground, and neutral-to-ground voltage transients. Receptacles shall have a minimum of two, 130V, 20mm metal oxide varistors (MOV), visible and audible surge status indicators, thermoplastic base, and ivory face. Devices shall not be used to provide "down-stream" protection of other receptacles.
3. Preferred manufacturers are Hubbell, Pass and Seymour, Eaton, and Leviton.

K.28 LIGHTNING PROTECTION SYSTEMS

A. Provide lightning protection system for the protection of University structures from direct lightning strikes.

B. This is an optional system that should be evaluated for inclusion in new construction projects. Evaluation shall be made in accordance with guidelines set forth in NFPA 780, Lightning Protection systems, Appendix H, Risk Assessment Guide. Submit copies of the evaluation for review by the Senior Electrical Engineer.

C. The lightning protection system shall be comprised of air terminals, conductors, ground terminals, counterpoised ground conductor, interconnecting conductors, arresters and other connectors or fittings required to complete the system. All conductors shall be tinned, stranded copper. The lightning protection ground components shall be connected to the electrical service ground. System design shall be in accordance with NFPA 70, National Electrical Code, NFPA 780, Lightning Protection Systems and the LPI-175, Lightning Protection Institute, Standard of Practice. The system shall be LPI certified, and a UL Master Label Certificate shall be provided with the as-built documents.

K.29 OAKLAND CAMPUS – OUTDOOR LIGHTING STANDARDS

A. Unless noted otherwise, exterior lighting fixtures shall be DarkSky Approved or provide equal performance. Fixtures and designs shall minimize up light, glare, light trespass, and blue light output.

B. Correlated color temperature (CCT) of LED light sources installed outdoors shall be 3000K. Any deviation from this requires approval by the University Senior Electrical Engineer.

C. Site area lighting within Historical District shall be Type V LED, pole-mounted traditional luminaires (or Type III with house shields, where necessary), individual photocells, and fuses as manufactured by Lumec or Heritage Casting and Ironworks as follows:

Lumec
Luminaire Cat # L60-006-55W32LED3K-T-GL-C-LE5-UNIV-SF60-PH7-BKTX
Pole Cat # R80-11.5-FS2-TBC1-BKTX
Banner Arms Cat # BAS24(2)-BKTX

Heritage Castings & Ironworks
Luminaire Cat # F146-L-CAC70WLED-120V~277V-3000K-IES3_5-CHY-PCB-RAL9011-TXT
Pole Cat # P440-BC-RAL9011-TXT
Banner Arms Cat # BA1-CMx2-RAL9011-TXT

D. Traditional pole foundations shall be at least 48” deep, 20” diameter with a 1” chamfered edge.

E. Bollards within Historical District shall be LED, as manufactured by Lumec or Heritage Casting and Ironworks as follows:

Lumec
With eye bolts: BOR80-____-120-BCH2-TBC1-BKTX
Without eye bolts: BOR80-____-120-TBC1-BKTX

Heritage Castings & Ironworks
With eye bolts: B833-L2-FPC-LED__W-3000K-120~277V-TYPE_-EB2-RAL9011-TXT
Without eye bolts: B833-L2-FPC-LED__W-3000K-120~277V-TYPE_-RAL9011-TXT

F. Non-lighted bollards within Historical District shall be manufactured by Lumec or Heritage Casting and Ironworks as follows:

Lumec
With eye bolts: BOR80-DSH-BCH2-TBC1-BKTX
Without eye bolts: BOR80-DSH-TBC1-BKTX

Heritage Castings & Ironworks
With eye bolts: B633-B-EB2-RAL9011 TXT
Without eye bolts: B633-B-RAL9011 TXT

G. Traditional bollard foundations shall be at least 36” deep, 20” diameter with a 1” chamfered edge.

H. LED retrofits should be evaluated for replacements in existing luminaires, provided by Lumec or Heritage Castings and Ironworks. All new outdoor lighting shall be LED.

I. Exterior building mounted lighting visible from the street (low lying fixtures) shall be textured bronze trapezoid luminaires, Lithonia WDGE series or approved equal.

J. Exterior building mounted lighting on the roofs (not visible from the street) shall be Lumark XTOR Crosstour LED Series or approved equal.

K. In-ground lighting is not acceptable for any application.

K.30 BRADFORD/TITUSVILLE CAMPUSES – OUTDOOR LIGHTING STANDARDS

A. University Architect is developing new exterior lighting standards for satellite campuses. Below information is for historical purposes only.

B. Walkway Lighting
1. Luminaire Cat # Lithonia KAD-LED 40C 700 40K R3 277 RPUMBAK__04 HS DDBXD
2. Pole Cat # SSA12D4-4R00-BM

C. Parking/Roadway Lighting
1. Luminaire Cat # KAD-320-R4-TB-SPD04-SCWA-DF-LPI DARK BRONZE
2. Pole Cat # SSA20__-4R00-BM or SSA16__-4R00-BM (depending on photometrics).
3. SSA25__-4R00-BM (for the main road).
4. Minimum of 1fc from curb-to-curb.

D. In-ground lighting is not acceptable for any application.

K.31 GREENSBURG CAMPUS – OUTDOOR LIGHTING STANDARDS

A. University Architect is developing new exterior lighting standards for satellite campuses. Below information is for historical purposes only.

B. Walkway Lighting
1. Luminaire: Cooper McGraw-Edison GSM-AM-150-MP-MT-3F-FG-BZ, 150-watt pulse start Metal Halide.
2. Pole: Cooper SSA4T12WFM1, straight aluminum, 12 foot height, 4” square shaft, standard grounding lug and dark bronze polyester powder coat finish machined for one CA40 direct arm.
3. Mounting Bracket: MA1006-BZ

C. Parking/Roadway Lighting
   1. Luminaire: Cooper McGraw-Edison GSM-AM-320-MP-MT-3F-FG-BZ, 320-watt pulse start Metal Halide.
   2. Pole: Copper SSA5T25WFM1, straight aluminum, 25 foot heights, 5” square shaft, standard grounding lug and dark bronze polyester powder coat finish machined for one CA40 direct arm.

D. In-ground lighting is not acceptable for any application.

K.32 JOHNSTOWN CAMPUS – OUTDOOR LIGHTING STANDARDS

A. University Architect is developing new exterior lighting standards for satellite campuses. Below information is for historical purposes only.

B. Walkway Lighting
   1. Luminaire: Eaton Streetworks MPW-AF-U-ASYM-AP-PHOTOCELL
   2. Pole: Valmont 0908-30504TPP2-SBF

C. Area Lighting
   1. Luminaire: LSI Industries, Inc MRM-LED-18L-SIL-FT-UNV-DIM-30-70CRI-MSV-PHOTOCELL
   2. Pole: TBD

D. In-ground lighting is not acceptable for any application.

K.33 LAMPS

A. Incandescent lighting shall not be used unless there is a specific programmatic need; e.g., research. Any applications shall be reviewed and approved by the University’s Senior Electrical Engineer. All incandescent lamps shall be of the energy savings type, rated for 130V.

B. The Professional shall consider maintenance items such as lamp life, lumen deprecation, existing lamp types, accumulation of dirt on lens, lower reflectances of ceiling and walls. Consideration should be given to ease of lamp replacement and overheating of ballasts caused by poor ballast location.

C. Linear fluorescent lamps shall not be used in any retrofit or new installations. Industrial LED strip lights shall be used in all mechanical, electrical and telecom rooms.

D. Linear LED retrofit lamps and drivers shall be Type C, i.e., LED lamp(s) with separate, fixture mounted LED driver.

E. Metal halide, halogen, and high-pressure sodium luminaires shall not be used in any retrofit or new installations.

F. Exit signs lettering shall be RED and shall use LED lamps, not exceeding 3 watts total per luminaire.

G. Edge-lit LED exit signs and self-contained exit signs powered by a radioactive source shall not be used.

H. All similar lamp types shall be obtained through one source from a single manufacturer.

I. Architectural accent lighting shall be minimized and shall only be used where approved by the University’s Senior Electrical Engineer. All accent lighting shall use LED lamps.

J. All LED lamps shall have a minimum color rendering index (CRI) of 80 and shall have the longest commercially available life.

K. Correlated color temperature (CCT) of LED light sources installed indoors shall be 4000K in commercial, educational, and laboratory spaces and 3000K in housing spaces. Any deviation from this requires approval by the University Senior Electrical Engineer. The use of white color tuning luminaires must be approved by the University's Senior Electrical Engineer.

L. Compact fluorescent lamps shall not be used in retrofit or new installations.

K.34 LED DRIVERS

A. The driver or power supply for the luminaire shall be modular and replaceable. All drivers in lighting fixtures installed in hard ceilings shall be accessible from the room side of the fixture. Alternatively, a remote driver shall be provided in an easily accessible location.

B. The driver shall meet the emission standards of IEC EN-61000-6-3 at a minimum. For healthcare and other applications with EMI sensitive equipment, provide drivers that meet more stringent standards as required.

C. The LED luminaire shall have a power factor of 0.90 or greater at all standard operating voltages.

D. The Total Harmonic Distortion (current and voltage) induced into an AC power line by a luminaire shall not exceed 20% at any standard input voltage for an LED Luminaire. The LED luminaire shall comply with ANSI C82.11, or equivalent ANSI LED Standard.

E. The LED Luminaire shall include surge protection to withstand high repetition noise and other interference:

F. The surge protection which may reside within the driver shall protect the luminaire from damage and failure for transient voltages and currents as defined in ANSI/IEEE C64.41 for Location Category A-Low where failure does not mean a momentary loss of light during the transient event.

G. Surge protection performance shall be tested per the procedures in ANSI/IEEE C62.45 based on ANSI/IEEE C62.41 definitions for standard and optional waveforms for Location Category A-Low.

K.35 LIGHTING CONTROLS

A. All exterior lighting shall be controlled by photocells. Photocells shall be placed to provide the optimum "turn on time" for security consideration. One (1) photocell shall be provided for each luminaire and each luminaire shall be individually fused. All photocells shall fail "ON".

B. Multi-levels of switching (dimming) shall be provided, as necessary, in conference or classroom applications.

C. Acceptable manufacturers of digital or networked lighting controls shall be provided by Acuity (nLight/SensorSwitch). Additional manufacturers may be approved by the University's Senior Manager of Electrical Engineering.
   1. Note: Networked lighting controls shall only be used where no other option exists to comply with energy codes.

D. Acceptable manufacturers of digital (24V), non-networked lighting controls shall be provided by Legrand (Wattstopper), Acuity (SensorSwitch), Lutron, or Eaton (Leviton).

E. Acceptable manufacturers of standalone lighting controls shall be provided by Legrand (Wattstopper), Acuity (SensorSwitch), Lutron, or Eaton (Leviton).

F. Wireless lighting controls for special applications may be used only when approved by the University's Senior Electrical Engineer.

G. Wall mounted lighting controls shall be installed on the strike side of a door and mounted within 12". Architects/Design Professionals to consider this when designing glass mullions for doorways.

H. Reference "APPENDIX 2 – LIGHTING CONTROLS MATRIX" for design guidance by space type.

I. Timeclocks shall be used only with approval from the University's Senior Electrical Engineer.

J. Adjustable timer switches, with flicker warning, shall be used in mechanical rooms where air or equipment movement or obstructions make occupancy sensors impractical. Any renovation work that addresses any of these areas shall install automatic control.

K. Main electrical vault lighting shall be on the normal/emergency system and shall be controlled manually (toggle switches).

L. The Professional shall provide a very thorough sequence of operation description on the drawings for all lighting control configurations and integrations. Details shall include occupancy/vacancy mode, manual switch control operation, raise/lower or pre-set scene control, sensor time-out delay to off, average maintained illuminance, high-end trim setting (if dimmable), daylight harvesting details, shades, etc. This sequence of operation will be used to provide a commissioning agent or factory authorized start-up person the appropriate information to properly configure the system.

M. Occupancy/Vacancy Sensor coverage maps shall be shown on a floor plan and submitted for review by the University Electrical Engineers. Occupancy/Vacancy Sensors shall be placed appropriately to eliminate false ons and be suitable for the application or space. Occupancy/Vacancy Sensors shall be ceiling mounted or wall mounted as a wall switch combination device. Occupancy/Vacancy Sensor should not have a pivot-able mounting bracket.

N. Emergency lighting control devices shall be UL924 approved and be equipped for fail safe operation. Emergency lighting control devices shall interface to Fire Alarm System only when required by building codes. Preferred manufacturers include Legrand, Acuity, Philips, Lutron or approved equal.

O. Emergency luminaires and exit signs utilizing battery packs shall not be used except where required by code; e.g., in emergency genset rooms.

P. Dimming, where required by codes or special applications as approved by the University's Senior Electrical Engineer, shall be by dimmable LED Drivers using 0-10V control.

Q. Dimming: where dimming is specified, the luminaire shall be capable of continuous dimming without perceivable flicker over the range of 100% to 1% (or 10% with University Project Manager approval) of rated lumen output. Dimming shall be controlled by a 0-10V signal, unless otherwise noted or specified.

1. Dimming switches and other control system components shall be compatible with the LED driver type.
2. The Luminaire and dimming controls shall produce a smooth change in lumen output, without any visible flicker.
3. The luminaire shall be capable of dimming without any visible change in CCT and color rendition.

K.36 OPTICS

A. Prismatic shielding in troffers shall be 0.125" minimum thickness, Pattern #12, lens. Volumetric or flat-panel LED luminaires are permissible. All lenses shall be diffused.

B. Parabolic louvers shall not be used.

C. Direct/indirect luminaires shall only be used in special applications with the approval of the Senior Electrical Engineer. Direct/indirect optics shall be 80% down light minimum. Direct/Indirect luminaires shall be installed such that the space between the top of luminaire and the bottom of ceiling is 18" or greater.

D. Luminaires utilizing snap-in lenses shall be designed and installed in such a way as to prevent any light leakage around the edges of the lenses.

E. The optical assembly of the LED luminaire shall be constructed so that individual LED images shall not be visible to the occupant.

K.37 LUMINAIRE MANUFACTURERS

A. Every luminaire, ballast/driver, lamp/LED chips, and occupancy/vacancy sensor type shall have three manufacturers and model numbers, each from a different manufacturer's representative, specified. The luminaire line for each manufacturer's representative used shall include every luminaire type specified. Preferred manufacturer's representatives are as follows:
   1. Architectural Lighting Sales, Inc.
   2. Gormley Farrington, Inc.
   3. LaFace & McGovern Associates, Inc.
   4. Repco II, Inc.

K.38 LED LUMINAIRES

A. Each Luminaire shall consist of an assembly that utilizes LEDs as the light source, in addition, a complete Luminaire shall consist of a housing, LED array, and an electronic driver (power supply). Components such as the LED array and driver shall be modular and replaceable without removing the Luminaire.

B. All LED luminaires shall have a CRI of at least 80. Artwork and studio lighting shall be at least 90 CRI.

C. All LED luminaires lifetime measurement criteria shall be based on LM-70, greater than 50,000 at L70. The LED luminaire shall be tested in accordance with LM-79, LM-80 and TM-21.

D. LED luminaires shall include a minimum 5-year warranty on the entire luminaire including the driver.
   1. The manufacturer shall provide a warranty against loss of performance and defects in materials, finishes, and workmanship for the luminaires and all components. Replacement luminaires shall be provided promptly after receipt of luminaires that

have failed at no cost to the University. All warranty documentation shall be provided to the University prior to random sample testing.

2. Failure of the LED light source shall be defined as failure of negligible output of 10% or more individual LEDs within the LED array, bar, etc.

E. The individual LEDs shall be connected such that a failure of one LED will not result in the loss of the entire luminaire.

F. Each luminaire shall be listed with a nationally recognized testing laboratory (including but not limited to UL, CSA, ETL) under UL1598, and UL 8750, or an equivalent standard from a recognized testing laboratory.

G. Electrical connections between normal power, driver and LED boards must be modular utilizing a snap fit connector. All electrical components must be easily accessible after installation from the room side and all electrical components must be able to be replaced without removing the fixture from the ceiling.

H. Each luminaire shall have the manufacturer's name, trademark, model number, serial number, date of manufacturer (month-year), and lot number as identification permanently marked inside each unit and the outside of each packaging box: Design Consultant to verify.

I. The following operating characteristics shall be permanently marked inside each unit: rated voltage and rated power in watts and volt-amperes.

J. Before any customer design qualification testing is performed, the sample luminaires shall be energized for a minimum of 24 hours, at 100% on-time duty cycle, at a temperature of +70°F (+21°C).

K. To accommodate future maintenance and ensure availability of direct replacements, no luminaire shall be less than 6" wide, unless approved by the University's Senior Electrical Engineer. Non-compliant fixtures must be submitted to the University for approval prior to the DD submission.

L. Volumetric luminaires shall have a full door (hinged); physical baskets are not permitted.

M. All metal parts to be chemically treated with a rust resistant phosphatized solution, internal components and reflecting surfaces to have a factor of minimum 90%.

N. All luminaires shall be painted after fabrication.

O. Provide luminaires, completely factory-assembled and wired and equipped with necessary light sources, drivers, wiring, shielding, reflectors, channels, lenses, etc., and deliver to the job ready for installation.

P. LED troffers shall have a hinged frame, either via a piano style or die-formed steel T-hinges along with two positive cam latches. All components of luminaires shall be accessible from below the finished ceiling except flat-panel LED luminaires where used in ACT applications.

Q. Provide a minimum of two support points for all surface, pendant or recessed mounted luminaires. The supports shall be tied to the building structural system. The support points shall be totally independent of the ceiling system and support structures of other building systems.

K.39 QUALITY OF ILLUMINATION

A. The latest published standards from the Illuminating Engineering Society shall be used as a standard for lighting levels. Provide a spreadsheet showing all room names and numbers along with target illumination levels.

B. A photometric layout and occupancy coverage map shall be provided with the DD submittal.

C. In offices and classrooms, the maximum to minimum ratio shall never be greater than 2:1.

D. Maximum Luminance Ratios for Offices containing Visual Display Terminals (VDTs)*:
1. Between paper-based visual tasks and an adjacent VDT screen .....3 to 1
2. Between a visual task (paper or VDT) and adjacent dark surroundings .....3 to 1
3. Between a visual task (paper or VDT) and adjacent light surroundings.....1 to 3
4. Between a visual task (paper or VDT) and more remote dark surfaces .....10 to 1
5. Between a visual task (paper or VDT) and more remote lighter surfaces.....1 to 10

*The luminance of the VDT is the average luminance of a character-filled screen.

K.40 FIRE ALARM SYSTEM

A. All renovation projects that require the removal or relocating of fire alarm devices shall replace the smoke detectors (if any) within the scope of work. New smoke detectors shall match existing systems.

B. Fire alarm systems shall be designed in accordance with NFPA 72, Standard for the Installation, Maintenance, and Use of Fire Protective Signaling Systems; NFPA 72-E, Standard on Automatic Fire Detector; NFPA 72-G; Guide for the Installation, Maintenance and Use of Notification Appliances for Protective Signaling Systems, IBC, IFC, ADA and all local codes.

C. The fire alarm system shall be an addressable type with individual address for each initiating device. All addressable devices shall be labeled with the address in a visible location on the device, so that the device does not have to be removed to view the address.
1. Notification devices shall not be addressable (e.g., TrueAlert addressable notification appliances and speakers.)

D. The fire alarm systems shall be connected to normal/emergency power. Battery backup shall be provided in the fire alarm control panel in accordance with the NFPA.

E. All fire alarm cable shall be installed in raceway. The use of MC cable for fire alarm wiring is prohibited.

F. Minimum wire size for the fire alarm system strobes shall be # 14 AWG, type THHN. Data and speaker cable shall be per the manufacturer's recommendation. All conductors shall be solid (or as recommended by the manufacturer).

G. A consistent color code shall be used for the fire alarm system conductors throughout the installation. When tying into existing systems, the existing color code shall be matched.

H. The control panel shall contain trouble, supervision, and alarm contacts that are input into the Campus-wide Building Management and Security Systems.

I. Control panels shall be of modular design for ease of expansion and contain built-in surge suppressors.

J. Manual pull stations shall be double-action with key lock reset. Manual pull stations shall not have a glass rod or glass plate which must be broken to activate the system.

K. An annunciator panel shall be installed in a public area acceptable with local authorities so that a visual indication of the activated zone can be easily identified.

L. In finished areas where surface mount devices are necessary, a factory-finished back box shall be used for audio/visual notification appliances. Color of back box and notification appliance shall match.

M. The control panel shall contain contacts to tie into monitoring systems as follows:
1. Oakland Campus: Guardian Remote Supervising Station using the following DACT components:
    a. (1) Bosch Radionics D7412G Panel, Version 2 (or newer)
    b. (1) Bosch D8109 Fire Enclosure (16” x 16” x 3.5”)
    c. (1) Bosch D8004 Transformer Enclosure (20A 125V Red Duplex req.)
    d. (1) Radionics D928 Dual Phone Line Switcher
    e. (1) Honeywell HWF2-COM Series dualpath IP/cellular communicator
        i. Requires data port (w/ activation and phone number assigned by Pitt IT) and N/E receptacle
    f. (2) Amseco XT-1640 Transformers
    g. (3) 12CE75 Batteries (Powersonic PS-1270, Rechargeable Sealed Lead-Acid)
    h. (1) Battery Harness.
2. Bradford Campus: Simplex Monitoring System located in the campus police station.
3. Greensburg Campus: The monitoring system located in McKenna Hall as well as Integrated Systems, Inc., West Mifflin, PA.
4. Johnstown Campus: The Honeywell monitoring system located in Biddle Hall.
5. Titusville Campus: The monitoring company is Unicom Protection Company.

N. A certificate of compliance shall be competed for each system in accordance with NFPA 72.

O. The contractor shall test each device in a fire alarm system and document said test in a printout showing compliance with specifications and that each device has been tested. This document shall be provided with the Operation and Maintenance Manual. All testing shall be witnessed by University personnel or their designee.

P. Fire alarm testing shall occur only after the fire alarm system has been completely installed and all integrated building components are ready for testing. Integrated building components that must be functional prior to fire alarm testing may include the Building Management System, fire suppression systems, fire pump, fire doors, smoke dampers, smoke control systems, air handling units, elevators, and fire command center, as applicable.

Q. The fire alarm drawings shall graphically depict the fire alarm zones. All devices shall have their addresses shown on the drawings and clearly marked on the devices in the field.

R. The fire alarm supplier shall update their construction drawings to reflect the installed conditions (these are NOT the drawings supplied by the professional). These updated drawings shall be part of the Operation & Maintenance Manual supplied for the fire alarm system.

S. Strobe lights shall be provided in spaces as required by the Americans with Disabilities Act Guidelines.

T. Voice alarm systems shall be used (regional campuses may use tone alarm systems at their Facilities Management Department’s discretion where not required by code). The Professional shall delineate the speaker placement and wiring requirements to assure

correct annunciation of an alarm signal to the affected zone(s). Where horizontal zoning is used, speakers shall be appropriately zoned to allow distribution of multiple messages. Stairwells shall not be included in horizontal zoning, but instead, shall only alarm for “all-building” alarms; e.g., main flow switch.

1. Fire pump running shall not be used as an alarm signal but rather as a trouble signal.

U. For the Oakland Campus, the following mass notification system shall be used.

1. Two intelligent addressable modules (IAMs) shall be provided for inputs from the security system: one for emergency evacuation and one for security lockdown.
2. The emergency evacuation message shall be as follows: TONE 900Hz (Siemens) or 1000Hz (Simplex), two pulses per second with strobe light activation followed by audible message. Runs until manually reset or silenced locally: “May I have your attention please. A security alert has been reported. Please leave the building by the nearest exit. Do not use the elevators.”
3. The security lockdown message shall be as follows: CHIME with temporary strobe light activation followed by audible message repeated for 30 seconds (to complete three full loops); then again every hour until manually reset. Audible and strobes will stop after each 30 second notification until repeated: “May I have your attention please. A security emergency has been reported. Remain in the building. Stand by for further instructions.”
4. All notification device cover plates shall be blank or have the word "ALERT;” i.e., the word “fire” shall not appear.

V. In stairwells, notification devices shall be programmed with visible and paging functions only, i.e., audible alarms shall not be broadcast in stairwells.

W. The Professional shall use a computer-based design program or acoustic measurements combined with the knowledge of the specified speakers’ performance characteristics, using mathematical formulas developed for the purpose, to design the audio/visual notification appliance layout.

X. A fire alarm central command station shall be provided for high-rise buildings in accordance with the IFC and NFPA 72. Locating central command station in the lobby requires approval of the authority having jurisdiction.

Y. Smoke and heat detection systems (including duct detectors to shut down fans) shall only be used where required by codes. If required, smoke detectors shall be photoelectric type with alarm verification. When required by codes, smoke detectors shall be used in public areas and heat detectors shall be used in areas such as mechanical rooms, kitchens, and storage rooms where dust or smoke can be present under normal working conditions. Combination smoke/heat detectors shall not be used. The Professional shall include smoke and heat detector coverage circles or other spacing criteria on the plans to demonstrate complete coverage. If duct detectors are required, provide remote indication in a location close to the detector and visible from floor.

Z. Fire alarm systems shall include elevator recall even where the elevator controllers in existing buildings do not have recall capabilities. In that case, provisions shall be made to connect the fire alarm recall to a future upgraded elevator controller.

AA. The Professional shall include a sequence of operations presented on the drawings as an input/output matrix per NFPA 72, Annex A.

BB. Fire alarm systems shall be Siemens Cerberus PRO, Johnson Controls Simplex, or Edwards Fire Safety (Titusville Campus only). Fire alarm system vendors who materially

participate in the fire alarm system design shall not be eligible to bid on the construction contract.

CC. The University Office of Risk Management, Environmental Health and Safety, and Liberty Mutual (the University's insurance carrier) will review and comment on all fire alarm progress design documents and shop drawings. The University Project Manager will direct the Professional as to the incorporation of these comments.

DD. Tamper and Flow switches shall each have their own individually addressable modules.

EE. A fire prevention plan shall be included as part of the construction documents for review as required in Division B. The project-specific plan is to be developed by the Contractor/Construction Manager.

FF. If multiple companies act as manufacturer's reps for the same manufacturer (e.g., Siemens), they must provide a fire alarm system that is available to all of the manufacturer's reps. A fire alarm system that is proprietary to only one of the reps is not acceptable.

K.41 EMERGENCY RESPONDER COMMUNICATION ENHANCEMENT SYSTEMS (ERCES)

A. When required by the AHJ, the University shall engage a third-party consultant to perform an emergency responder radio coverage study to determine if an ERCES is necessary. The consultant will be tasked with testing for the following frequencies:

Channel	RX	PL	TX	PL	Freq.
PGH POL 3	453.400	186.2	458.400	186.2	25.0 kHz
PGH FIR 1	453.700	186.2	458.700	186.2	25.0 kHz
PGH FIR 2	453.850	186.2	458.850	186.2	25.0 kHz
PGH OPS	453.450	186.2	458.450	186.2	25.0 kHz
PGH EMS 1	462.950	100.0	467.950	100.0	25.0 kHz
PGH EMS 2	462.975	100.0	467.975	100.0	25.0 kHz
UNIV PGH POL	453.150	103.5	458.150	103.5	25.0 kHz

B. The electrical design shall provide raceway, grounding, power, fire alarm, and BAS provisions for the installation of an ERCES system, which may include (but not be limited to):

1. Two (2) emergency life safety circuits at the ERCES master panel location (typ. located on highest floor)
2. Five (5) fire alarm supervisory monitor modules for antenna failure, trouble, power loss, charger trouble, and low battery
3. 2" conduit sleeve from rooftop to ERCES master panel for cabling to antenna mast
4. Ground connection for antenna mast and associated lightning arrester
5. Conduit sleeves between floors and through fire and/or smoke barriers for antenna cabling
6. Outlet box for ERCES status annunciator in Fire Command Center with raceway path to ERCES master panel.
7. Wiring from general alarm and trouble aux contacts in the ERCES panel to the BAS panel.

K.42 SECURITY SYSTEM

A. The Professional, under the guidance of the University's Project Manager, shall coordinate all security systems with the University of Pittsburgh Police Department Integrated Security Division.

B. Door lock releases shall be tied into fire alarm systems as required by codes.

K.43 TELECOMMUNICATIONS SYSTEM

A. The Professional, under the guidance of the University's Project Manager, shall coordinate telecommunications systems with the University Computing Services and System Development Division (refer to Division L Pitt IT Specifications).

K.44 INSTRUCTIONAL EQUIPMENT

A. The Professional, under the guidance of the University's Project Manager, shall coordinate the power, control, and lighting requirements for instructional equipment with the University Center for Teaching and Learning (Teaching Center). Instructional equipment includes but is not limited to the following: projection, reproduction, imaging, sound, photography, film, and television.

B. Electrical design shall comply with the requirements outlined in Division N Classroom and Lecture Hall Design standards.

K.45 ELECTRICAL ACCEPTANCE TESTING

A. Field acceptance testing shall be performed according to recommendations of the InterNational Electrical Testing Association (NETA), NEMA, ANSI, IEEE, and the manufacturer's instructions. The acceptance testing shall include verification of electrical and mechanical integrity as well as functional performance.

B. The following systems and equipment shall be included as a minimum in the testing program:
   1. All medium-voltage (over 600V) electrical equipment, including cable systems and motors
   2. Main electrical service switchboard or switchgear
   3. Grounding system
   4. Emergency and optional standby systems (gensets and ATSs)
   5. Fire alarm system. (All devices)
   6. Motor starters and VFDs
   7. UPSs
   8. Lighting control systems.
   9. The Professional shall determine if additional systems or equipment should be tested. The cost of testing should be justified by the avoided cost of an unscheduled failure or its impact on personnel safety and the mission of the facility.

C. Proposed test procedures and report forms shall be submitted for review in advance of testing.

D. Testing shall be performed by a testing company that is professionally independent of the installers of the equipment or systems being evaluated. Manufacturers' service organizations or similar factory-authorized service companies, including ABM, Square D, Eaton, and HVM, are acceptable. The name of the proposed testing organization shall be submitted to the University's Senior Electrical Engineer for approval.

E. The testing personnel shall have National Institute for Certification in Engineering Technologies (NICET), NETA, or equivalent certification and a minimum five years' experience in testing the specific types of equipment.

F. The Contractor shall be responsible to hire, supervise, and assist the independent testing company, and correct all problems identified.

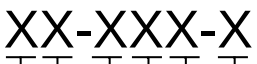
G. Tests on medium-voltage cable shall consist of a non-destructive dielectric test of the insulation of the cable system. Tests shall be performed after all splices and stress cones have been completed to fully test the installation. A Very-Low-Frequency (VLF) AC highpot cable tester shall be used in accordance with IEEE 400.2. DC hipot testers shall not be used. The VLF test voltage shall be 10kV for new 133% insulation level, 5kV cable and 7kV for existing 5kV cable.

H. When replacing any three-phase electrical equipment, perform phase rotation check and record rotation and cable marking before removing existing conductors. After equipment replacement and prior to energizing any load, perform phase rotation check and confirm that rotation matches that of the original equipment. For medium voltage equipment and buildings' main unit substations, both the initial and final phase rotation checks shall be reviewed and approved by either the University's Electrician Foreman or Senior Electrical Engineer before proceeding. Immediately after load is energized, confirm that affected gensets shut down, elevators are operational, and motor rotation is correct.

I. Completed test reports shall be submitted for review prior to placing equipment in service and shall identify "as found" and "as left" conditions.

APPENDIX 1 – ELECTRICAL EQUIPMENT NAMING CONVENTION

The below naming convention should be used for all new builds and complete renovations (i.e., full guts); it should be considered when performing other large renovations.



1. **Building Floor**
   - SB Sub Basement
   - B Basement
   - G Ground floor (as needed)
   - 1 First floor
   - M Mezzanine (as needed)
   - 2 Second Floor
   - …
   - P Penthouse
   - R Roof
2. **Building Area (optional, only as required)**
   a. Not beneficial when naming panels based on quadrants of a drawing (e.g., A, B, C, D) in new construction or large renovations. Once building is constructed or renovations are complete, this quadrant breakdown is not known/used.
   b. This naming option may be beneficial if equipment is located within a specific space on the floor (e.g., lighting closet “F”).
3. **Equipment Type**
   - D Distribution Panel
   - <blank> Branch Panel
4. **Voltage**
   - H 480Y/277V
   - L 208Y/120V
5. **Panel Sequence**
   1, 2, 3, etc.
6. **Source/Load Type**

N	Normal	Fed from normal distribution
LS	Life Safety	Fed from LS ATS distribution
LR	Legally Required	Fed from LR ATS distribution
OS	Optional Standby	Fed from OS ATS distribution
NE	Normal-Emergency	For existing buildings with blended normal-emergency types
UP	UPS	Fed from a UPS
RE	Research	Specifically fed from research generator/ATS. This may include both lab panels as well as mechanical equipment panels.
E	Emergency-Only	For existing buildings with remaining emergency-only panels or generator power distribution panels

Examples:

7B-DH1-N	Seventh floor, electrical riser closet “B”, distribution panel, 480Y/277V, panel sequence 1, normal power
1-L3-LS	First floor, branch panel, 208Y/120V, panel sequence 3, life-safety power

APPENDIX 2 – LIGHTING CONTROLS MATRIX

Interior Lighting Controls						
Space Type	Lighting Controls System Type	Manual Controls	Automated Controls	Time-Out Settings	Remarks	IECC 2018
Egress Corridors	Line Voltage	None	Automatic On	15 minutes	Ceiling and/or Corner Mount Dual Technology Occupancy Sensors	C405.2 Exception 2
Entry Vestibules/Lobbies	Line Voltage	None	Automatic On	10 minutes	Ceiling and/or Corner Mount Dual Technology Occupancy Sensors	C405.2 Exception 2
Open Laboratories	Line Voltage	None	Automatic On	10 minutes	Ceiling Mount Dual Technology Occupancy Sensors. Refer to Division P in University Design Manual.	C405.2.1.1 (2) Exception
Private Laboratories	Line Voltage	On/Off	Automatic On	10 minutes	Ceiling Mount Dual Technology Occupancy Sensors. Refer to Division P in University Design Manual.	C405.2.1.1 (2) Exception
Lecture Halls (w/ Stairs)	Line Voltage	On/Off + Dimming	Automatic On	10 minutes	Ceiling Mount Dual Technology Occupancy Sensors w/ 0-10V Manual Dimming Control. Refer to Division N in University Design Manual.	C405.2.1.1 (2) Exception
Library General Spaces	Line Voltage	None	Automatic On	15 minutes	Ceiling Mount Dual Technology Occupancy Sensors	C405.2.1.1 (2) Exception
Loading Docks	Line Voltage	None	Automatic On	10 minutes	Ceiling and/or Corner Mount Dual Technology Occupancy Sensors	C405.2.1.1 (2) Exception
Open Office	Line Voltage	On/Off	Automatic On	10 minutes	Ceiling and/or Corner Mount Dual Technology Occupancy Sensors	C405.2.1.3
Restrooms	Line Voltage	None	Automatic On	15 minutes	Ceiling Mount Dual Technology Occupancy Sensors	C405.2 Exception 2
Egress Stairwells	Line Voltage	None	Automatic On	5 minutes	Luminaire should be furnished with an integral sensor that dims to 10% after time-out	C405.2 Exception 2
IT Closets	Line Voltage	On/Off	Countdown Timer	Selectable	Wall Mount Timer Switch w/ Flicker Warning. Refer to Division L in University Design Manual.	C405.2.2.1 Exception 2.3
Mechanical Rooms	Line Voltage	On/Off	Countdown Timer	Selectable	Wall Mount Timer Switch w/ Flicker Warning	C405.2.2.1 Exception 2.3
Custodial Closets/Storage Rooms (up to 15' x 15')	Line Voltage	On/Off	Manual On/Auto Off	5 minutes	Wall Mount Line-voltage Dual Technology Vacancy Sensor	C405.2.1.1
Library Study Rooms	Line Voltage	On/Off	Manual On/Auto Off	10 minutes	Wall Mount Line-voltage Dual Technology Vacancy Sensor	C405.2.1.1
Private Office (up to 10' x 10')	Line Voltage	On/Off + Dimming	Manual On/Auto Off	10 minutes	Wall Mount PIR Vacancy Sensor w/ 0-10V Manual Dimming Control	C405.2.1.1
Classrooms	Low Voltage	On/Off + Dimming	Manual On/Auto Off	10 minutes	Ceiling Mount Dual Technology Vacancy Sensors w/ 0-10V Manual Dimming Control. Refer to Division N in University Design Manual.	C405.2.1.1
Computer Labs	Low Voltage	On/Off	Manual On/Auto Off	10 minutes	Ceiling Mount "Small Motion" Dual Technology Vacancy Sensors	C405.2.1.1
Conference Room	Low Voltage	On/Off + Dimming	Manual On/Auto Off	10 minutes	Ceiling Mount Dual Technology Vacancy Sensors w/ 0-10V Manual Dimming Control	C405.2.1.1
Large Meeting/Conference Spaces	Low Voltage	On/Off + Dimming	Manual On/Auto Off	10 minutes	Ceiling Mount Dual Technology Vacancy Sensors w/ 0-10V Manual Dimming Control	C405.2.1.1
Lounges	Low Voltage	On/Off	Manual On/Auto Off	10 minutes	Ceiling Mount Dual Technology Vacancy Sensors	C405.2.1.1
Private Office (> 10' x 10')	Low Voltage	On/Off + Dimming	Manual On/Auto Off	10 minutes	Ceiling Mount Dual Technology Vacancy Sensors w/ 0-10V Manual Dimming Control	C405.2.1.1
Electrical Closets	None	On/Off	None	N/A	Toggle Switch	C405.2 Exception 1

General Remarks:

1. Lighting controls applications shall be in compliance with IECC/ASHRAE 90.1 standards under the latest Uniform Construction Code approved by Pennsylvania Labor & Industry, and (where applicable) with LEED. The more stringent requirement shall apply to the design.
2. For spaces that require Low Voltage lighting control devices as noted in the table above, the preference is to utilize 24V, non-networked devices (e.g. SensorSwitch in lieu of nLight) where the application requires two or fewer lighting zones/power packs. Networked lighting controls shall be utilized for solutions requiring more complex controls such as three or greater lighting zones/power packs. For project areas with greater than six independent networked lighting controls systems, contact the Senior Manager of Electricial Engineering to discuss the option of providing a centralized lighting control panel for ease of operations and maintenance.
3. Spaces requiring ceiling occupancy/vacancy sensors follow the assumption that the devices can be surface- or pendant- mounted to a height of approximately 12'-0" or less. Coordinate automated lighting controls for high-bay applications with the Senior Manager of Electrical Engineering.
4. Provide automatic daylight dimming controls as required per IECC 2018 C405.2.3 or applicable LEED requirements.