SECTION 16010 – "BASIC ELECTRICAL REQUIREMENTS"

In addition to the requirements previously presented herein, each specification shall contain the following general information:

1.0 General:

A. Incorporate, by reference, Division 1 into Division 16.

B. Define the contractors and subcontractors covered by Division 16.

2.0 Laws, Ordinances, Regulations and Requirements:

A. State that all workmanship must conform to all pertinent laws, ordinances and regulations of all bodies having jurisdiction.

B. Identify all references.

C. State which standards apply: ASTM, NEC, NFPA, UL, NETA, etc by Title and Standards Number.

3.0 Tests:

A. Define the Contractor's responsibility for execution, notification, documentation of results, and witnessing.

B. Define, in detail, the factory and field tests required as part of the contract. As a minimum, factory acceptance tests shall be required for generators, transformers, UPS, switchgear, paralleling switchgears. Field acceptance testing shall be completed in accordance with International Electrical Testing Association Inc. (NETA) Acceptance Testing Specifications.

C. The Contractor shall be required to perform an infrared thermographic inspection of all current carrying equipment and connections per NETA Standards, six months after beneficial occupancy, and provide a report to the Owner. The inspector shall be Level III certified in infrared testing by the American Society of Nondestructive Testing (ASNT).

D. A commissioning plan shall be provided for electrical systems. See Section 15010, 3.A. for requirements.

4.0 Instructing Owner's Personnel:

A. Require the contractor and manufacturers' agent to fully instruct the representatives of the University in all details of operation of the equipment installed under his contract.

B. Each contractor shall be directed to provide three (3) copies of printed instructions in separate hardback, three-ring loose-leaf binders and an electronic copy in Adobe or other acceptable format. The instructions shall be prepared by section and contain detail operating and maintenance data including wiring and piping diagrams. Each section shall be labeled and include detailed parts list data and the name, address and phone number of the nearest supply source. The manuals must provide all the information required to run the building efficiently.

C. The manufacturer's spec. sheets, if generalized in any way, will be clearly marked to show exactly which item has been supplied, and the job designation for that item will be noted on manufacturer's specification sheet which includes all details for this unit.

D. If there are differences between pieces of equipment, then include a specification sheet for each, properly marked.

E. Include control diagrams, single-line diagrams, interconnection (point to point) wiring diagrams, sequence of operations, and service instructions.

F. Provide one section for preventive maintenance procedures (recommended materials and procedures, frequency, etc.).

G. Include Contractor's phone numbers and any other reference required to obtain warranty service.

5.0 Mechanical-Electrical Coordination:

A. Include an article which clearly defines the extent of responsibility between the mechanical and electrical contractors regarding equipment which involves the work of both trades.

B. Require coordination drawings among all trades.

6.0 Description of Work:

A. Include a description of the scope of work highlighting all major systems.

7.0 Shop Drawings:

A. Each shop drawing submitted shall be identified by the following:

1. Project Name
2. Specification Section
3. Drawing Numbers
4. Shop drawing data shall include but not be limited to:
   a. Manufacturer's catalog designation.
   b. Complete data and wiring diagrams.
   c. Dimensions, capacities, ratings, weights, materials, finishes, and storage conditions.
   d. Recommended installation procedures, performance, and conditions of performance, testing, and certifications if required.

5. Each submittal shall be required to bear the review stamp of each contractor associated with the processing of the document. The processing of shop drawings shall follow contractual relationships between the Prime Contractor and all Subcontractors.
6. Shop drawings which require coordination of two or more trades shall be required to bear the stamp of the coordinating trades.

8.0 Record Drawings

A. The specifications must define the requirements for the record drawings. At a minimum, these drawings must identify locations and size of all major raceway systems; locations of all devices; updated panel schedules, equipment locations; substitutions; depth of ductbanks, routing of duct banks. Also record on as-built drawings the dimensioned locations of other piping systems where they cross underground electrical duct banks. Provide digital pictures of duct bank crossings with other piping systems and at building entrances.

C: Require an electronic file of drawings in a version compatible with current University CADD software.

9.0 Sleeves:

A. The specificationsand drawings must define and detail the installation of grouting and waterproofing of sleeves and fireproofing, if necessary.

B. Each through penetration fire-rated sealant shall be located on as-built drawings and identified by UL directory file number.

10.0 Contract Drawings: The following applies to the preparation of drawings:

A. All Division 16 drawings will be labeled as follows: E-1, E-2, etc.

B. Separate sheets must be used for plans, details, schedules, single line diagrams, and risers.

C. Standard University details must be used where applicable.

11.0 Additional Design Considerations:

A. All primary (high voltage) main breakers installed on the campus will be monitored (amperes and breaker status) from the centrally located Operations Control Center.

B. Coordination of the design for the location of all floor and wall openings, lintels, equipment pads, etc. is the responsibility of the professional engaged to design the system which penetrates the floor, wall or roof.

C. The following is a list of prohibited installations:

1. Armored Cable. (Type AC)
   C: (MC cable with insulated internal ground wire is acceptable.)
2. Aluminum wires and cables.
3. Aluminum bus duct.
4. Aluminum windings in transformers and motors.
5. Plug-on twin breakers.
6. Aluminum bus in panelboards or switchboards.
7. Underslab/inslab conduits.
8. Direct burial of underground cable.

D. All equipment must be installed on raised concrete pads. Pads shall be a minimum of 4 inches high.

E. Work sequence required to accommodate Owner's occupancy requirements must be described.

F. Temporary work required to facilitate construction or Owner's occupancy requirements (i.e. maintenance of service) must be identified. Work and connections requiring interruption of services shall be identified and coordinated with Owner and performed only with prior written approval of Owner. Seven-(7) days prior notice of service interruption is required.

G. The A/E shall demonstrate that electrical equipment is able to fit in space allotted with required clearances. Also demonstrate that equipment removal paths from the building are defined.

12.0 Power System Study:

A. A power system coordination and short circuit study shall be performed. Provide a system fully coordinated. A complete short circuit protection and coordination study shall be prepared to denote actual items of equipment proposed to accomplish the required degree of coordination between protective devices from the external source feeding the building through all internal switchboards and panelboards. The study shall provide the time-current characteristic curves of protective devices set by the Utility Company, and medium voltage substations. Define exact limits that must be included in the study. Study shall also evaluate withstand ratings of passive equipment such as bus duct, automatic transfer switches, contactors, and safety switches.

B. The minimum interrupting rating of 15KV class switchgear shall be 500 MVA.

C. The professional shall design the system for power factor correction to 95 percent.. Capacitors should be placed locally at motors 20 HP and above, except for motors fed from VFDs. In addition, secondary automatic power factor correction capacitors shall be provided to further correct to 95 percent.

13.0 Power Capacity Analysis:

A. An electrical power capacity analysis shall be performed to confirm existing power system capacities to handle additional loads on renovation projects and building expansion projects. For projects with demand loads of 100 KVA or more, the capacity analysis shall include local panelboards, affected power risers or feeders and the service feeder or transformer. For new buildings, a service capacity study shall be performed in conjunction with the Office of the University Engineer. A load study of the existing capacity shall be preformed on all projects that intend to draw power from a campus sub.

END OF SECTION

SECTION 16050 – "BASIC MATERIALS AND METHODS"

1.0 Contract Specifications:

A. Define the Contractor's responsibility for applying, obtaining and paying for all charges associated with the connection to non-University owned utilities.

B. Prior to the connection to University owned utilities, the Contractor shall obtain permission and coordinate such with the University Engineer. Refer to Part 1 – General, Article XIII – Site Utilities.

C. Define the Contractor's responsibility for performing all excavation and removal of all excavations from the site. Refer to appropriate site sections of the specifications.

D. Define shoring, excavated material storage, removal of unsuitable materials, trench depth, support of trench materials (i.e. pipe) and security requirements.

E. Include a description of the Contractor's responsibility regarding removal, relocation, and salvage rights. The University reserves right of first refusal on the salvage value of all electrical equipment and cable.

F. Excavation and Backfill:

1. As a minimum, the contract documents shall impose the following conditions upon the Contractor:

a. Perform all excavation, backfilling and pumping necessary for completion of work.
b. Carefully remove and export from the site all excavations, shrubbery, and sod. When underground work is complete and trenches are backfilled reinstall new sod and shrubbery to meet prior conditions or those defined by the University's Landscape Architect. Replace any damaged items to the satisfaction of the University Representative.
c. Coordinate with the University's Landscape Architect regarding tree removal/protection standards and all other landscape standards.
d. Trench depth shall allow adequate cover over piping, ducts and conduit. Walls shall be perpendicular to the top of piping and ducts and trench bottoms shall be graded in the direction of flow as required. Where necessary provide sand, pea gravel or other underlie required by the pipe or equipment manufacturer.
e. Each contractor shall provide sheathing, shoring and bracing necessary to complete his excavation and backfilling work.

f. It shall be the responsibility of the design professional and each contractor to check with the various utility companies and the PA 1-Call System. Each contractor is responsible for damage during excavation to existing piping or equipment. Such damage shall be repaired promptly without cost to the Owner.

g. Backfill after inspection and approval. Backfill shall be made with 100 percent clean imported earth, free from rocks, frozen particles, debris or other foreign materials. Deposit in uniform layers not over six inches (6") thick with each layer mechanically tamped before the next layer is applied. Partial backfill on piping with all joints exposed is mandatory for all underground systems. Final backfill may commence only after testing procedures have been completed and approved.

h. Each contractor shall perform all cutting and patching to sidewalks, curbs, bituminous paving, walls, etc. required by performance of excavation and backfilling. Install and maintain temporary paving as required. Make repairs to sidewalks, curbs, paving, etc. in complete blocks, partial patching will not be acceptable.

i. All trenches shall be backfilled at the end of each working day. Where a trench must be left open, provide steel plates of adequate size and strength over entire open area.

j. The A/E is responsible for reviewing all City of Philadelphia Agency's, Philadelphia Gas Works, Philadelphia Electric Co., SEPTA, Telephone Companies, Amtrak, Local Cable Companies, and Conrail requirements associated with installing, excavating and backfilling adjacent to non-University owned underground utilities. The contract documents shall not violate existing compliant conditions.

k. Contractors shall submit unit pricing for each type of work related to the excavation and installation of equipment, i.e. conduit, manholes, excavation, restoration etc.

G. Define requirements for access panels, firestopping, roof penetrations, etc.

END OF SECTION

SECTION 16110 – "CONDUIT"

This section is intended to define the general installation requirements for the conduit systems installed at the University of Pennsylvania.

The National Electrical Code shall govern the actual sizing of conduit during the design process. Minimum design conduit sizing shall accommodate type XHHW insulated wire.

1.0 Conduit shall be identified in accordance with Section 16195 – "Electrical Identification".

2.0 Each electrical system, such as lighting (277 volt), receptacle (120 volt), emergency lighting, fire alarm system, telephone/data system, Building Automation System, security system, and CCTV system, shall be routed in a dedicated conduit system.

3.0 Conduits shall be designed to run parallel with the lines of the building. Electrical conduits shall not be hung on hangers with any other service pipes, ducts, or other systems and shall be supported independent of any ceiling support systems. Related conduits shall be grouped together and supported from a conduit rack; provide space on rack for 25 percent additional conduits. Refer to Section 16190 for additional supporting requirements.

4.0 Rigid steel fittings shall be of the threaded type only; EMT fittings shall be of the compression type in mechanical and electrical equipment rooms; EMT fittings with set screws are permitted elsewhere

5.0 Exposed raceways shall be installed above water and steam piping. Maintain a minimum 12 inches clearance between conduit and surfaces with temperatures exceeding 104 degree F.

A. Maintain a minimum clearance of at least 6 inches between power conduits and telecommunications conduits and at least 12 inches between power conduits and unshielded twisted-pair telecommunications cables or as required by EIA/TIA Standard 569.

6.0 Raceway shall be designed with expansion joints to allow for thermal expansion of conduit system and of the building (at expansion joints) and keep stresses within the allowable limits of the conduit.

7.0 Junction/pull boxes shall be located to facilitate installation of cables and insure that the pulling tension of cables is not exceeded. However, install no more than the equivalent of (3) 90-degree bends between boxes.

8.0 Conduit and support systems shall be designed to meet applicable seismic codes.

9.0 Lateral installation of conduit on rooftops is not permitted.

10.0 In general, conduit sizes and types shall be suitable for the applications. The following is a summary of minimum conduit requirements.

A. All conduits shall be a minimum 3/4 inch.

B. Underground Installations:

1. Concrete encased ductbanks under roadways, parking lots, or other areas subject to vehicular traffic: Use schedule 40 PVC conduit; ductbank shall be steel reinforced
2. Concrete encased ductbanks under all other area:
   a. More than five feet from foundation wall or outdoor equipment pads: Use schedule 40 PVC.
   b. Within five feet of foundation wall or outdoor equipment pads. Use rigid steel conduit.

3. Direct Burial Branch circuit wiring for lighting, pumps, receptacles, etc.: Use Schedule 40 PVC conduit.
4. Installation of conduits under slab on grade is strictly prohibited. Only service entrance feeders shall be permitted to be installed under slab. All feeders within the building will be served by raceway systems installed within the structure.
5. Duct banks and conduit shall be installed above water and steam piping. Maintain a minimum 6-foot clearance between underground conduit or duct banks and any parallel steam lines. Underground crossings above steam lines shall maintain a minimum 24-inch clearance to be filled with foam glass insulation.

C. In slab, above grade:

1. The installation of conduit in slab is prohibited.

D. Outdoor Locations, Above Grade: In corrosive environments, use 40 MIL thick PVC coated rigid steel conduit with PVC coated threaded fittings; otherwise rigid steel conduit.

E. Wet and Damp Locations: In corrosive environments, use 40 MIL thick PVC coated rigid steel with PVC coated threaded fittings; otherwise use rigid steel conduit. All

roof conduit penetrations shall use PVC coated rigid steel conduit.

F. Dry Locations:

1. Switchboard and panelboard feeders: EMT.
2. Feeders or branch circuits 100 amps and larger: EMT.
3. Circuits operating above 600V: Rigid steel conduit.
4. Exposed conduit in finished areas: Coordinate with Architect.
5. Exposed conduit in non-finished areas (equipment rooms, storage rooms, etc.): Use EMT with compression fittings except RGS up to 8 feet above finished floor.
6. Equipment Rooms: Install rigid steel conduit in rough-use areas like mechanical and electrical equipment rooms, janitor's closets, etc.
7. Conduits in exterior walls: Rigid steel conduit.
8. Conduit in Interior Walls: Electrical metallic tubing.
9. Above False Ceiling: Electrical metallic tubing or MC cable with insulated ground conductor.

G. Hazardous Locations: Use galvanized rigid steel conduit.

H. Battery Storage Rooms: Rigid conduit.

I. Metal Clad (MC) Cable Installations

1. Type MC cable installation shall be in accordance with the following: No more than nine (9) total current-carrying conductors in multiple MC cable runs shall be bundled together into a single MC cable hanger. Wireway or ladder type tray with dual supports may also be used to support MC cable with fill as allowed by the NEC. Neutrals shall be counted as current-carrying conductors.
2. MC cable shall be run parallel or perpendicular to walls. No diagonal runs shall be permitted.
3. Maintain a clearance of at least 6 inches from hot water and other high-temperature pipes and telecommunications conduits, and at least 12 inches from unshielded twisted-pair telecommunications cables.
4. The arrangement of MC cables and fastening methods shall be subject to the approval of the Owner. Securely support all MC cable with cable hangers, individual spring steel support clips, steel trapeze hangers, threaded rods or dedicated No. 8 AWG drop wires. Cable supports shall be fastened to concrete slabs, beams, joists or other structural members of the building. Do not support MC cable on hung ceilings or on ceiling support wires. The use of cable ties to support MC cable is prohibited.

5. Support MC cable every 6 feet and within 1 foot of every box, panelboard, fitting, or cable termination.
6. All MC cables passing through fire-rated walls or electrical/telecommunications room walls shall be provided with a UL-listed, fire-rated penetration assembly.

J. Flexible Metal Conduit:

1. Provide flexible conduits for connections to motors, transformers, and other electrical equipment when it is subject to movement, vibration, misalignment, cramped quarters or where noise transmission is to be eliminated or reduced. Do not use flexible non-metallic conduit. Flexible conduit shall be of the liquid-tight type when installed under any of the following conditions:

    a. Exterior locations.
    b. Moisture or humidity laden atmospheres where it is possible for condensation to accumulate.
    c. Corrosive atmospheres.
    d. Where water or spray due to wash-operations is frequent or possible.
    e. Wherever there is a possibility of seepage or dripping of oil, grease or water.
    f. Connections to pumps.

K. All other applications not specified herein, use rigid steel conduit.

L. Paint all medium voltage conduit and junction boxes red and identify with voltage.

END OF SECTION

SECTION 16120 – "WIRE AND CABLE"

All wiring and cables shall conform to the latest NFPA 70 and applicable ASTM and NEMA Standards and shall be UL Listed for the application.

Conductor Material:

A. All conductors shall be copper. Aluminum conductors shall not be installed.

Building Wire and Cable:

A. Description: Single, annealed, conductor, insulated wire; 98 percent conductivity at 20 degrees C. Wires and cables manufactured more than 12 months prior to date of delivery to site shall not be used.

B. Insulation Voltage Rating: 600 volts.

C. Insulation Temperature Rating: 90 degrees C.

D. Insulation Material: Thermoplastic - dual rated THHN/THWN-2 or XHHW-2

E. Use solid conductor for feeders and branch circuits 10 AWG and smaller; larger conductors shall be stranded.

F. Use stranded conductors for all control and communication circuits.

G. High Temperature Areas: Wire installed in areas and locations subject to temperature unsafe for the thermoplastic insulation shall be heat resistant and be type V, FEP, TFE, SA OR Z as required.

1.0 Connectors and Splices:

A. UL-Listed, factory-fabricated, wiring connectors of size, ampacity rating, material, type, and class for application and for service indicated. Cable termination lugs shall be compression type.

2.0 Color Coding:

A. 120/240V, 1 Phase: Black, red, white, green.

B. 120/208V, 3 Phase: Black, Red, Blue, White, and Green.

C. 277/480V, 3 Phase: Brown, Orange, Yellow, Gray, and Green.

D. Isolated Ground Conductors: Green with yellow tracer(s).

3.0 Refer to Section 16195 – Electrical Identifications for additional requirements.

4.0 Provide all required voltage drop and pulling tension calculations so that the voltage drop does not exceed the guidelines outlined in the NEC or equipment requirements. Tension calculations shall be performed to confirm that the cable allowable pulling tension and side wall bearing pressure is not exceeded.

5.0 A dedicated neutral shall be installed with each lighting and appliance panelboard branch circuit. A shared neutral is not permitted. For electrified furniture systems, the preferred furniture wiring arrangement is to provide a separate neutral for each phase conductor. If a shared neutral is provided in electrified furniture, a common neutral of #10 minimum size shall be provided in the branch circuit(s).

6.0 As a minimum, cables shall be sized in accordance with the National Electrical Code. The cable sizing shall also take into consideration future loads/upgrades which may be planned.

7.0 In areas where solid-state power supplies for computers or instrumentation are used (such as offices and laboratories), the design shall be based on the affect of harmonics. The harmonic design shall include K rated transformers, oversized feeder neutrals, and panelboards with 200 percent neutral bus. K13 transformers shall be used in laboratories and K4 transformers in offices.

END OF SECTION

SECTION 16121 – "MEDIUM-VOLTAGE CABLE"

1.0 All cables shall conform to the latest NFPA70 and applicable ASTM, ICEA and AEIC Standards and shall be UL listed for the application.

2.0 Cable Manufacturers:

A. The Okonite Company – Type Okoguard – Okoseal.

B. The Kerite Company – Type SPS.

C. Pirelli – Type Eprotenax

3.0 Medium-Voltage Cable:

A. The cable shall be rated 105 degrees C for normal operation, 140 degrees C for emergency operation and 250 degrees C for short circuit conditions.

B. Construction: Single conductor class B stranded bare compact round copper conductor, extruded semiconducting strand screen, ethylene-propylene rubber (EPR) insulation, extruded semiconducting insulation screen, bare copper shielding tape or concentric wire shield, and a polyvinyl chloride jacket overall.

C. Conductor: The conductor shall be uncoated soft copper, compact round, class B stranded in accordance with ASTM B-8.

D. Conductor Screen: An extruded layer of thermosetting semiconducting EPR compound with a volume resistivity not in excess of 10 ohm-meters at 105 degrees C shall be applied over the conductor. The compound shall have a minimum elongation after an air oven test at 121 degrees C for 168 hours of 100 percent and a brittleness temperature not warmer than –50 degrees C. The thickness of the insulation screen shall be per AEIC CS6.

E. Insulation: The insulation shall be a thermosetting ethylene-propylene based elastomer which meets or exceeds the electrical and physical characteristics of ICEA S-68-516 and AEIC CS6. The ethylene content of the base elastomer shall not exceed 72 percent by weight. The insulation shall be triple tandem extruded with the conductor and insulation screens, and be applied in accordance with the above referenced industry standards.

F. Insulation Screen: The insulation screen shall be an extruded semiconducting EPR compound with a volume resistivity not in excess of 10 ohm-meters at 105 degrees

C and have a minimum elongation after air oven test at 121 degrees C for 168 hours of 100 percent and a brittleness temperature not warmer than –50 degrees C. The screen shall be applied in complete accordance with AEIC CS6.

G. Metallic Shield: The metallic shield shall be a 5 mil bare copper tape applied helically over the insulation shield with a 25 percent minimum overlap or an equivalent concentric wire shield.

H. Jacket: The overall jacket shall be black polyvinyl chloride and meet the requirements of ICEA S-68-516, Part 4. The thickness shall not be less than 80 percent of the specified minimum average.

I. Identification: An identifying legend shall be printed on the jacket with contrasting ink or by indent printing and be repeated at two-foot intervals. The minimum information shall include: Manufacturer's Name - Conductor Size - Conductor Material (copper or aluminum) - Insulation Type & Thickness - Voltage Rating and Applicable UL Ratings.

4.0 Splices and Terminations:

A. Splicing and Terminations: All terminations and splices shall be of the hand-wrapped, tape type. Pre-molded, cold-shrink, heat-shrink, or other factory-assembled kits shall not be used. Make all ground connections to copper tape shields by soldering. Mechanical or spring-tension ground connections shall not be used unless soldered in place. All work shall be performed in a manner recommended by the cable manufacturer. Termination and splice installers for medium-voltage cables shall have a minimum of four (4) years documented experience in the installation of medium-voltage splices/terminationsand the University Operations and Maintenance office shall approve resume of installer prior to work.

5.0 Cable Identification Tags:

A. See Section 16195 for identification requirements.

6.0 Installation of Cables:

A. Calculate cable-pulling tensions, sidewall bearing pressures, bending radii for installation and jam ratios for each length of cable to be installed. These parameters shall be within the limits of the cable manufacturer's recommendations.

B. Pulling lubricant shall not be deleterious to cable insulation.

7.0 Field Quality Control:

A. Applicable Codes, Standards and References.

1. All inspections and tests shall be in accordance with the following applicable codes and standards except as provided otherwise herein:

a. National Electrical Code (NEC)
b. Institute of Electrical and Electronics Engineers(IEEE)
c. International Electrical Testing Association (NETA)
d. Insulated Cable Engineers Association (ICEA)
e. Association of Edison Illuminating Companies (AEIC)
f. American Society for Testing and Materials (ASTM)
g. Underwriters Laboratories (UL)
h. OSHA Part 1910, Subpart S, 1910.308

B. In addition, the cable shall be tested upon delivery on site, after installation and after final connections have been made.

C. Cable shall be given DC hi-pot step voltage tests. Test at two times the cable rated voltage before removal from the reel and after the cable is pulled but prior to splicing. Perform a third test after the cable is spliced at one times the operating voltage.

8.0 At a minimum, cables shall be sized in accordance with the National Electrical Code. The cable sizing shall also take into consideration future loads/upgrades which may be planned. The sizing of these cables for future expansion shall be coordinated with the University.

END OF SECTION

SECTION 16130 – "BOXES"

1.0 All boxes shall conform to the latest NFPA70 and the applicable NEMA Standards. The boxes shall also be UL listed for the application, UL 514A.

2.0 At a minimum, boxes shall be sized in accordance with the NEC (NFPA) and shall take into consideration future cables that may be installed.

3.0 General:

A. Product Selection: Select boxes of types appropriate for each use and location:

1. Select covers for boxes of types appropriate for each use and location.
2. Provide gaskets for covers of boxes in damp or wet locations.

B. Corrosion Resistance: Provide galvanized or other approved corrosion resistant finish for all boxes, accessories and fittings. Galvanizing shall be performed after fabrication.

C. Weatherproof Outlet Boxes: Provide corrosion-resistant cast-metal weatherproof outlet boxes, of types, shapes and sizes, including depth of boxes, with threaded conduit ends, cast-metal face plates and spring-hinged waterproof caps suitably configured for each application, including face plate gaskets and corrosion-resistant fasteners.

D. Junction and Pull Boxes: Galvanized sheet steel junction and pull boxes shall be equipped with screw-on covers and of types, shapes and sizes, to suit each respective location and installation. Box shall be installed with stainless steel nuts, bolts, screws, washers, etc. Boxes shall be galvanized after fabrication.

E. In general, floor boxes shall not be installed. Floor box installation shall be closely coordinated with the Office of the University Engineer.

F. Underground boxes for outdoor lighting circuits shall be PVC with minimum size of 10" x 10" x 6". Outdoor circuits shall be GFCI protected.

G. Hazardous Locations: Provide outlet boxes conforming to UL 886 for hazardous locations and install in conformance with NFPA 70 Articles 500 through 555.

H. Prohibited Work:

1. Sectional (gangable) boxes.
2. Device plates as covers for boxes in exposed location.
3. Round boxes where conduit must enter box through side of box, which would

result in difficult and insecure connections when fastened with locknut or bushing on rounded surface.

4. Back-to-back or through-wall boxes for outlets.
5. More than one extension ring on an outlet box.

I. At the following locations use threaded hub type boxes with gasketed weatherproof covers:

1. Exterior locations.
2. Where installed on unfinished walls, columns or plasters. Cover gaskets may be omitted in dry locations.
3. Where exposed to moisture laden atmosphere.
4. At kitchen and cafeteria equipment with, or within 4 feet of, steam connections.

J. Mount pull boxes concealed in nonaccessible walls or ceiling, with the covers flush with the finished wall or ceiling.

END OF SECTION

SECTION 16141 – "WIRING DEVICES"

1.0 The design shall be in accordance with NFPA70. The devices shall be in accordance with the applicable UL, NEMA, and ANSI/IEEE Standards.

2.0 Related work specified elsewhere

A. Fume Hoods.

B. Laboratory Casework.

3.0 The professional is responsible for selecting devices for the environment and the usage. (i.e. GFCI, IG, Surge Suppression, watertight, weatherproof while in use).

4.0 No more than six (6) duplex receptacles shall be placed on a branch circuit. No more than four (4) receptacles serving PCs shall be on a branch circuit.

5.0 Where multiple receptacles or flexibility of wiring is required, devices shall be installed in surface metal raceway like Wiremold 3300.

6.0 Provide appropriately rated Transient Voltage Surge Suppression (TVSS) on the building secondary service switchgear, at main distribution power panels, and at each Receptacle and Appliance panelboard serving sensitive electronic equipment.

7.0 The designer is responsible for closely coordinating the needs of the user with the architect and the University. The layout of the receptacles shall be such that these needs are met.

8.0 Receptacles shall be located adjacent to equipment requiring regular maintenance. Duplex receptacles for floor polishers/steamers will be provided every fifty (50) feet on centers in corridors.

9.0 Approved Manufacturers: Hubbel, P&S, Arrow-Hart, GE.

END OF SECTION

SECTION 16170 – "GROUNDING AND BONDING"

1.0 All materials that are part of the grounding system shall be copper.

2.0 The professional shall document the work associated with the grounding system – reference to NEC only is unacceptable. The grounding system shall include the following grounding electrodes: building metal water pipe, building structural steel, Ufer ground (connection to reinforcing steel not smaller than #4 in the column footings and grade beams) at approximately every 100 feet around building, and a ground loop around the entire building (#4/0 AWG minimum size). Ground rods tied to the loop shall be provided at the service entrance ground bus (triad), at each lightning downcomer (when provided), and at each corner of the building. Known areas of high soil resistivity will be provided with additional ground rods or chemically enhanced ground rods.

3.0 A separate ground conductor shall be installed with all branch circuits. Reliance on the conduit as the grounding means is unacceptable.

4.0 Isolated ground conductors, if required, shall be connected to the building ground system at its separately derived supply transformer grounding location. The design shall be in accordance with IEEE Std.1100 guidelines.

5.0 All underground connectors shall be of the exothermic welded type.

6.0 The professional shall specify grounding systems that meet the following ground resistance values.

A. Data Center: Less than 2 ohms.

B. Outdoor Transformer/Switchyard: Less than 5 ohms.

C. Low-Voltage Building Service: Less than 10 ohms.

D. Medium-Voltage Service: Less than 5 ohms.

7.0 Testing of the system shall be documented as part of the design to verify conformance. Include the following:

A. Perform a megger test using the "Fall-of-Potential Method" to determine that the proper ground resistance has been achieved, and submit a written report of the megger test of ground resistance

B. Perform ground fault protection system performance testing for each 480-volt

switchboard having ground fault protection and for any generator system.

C. Perform Ground Continuity Tests:

1. From main switchgear to grounding electrode and/or cold water main.
2. Between each main secondary feeder switchboard ground and its termination point (distribution panels, panelboards, motor control centers, UPS systems, electric heater disconnects, chiller starters, and other such equipment) and all feeders shown on single-line diagram.
3. Between each distribution panel to panelboards and between each panelboard to panelboard (excluding branch circuits).
4. Test each receptacle for proper polarity and ground using a plug-in test device.

8.0 Provide test wells for underground grounding loop in at least two (2) locations.

END OF SECTION

SECTION 16190 – "SUPPORTING DEVICES"

1.0 Supporting devices/systems shall be designed to support the weight of the equipment, raceways, etc. The systems shall also meet seismic requirements. The devices/systems shall be in accordance with applicable portions of NFPA70, ASTM, UL, and NELA. The design shall document the supporting devices.

2.0 General:

A. All supporting devices shall be used for the specific purpose for which they were manufactured.

3.0 Coatings:

A. Coating: Supports, support hardware, and fasteners shall be protected with zinc coating or with treatment of equivalent corrosion resistance using approved alternative treatment, finish, or inherent material characteristic. Products for outdoor use shall be hot-dip galvanized after fabrication.

4.0 Manufactured Supporting Devices:

A. Raceway Supports: Clevis hangers, riser clamps, conduit straps, threaded C-clamps with retainers, ceiling trapeze hangers, wall brackets, and spring steel clamps.

B. Powder-Driven Threaded Studs: Powder – Driven devices shall not be used unless specifically approved by the University.

5.0 Supports:

A. Strength of each support shall be adequate to carry present and future load multiplied by a safety factor of at least four. Where this determination results in a safety allowance of less than 200 lbs., provide additional strength until there is a minimum of 200 lbs. safety allowance in the strength of each support.

B. Walls of light weight construction shall be reinforced with strut before hanging electrical equipment

END OF SECTION

SECTION 16195 – "ELECTRICAL IDENTIFICATION"

1.0 Adhesive Marking Labels for Raceway: Pre-printed, flexible, self-adhesive labels with legend indicating voltage and service identifying Emergency Power and Fire Alarm conduits.

A. Label Size: As follows:

1. Raceways 1-inch and Smaller: 1-1/8 inches high by 4 inches long.
2. Raceways Larger than 1-inch: 1-1/8 inches high by 8 inches long.

B. Color: Black legend on orange background.

2.0 Wire/Cable Designation Tape Markers: Where multiple branch circuits are present in the same splice or pull boxes, panelboards, switchboards, or other points of access, identify with tape markers using Vinyl or vinyl-cloth, self-adhesive, wraparound, cable/conductor markers with preprinted numbers and letters. Such identification shall include circuit number, gauge of conductor and either destination (at source locations) or source (at destination and intermediate locations).

3.0 Plasticized Card Stock Tags: For high voltage and 480 volt feeder cables, provide phenolic tags with machine printed legend to suit the application. Provide orange background, except as otherwise indicated and eyelet for fastening. Tags shall identify circuit number, conductor gauge, and destination (at source location) or source (at destination and intermediate locations).

4.0 Nameplates: Engraved three-layer laminated plastic, black letters on white background. Embossed tape will not be permitted for any application. Provide nameplates with equipment name and drawing schedule identification for all electrical equipment including panelboards, cabinets, switchgear, switchboards, starters, and fire alarm devices. Devices serving a dedicated load shall be identified in a similar manner. Identify the incoming breakers or switches on high voltage switchgear and fused switch lineups with the sound circuit identification number and their location. A schedule or drawing shall identify proposed nameplates and be approved by the University (to be compatible with the MIMS system).

5.0 Fasteners for Plastic Laminate and Metal nameplates: Provide self tapping stainless steel screws or No. 10/32 minimum stainless steel machine screws with nuts, and flat and lock washers. Glue-on nameplates are not permitted.

6.0 Cable Ties: Provide fungus-inert, self-extinguishing, one piece, self locking nylon cable ties 0.18 inch minimum width. Fifty (50) pounds minimum tensile strength and suitable for a temperature range from -50 degrees F. to plus 350 degrees F. Provide ties in specified colors when used for color coding.

7.0 Underground Warning Tape: Provide 4 inch wide plastic tape, detectable type, colored red with suitable warning legend (located 12 inches below grade) above all underground conduits and ductbanks.

8.0 All receptacle cover plates, including laboratory multi-outlet raceway receptacles, shall be identified as to panel and circuit number; this information shall be identified by means of a printed label. Label shall be translucent or clear polyester, waterproof, and scratchproof.

9.0 Control wiring shall be identified and tagged at all terminals with plastic stick-on labels to correspond with identifications as shown on Vendor's Drawings.

10.0 Arc Flash and Shock Warning Signs:

A. Provide nameplate type markings on all switchgear, switchboards, panelboards, motor control centers, starters, VFDs, and control panels per NEC Article 110 indicating the following:

1. Voltage (phase to phase)
2. Available Short Circuit Current (amperes)
3. Flash Protection Boundary (inches)
4. Prohibited Shock Approach Boundary (inches)
5. Limited Shock Approach Boundary (inches)

END OF SECTION

SECTION 16300 – "POWER DISTRIBUTION SYSTEM"

1.0 The distribution systems shall be designed so that a high level of reliability is maintained. A system may include primary and secondary selection with main-tie-main on the primary (13.2 kV) and main-tie-main on the secondary (480 or 208). Systems shall be equipped with automatic transfer schemes on both the primary and secondary. Primary main-tie-main switchgear shall include bus differential protection and shall coordinate with upstream substation breakers. The design of the distribution system varies with project size and must be coordinated with the University. The designer is responsible for assessing the needs of the University and basing the design on such. In general, all buildings will have two (2) primary (13.2KV) feeds. Where fused primary selector switches are provided on transformers/substations, non-load break switches shall be provided upstream to allow for isolation and maintenance of the selector switches without de-energizing the primary service.

2.0 In general, all secondary switching devices shall be breaker type. Mains, ties, and 1000 amperes or larger feeder breakers shall be drawout power air circuit breaker type.

3.0 Metering shall be provided. Provide each secondary with a panel-mounted microprocessor-based monitoring device for digital readout of electrical parameters AC current A, B, C Phases, AC Volts A-B, B-C, C-A "including phase averages "A-N, B-N, C-N and average phase to N. Real Power (Watts) reactive power (VARS), Apparent energy (VAHR) for each phase. Real energy (WHR), reactive energy (VARHR), apparent energy (VAHR) for each phase. Frequency (Hz), Demand (AMPS), system real power (WATTS), System reactive power (VARS) and system apparent power (VA).

4.0 Switchgear General Construction

A. The switchgear enclosure shall be of metal-clad construction as described in ANSI standards. [In addition, the switchgear shall be Arc Resistant type as described in ANSI standards.]

B. The switchgear shall be factory assembled into convenient shipping groups and tested and of a coordinated design so that shipping groups are easily connected together at the site into a continuous line-up. Necessary connecting materials shall be furnished.

C. The switchgear shall be accessible from all sides. Primary cables connections shall be made at the top.

D. The switchgear assembly shall consist of one or more vertical sections, each of which shall have as appropriate for the application:
   1. Main bus compartment
   2. Primary connection compartment housing cable / bus duct connections,

current transformers and surge protection equipment

3. Primary circuit breaker compartment
4. Auxiliary compartment housing voltage and control power transformers.
5. Low voltage compartment housing relays, instruments and other low voltage equipment, as indicated in the detailed specification. The low voltage compartment shall be mounted on the equipment compartment and shall be of modular construction, capable of being field-mounted if necessary.

E. Each main bus compartment shall contain copper bus bars silver plated at electrical connection points 3 phase, 3- wire, fully insulated epoxy powder coating (sleeve type insulation is not permitted), with joints covered with preformed PVC boots held together with nylon hardware for easy installation and removal during servicing. Taped joints are not permitted except in unusual joint configurations. The ground bus shall be bare silver-plated copper, in minimum size of _ by 2 inches and shall extend full length of switchgear.

F. Each circuit breaker compartment shall include:

1. Hinged front door, interlocked with the breaker to prevent racking unless the door is closed. The door may not be opened until the breaker is in the disconnected position.
2. Primary and secondary disconnecting devices
3. Secondary disconnects. The secondary connections shall engage automatically during the racking operation when the breaker is moved from the disconnect position to test position. Secondary disconnects using plug and socket arrangement with an umbilical cord is not permitted. Also, no manual intervention to make the secondary connections shall be permitted.
4. Mechanical position indication shall be visible with door closed.
5. Circuit breaker driven automatic shutters. Shutters shall be independently operated and shall have provisions for installation of padlocks on each shutter to prevent inadvertent opening.
6. Safety interlocks. The racking mechanism of the circuit breaker shall be integral with the circuit breaker to minimize alignment problems and facilitate inspection and maintenance. Racking mechanisms installed directly in the switchgear structure, or which permit exposure to primary conductors during maintenance are not acceptable.

G. Each auxiliary compartment shall include the following:

1. A separate compartment front panel for each drawout position.
2. Necessary terminal blocks, control wiring, blocks and buses
3. VT, CPT or fuse rollouts, if needed
4. If the switchgear is Arc Vented, each drawout position of the auxiliary compartment shall be independently arc vented.

H. Provide taped mimic bus on each switchgear section.

5.0 Accessories

A cabinet shall be provided for storage of small accessories for the switchgear.

A. Circuit breaker racking tool

B. Circuit breaker compartment door tool

C. Circuit breaker manual spring charging tool

D. Manual circuit breaker trip & close tool

E. Relay and meter test plugs for drawout devices that accept test plugs.

F. Supply one breaker dolly per six breakers. Breaker dolly(s) are to be stored inside the circuit breaker compartment.

6.0 Switchboards – General Construction

Switchboard shall be of the modular type construction, constructed in accordance with the latest NEMA PB-2 and UL 891 standards, with the required number of vertical sections bolted together to form one metal enclosed rigid switchboard. The sides, top and rear shall be covered with removable screw on code gauge steel plates. Switchboard shall include all protective devices and equipment as listed on drawings with necessary interconnections, instrumentation and control wiring. All groups of control wires leaving the switchboard shall be provided with terminal blocks with suitable numbering strips. Service entrance switchboards shall be suitable only for use as service equipment and be labeled in accordance with UL requirements. System voltage, amperage, and interrupting capacity shall be as indicated on the drawings. Enclosure construction shall be [NEMA 1 indoor] [NEMA 3R outdoor].

7.0 Switchboard and switchgear enclosures shall be suitable for the environment. At a minimum, enclosures shall be NEMA 2 (drip-proof).

8.0 All power cable terminations shall be copper with compression type fittings, including all factory terminations.

9.0 Transformers shall be of the dry type with copper windings with fans preferred. If the transformer is not equipped with forced air cooling, the transformer shall be fully outfitted

for future forced air. All breakers, bus, etc. shall be sized to accommodate future forced air capacity. Transformers equipped with future forced air provisions shall also include temperature indicator and alarm devices. Cast coil transformers should be considered in wet and hostile environments and where across the line or delta-wye starting of large motors occurs.

10.0 Bus connections (in lieu of cable) with vibration isolation shall be provided to the primary and secondary side of the transformer in unit substations.

11.0 A ground bus shall be run the full length of the switchgear/substation and be connected at both ends to the building ground loop.

12.0 The professional shall prepare all calculations to verify ratings of the equipment.

13.0 At a minimum, the equipment shall be sized for present load, future anticipated load and thirty (30) percent spare capacity.

14.0 Each transformer shall be individually protected by relay or by fuse. Transformer protection shall include differential protection for sizes larger than 2500 KVA..

15.0 Medium voltage protective relays shall be Basler or Siemens.

16.0 The main power distribution equipment described herein shall be located in a room designed to house such equipment. The space must be adequately ventilated. Additionally, the room shall be located and spaces designed so that the largest piece of equipment is easily replaced. The designer is required to coordinate any requirements with the architect. The location for this room shall be the first floor of the building. This equipment shall not be located in the basement. Any location other than the first floor shall be coordinated with the University. Walls, floors, and ceilings shall have a minimum 1-hour fire rating.

17.0 TVSS equipment shall be provided at main 480-volt service switchboard or switchgear.

END OF SECTION

SECTION 16375 – "UNDERGROUND ELECTRICAL DISTRIBUTION SYSTEM"

1.0 Components of the Underground Electrical Distribution System shall meet all applicable Federal Specifications, ANSI Standards, ASTM Standards, NEMA Standards, NFPA70 Code, and UL listing requirements.

2.0 Refer to Section 16110 – "Conduit" for conduit and ductbank requirements.

3.0 All underground service entrance power and telecom/data cables shall be installed in a concrete encased ductbank.

4.0 Manholes, handholes, etc. shall be sized to accommodate the proposed cables, planned future cables plus include provisions for future unknown requirements.

5.0 The professional is responsible for coordinating any sheeting/shoring requirements.

6.0 The underground ductbanks shall be sloped down towards manholes so that no point in the system will allow for accumulation of water.

A. Ductbanks shall have a minimum of three feet of cover.

B. Provide a continuous bare #4/0 copper grounding conductor embedded in the concrete ductbank and connect to all exposed metal in manholes and to building ground loop(s) or substation ground bus at source and destination.

7.0 Manholes: Each manhole shall have a ground rod driven a minimum of 8 feet into undisturbed earth. Provide cable racks sufficient to support the cables being installed. Glazed porcelain insulators shall be provided for each cable.

8.0 The professional is responsible for performing any required pulling tension calculations to verify that the cable pulling tensions will not be exceeded and locating manholes accordingly. Under no conditions shall manhole spacing exceed 400 feet: the University requirements for future connections shall also be considered in the placement of manholes.

9.0 All unused or abandoned cables shall be removed and a non-corrosive (plastic) pull line left in the duct.

END OF SECTION

SECTION 16441 – "ENCLOSED SWITCHES"

1.0 Enclosed switches shall be of the heavy-duty fused type and meet applicable NEMA KS1 and UL 98 Standards.

2.0 Switches are an integral part of equipment maintenance. A switch shall be located adjacent to all equipment. The switch shall be readily accessible and clearly identified. Refer to Section 16195 – Identification. Switches shall be rated for available fault current.

3.0 The professional is responsible for locating switches in accordance with NFPA70 requirements and in locations that facilitate maintenance.

4.0 The enclosure types shall be UL listed for the applications.

5.0 The professional shall utilize fuses suitable for the load type and the short circuit current available. Fuses shall be rejection type and shall be RK1 or J Class for new work and may be RK5 for renovation work.

6.0 Outdoor switches shall have NEMA 4 enclosures.

7.0 Provide three (3) spare fuses of each size.

END OF SECTION

SECTION 16461 – "DRY TYPE 208/120 VOLT TRANSFORMERS"

1.0 The transformers shall meet the applicable standards of NEMA ST-20 and ANSI/IEEE C57.10, UL 1561.

2.0 Transformers windings shall be continuous copper and UL K-rated for harmonics as required. The professional shall review the affect of harmonics and select a transformer accordingly. Provide minimum K13 rated shielded isolation transformers for data centers, K13 for laboratories, and K4 for offices.

3.0 Transformers shall be sized for connected load with demand factors as allowed by NFPA 70, plus include thirty (30) percent spare capacity. Transformer sizing shall also take into consideration future loads that may be placed on the transformer.

4.0 Transformers insulation shall be 220 degrees C, Class H, and the temperature rise shall not exceed 115 degrees C over a maximum ambient temperature of 40 degrees C with a 30 degrees C hot-spot rise. The designer is responsible for coordinating the ventilation requirements of the transformer.

5.0 Provide vibration isolation and proper grounding for all transformers.

END OF SECTION

SECTION 16470 –"PANELBOARDS"

1.0 The panelboards shall meet NEMA Standard PB1, and UL 50, UL 67. The design shall be in accordance with NFPA70. Provide shop drawings.

2.0 Load center type panelboards are unacceptable. Single-phase panelboards are unacceptable. Twin mounted circuit breakers are not allowed.

3.0 All bus bars and terminations shall be copper.

4.0 Panelboard enclosure shall be dead front and suitable for the environment. Enclosure shall include a hinged door with lock keyed to University Standard.

5.0 All breakers shall be of the bolt-on type and fully rated.

6.0 The design shall include all calculations to determine available fault current. The panelboard shall have minimum ratings to meet these fault comments. Series rated panelboards shall not be used. The panelboard shall be sized for load plus thirty (30) percent spare capacity. In addition to this spare capacity, future additions/renovations shall be considered in sizing the panels. All spaces shall have bus bars installed.

7.0 The panels shall include 10 percent spare breakers and 20 percent spaces.

8.0 Panelboards shall be located in accordance with code. Additionally, panels shall be located in locked electrical rooms with one-hour fire-rated walls, so that access to the panels is restricted. Panels for labs or similar type spaces shall be located within the lab/space being served.

9.0 Panelboard loads shall be separated based on type. For example, motor loads and sensitive electronic loads shall not be served from the same panelboard. The designer shall review the loads/load types and verify that such load conflicts are avoided.

10.0 Designed phase loads of each panel shall be balanced within 10 percent. After circuits have been energized, phases shall be rebalanced to 10 percent and a typed circuit directory shall be provided by the Contractor.

11.0 Panelboards with 200 percent neutrals shall be used on the secondary of all K-rated transformers.

12.0 Transient Voltage Surge Suppression (TVSS) shall be provided on all panelboards serving electronic equipment including office computers and laboratory instrumentation.

END OF SECTION

SECTION 16482 – "MOTOR CONTROL CENTERS"

1.0 The Motor Control Centers (MCC) shall be designed and manufactured in accordance with the applicable sections of NFPA 70 and NEMA ICS 2, UL 845, UL 508C, and ANSI Standards. MCCs shall be Class1, Type B. Provide shop drawings and as-built drawings showing all control wiring and control devices.

2.0 The professional is responsible for assessing the need for Motor Control Centers. Where four (4) or more motors are grouped together, a Motor Control Center shall be utilized. The Motor Control Center shall have ratings suitable for the connected load plus thirty (30) percent spare capacity and thirty (30) percent space to accommodate future starters. The motor control centers shall be located adjacent to the loads served and in a locked room.

3.0 Enclosure shall be suitable for the environment. NEMA 1 enclosures shall not be used – provide minimum NEMA 2 (drip-proof) rating.

4.0 Bus shall be silver-plated copper; ground bus shall be installed to the full length of the MCC. Bus shall be braced to suit the available fault current.

5.0 All 480 volt starters shall be of the drawout type with thermal magnetic circuit breaker or Magnetic Circuit Protector (MCP). Professional shall review the starter type and the affect motor starting will have on the distribution system. Utilize solid state reduced voltage starters where the in-rush current is excessive. Starters shall include all features required to perform required functions (i.e. CPT, short circuit/ground fault protection, overload protection). Starters shall include pushbuttons, lights, and 2NO and 2NC auxiliary contacts.

6.0 Medium voltage (4160) starters shall be reactor type utilizing vacuum contactors. Multi-function motor protective relays shall be GE/Multilin MPR type.

7.0 Ground MCC to power supply source ground bus via a feeder ground conductor.

8.0 Provide bus stabs for future additions to line-up.

9.0 Provide nameplates for MCC, all starters, spares and spaces.

10.0 Spaces shall include buses, rails, and terminal blocks.

11.0 Mount MCCs on 4-inch high concrete pads.

END OF SECTION

SECTION 16483 – "ADJUSTABLE SPEED DRIVES"

1.0 Variable Frequency Drives (VFDs) may be employed to vary the flow of water and air. The A/E shall evaluate the specific application of each variable frequency drive and provide life cycle costing to prove its economic viability. VFDs shall be locally mounted near to the motor to limit distance between VFD and motor to less than 75 feet. Distances over 75 feet shall be analyzed for adverse effects on the cable insulation, disconnect switch and the motor insulation. VFDs shall be furnished under Division 15 and installed by Division 16.

2.0 The A/E shall consider the following issues when employing VFDs:

A. When main and standby equipment is to be controlled by variable frequency drives, separate drives shall be provided for redundant equipment. Manual bypass starters for VFDs are generally not required but should be considered on a case by case basis where life safety or risk of extensive losses are an issue.

B. Equipment motors shall be matched to the drive so that low speeds can be realized.

C. The operational overloads and starting conditions required by the application shall be defined. Typical requirements may be: variable torque = 115 percent for 1 min, constant torque = 150 percent for 1 min. VFD shall employ torque regulation which shall override speed command and lower frequency while maintaining Volts per Hertz control whenever load level surpasses preset limit.

D. The method in which control commands for the VFDs will be generated by the process shall be determined, i.e.:

1. Manual Speed Control
2. Analog current loop, 4-20 mA feedback signal to DDC
3. Isolated or nonisolated analog current automatic speed control signal from DDC
4. Process feedback input (pressure, temperature, flow, etc.)

E. A dry common trouble alarm shall be provided for input to the BAS.

F. VFD unit shall automatically restart and catch a spinning load when return-to-normal conditions occur.

G. Provide minimum 3 percent input line reactor for each VFD (up to 200 HP) to limit harmonic feedback into the electrical system. VFDs for motors larger than 200 HP shall be provided with split-phase harmonic cancellation transformers.

H. What speed range is required and whether the load will be operated beyond base speed range shall be defined. Provide "critical/resonant" frequency avoidance protection and adjustable carrier frequency.

I. It shall be determined if all parts of the rotating load are suitable for the range of vibration excitation frequencies.

J. It shall be verified that the motor is sized to provide the necessary load torque while operating at reduced speed. The power capability of the motor may be restricted at low speeds. The motor output capability shall be compared with the load requirement. An additional cooling fan may be required for constant torque loads.

K. How the VFD operates under fault conditions shall be defined; for example, a mechanical overload, an electrical short circuit in the motor circuit, or a ground fault in the load system.

L. The motor protection provided by the VFD equipment and any additional protection required for comprehensive system protection, e.g., overload, overspeed, reverse rotation, short circuit, transient voltage surge protection, etc. shall be defined.

M. The manufacturer shall be required to submit information for system operations and maintenance and provide, warranty, training, and operation and maintenance manuals.

N. The following manufacturers are approved for use.

Cutler-Hammer (Eaton Corporation) (SV 9000).

ABB Industrial Systems (ACH 550).

Yaskawa (formerly Magnetek) (GPD 506).

3.0 The heat rejection from the VFD controller and how the losses are removed from the equipment shall be defined. Ventilation fans should be considered in units over 50 HP.

4.0 The total input power factor (PF) (i.e., real PF and apparent PF) shall be defined.

5.0 Enclosure shall be suitable for the application and **shall be minimum NEMA 2 (drip-proof).**

END OF SECTION

SECTION 16500 – "PROGRAMMING CONSIDERATIONS"

1.0 General

A. During the schematic phases of the project, the A/E shall determine and document the pertinent electrical criteria and design basis for the project in conjunction with the University and the User. The following shall be addressed.

2.0 Services and Systems:

A. Source of electrical supply to project including voltage and capacity. A schematic load estimate for the project shall be calculated based upon historical watts per square foot (by load type), meter readings, billing data or by using connected loads and demand factors.

B. Demarcation points for electrical, telecom, data and other services shall be determined.

C. Emergency and/or standby generator power requirements shall be determined. A schematic load estimate and a description of the loads shall be provided, broken into emergency, legally required standby and optional standby categories.

D. The requirement for Uninterruptible Power Supply or other conditioned or voltage-regulated power shall be determined and a schematic load estimates provided.

E. The requirements for auxiliary systems such as lightning protection, intercom, public address, snow-melting, automatic clock, white noise, etc. will be determined in coordination with the User.

3.0 Provide hazardous area analysis, where required in coordination with the User group and the University fire protection and safety representatives. Type and extent of hazardous area classification shall be determined and documented during the initial design phase.

4.0 Placement of satellite electrical rooms shall take into consideration voltage drop limitations (3 percent) for branch circuits. This generally dictates an electrical satellite room every 20,000 gross square feet. Allow space for future equipment additions beyond that included in the project. Space requirements for electrical and telecom/data rooms shall be identified in the schematic phase of the project.

5.0 Ascertain equipment requiring special voltages, isolated grounding systems, magnetic field shielding, or radio frequency shielding or filtering. Ascertain outlet density for power and data in laboratory applications.

6.0 Lighting footcandle recommendations and switching, dimming and automatic lighting control schemes shall be reviewed with the University during schematic phase of the project.

END OF SECTION

SECTION 16510 – "BUILDING LIGHTING"

1.0 The lighting design and fixture selection shall meet applicable ANSI Standards. All fixtures shall be UL listed for the application. The overall design shall be in accordance with ASHRAE 90.1.

2.0 Lighting levels shall be in accordance with the guidelines outlined in the Illuminating Engineering Society of North America (IESNA) Handbook. Light levels shall be closely coordinated with the University.

3.0 Lighting calculations shall be performed to verify that the light levels meet the requirements indicated in 2.0. The professional is responsible for coordinating with the Architect and any required field investigation to develop parameters required for the calculations.

4.0 The professional is responsible for investigating and designing an energy efficient system. This includes the ballast, lamps and overall system performance (i.e. instant start electronic ballast/T-8 lamps).

5.0 The use of incandescent lighting is discouraged and shall only be used with prior approval.

6.0 All central lighting control systems, including dimming systems, shall be designed by the Professional Engineer in coordination with University Maintenance Personnel.

7.0 Controls:

A. Each area enclosed by ceiling height partitions shall have at least one accessible lighting control to independently control lighting within the area.

B. All enclosed areas larger than 500 square feet shall have an accessible lighting control so that general lighting may be reduced by at least one half throughout the area.

C. The total number of accessible lighting controls within an enclosed area shall not be less than one for each 500 square feet, exceptions being made on case by case basis for large spaces used as a whole, spaces served by automatic or programmable lighting controls, and controls for security or safety.

D. The use of occupancy sensors shall be investigated for all offices, restrooms, classrooms, and other areas of intermittent use. Daylight harvesting should be considered.

E. Normal lighting in common, un-occupied, and corridor areas (goal is minimum of 30 percent of building lighting load) shall be designed to be controlled via the BAS for energy curtailment.

8.0 Selection of luminaires and lamp types shall minimize the different lamp types utilized and required to be stocked by maintenance. Fluorescent lamp color should be 3500K.

9.0 Exterior Lighting:

A. Sufficient area lighting shall be provided to provide safe pedestrian transit under all conditions.

B. Mercury vapor lamps shall not be used. Metal halide lamps shall be considered.

C. Provide BAS control with local over-ride for all exterior lighting except Code required egress lighting. Photocells may be used for architectural accent lighting only (not for transit lighting).

D. Dimming lighting control systems for exterior lighting is prohibited.

E. Mounting heights of pole and exterior building luminaires should be limited to 36 feet above accessible grade for re-lamping purposes.

END OF SECTION

SECTION 16600 – "STANDBY/EMERGENCY POWER SYSTEM"

1.0 The professional is responsible for designing a system in accordance with applicable portions of the NFPA Codes, IEEE Standards, EPA Emission Standards and NEMA Standards. All products shall be UL listed for the application. Design in accordance with NFPA 110.

2.0 The professional is responsible for assessing the needs to comply with code plus ascertaining the University's requirements for additional loads that should be placed on the standby/emergency system.

3.0 The source of standby/emergency power shall be generators. Fuel shall be diesel oil.

4.0 Sizing of the standby/emergency system shall be in accordance with code. In addition to meeting the minimum system requirements, the systems shall include capacity for future planned additions plus thirty (30) percent spare capacity. The professional is responsible for verifying that an oversized generator does not create maintenance problems with regard to load testing.

5.0 The standby/emergency system shall be designed to accommodate the type loads placed on the system (i.e., motors, UPS, HID lighting, etc.).

6.0 Any noise issues shall be closely coordinated with the University. Systems shall be designed to accommodate the project requirements. Generators shall have critical grade silencers. Outdoor generator enclosures, if required, shall be sound attenuated.

7.0 The generator shall be located indoors and meet the location requirements outlined under Section 16300 for main power distribution equipment.

8.0 Fuel storage and fuel filling station shall have spill containment and be provided with spill absorption kit.

9.0 Provide separate UL 1008 listed transfer switches or circuit breakers for emergency life safety, legally required standby and optional standby loads.

10.0 Provide common trouble alarm, run status of generator and fuel tank low level alarm to the BAS.

11.0 As a minimum, storm water sump pumps, sewage ejector pumps, and the building automation and security systems shall be connected to the generator supply in addition to emergency life safety and legally required building loads. A duplex receptacle color-coded red and connected to the generator supply shall be provided in the electrical service entrance room, the main telephone room, the generator room, and the elevator machine room.

12.0 Field testing of the generator shall include a full load test for a minimum 4-hour period with temporary resistive load banks and installation acceptance tests as required by NFPA 110 including cold start and load acceptance tests. Provisions for periodic maintenance testing of the generator under building load (minimum 30% of nameplate rating) shall be included in the design.

END OF SECTION

SECTION 16610 – "STATIC UPS"

1.0 The system shall be designed in accordance with ANSI C62, CBEMA, NEMA, NFPA 70, UL 94, 1778.

2.0 Submit shop drawings showing dimensions, weights, interconnections, heat load, temperature requirements, description of operation.

3.0 Submit the size and location of service organization. Maximum response time shall be four (4) hours.

4.0 The UPS shall be sized to accommodate present loads, anticipated future loads, plus thirty (30) percent capacity. The design professional shall determine reliability requirements and design appropriate system.

5.0 The UPS shall include a maintenance bypass switch.

6.0 The UPS shall be placed in an environment to maximize unit life and reduce maintenance costs.

7.0 The sizing of battery systems and length of back-up time shall be closely coordinated with the University. Generally, battery capacity will be sufficient for 15 minutes of full load operation. The need for standby generator power to the UPS will be investigated with the University.

8.0 UPS shall be factory and field tested.

END OF SECTION

SECTION 16670 – "LIGHTNING PROTECTION SYSTEMS"

1.0 A lightning protection system shall be considered for each building. The professional shall review the building and surrounding structures to ascertain the requirements for such a system using NFPA 780 risk assessment calculation and coordinate with the University.

2.0 Any lightning protection system shall meet the applicable requirements of NFPA 780 and UL. The final installation shall meet and shall be certified as a UL Master Label System.

3.0 All air terminals, conductors, electrodes, etc. shall be copper. Care shall be taken to ensure that the copper will not come in direct contact with aluminum.

4.0 The installation shall be under the direct supervision of a L.P.I. (Lightning Protection Institute) certified "Master Installer".

5.0 No combination of materials shall be used that form an electrolytic couple of such a nature that corrosion is accelerated in the presence of moisture. If dissimilar materials are used, provide waterproof seals so that moisture is permanently excluded from the junction of such metals.

END OF SECTION

SECTION 16721-"FIRE ALARM SYSTEM"

1.0 This section is intended to define the general installation and testing requirements for the various fire alarm systems at the University of Pennsylvania. At a minimum, Local and National Codes that govern the layout and installation of the system shall be used during the design process.

2.0 References: National Fire Protection Association (NFPA):

A. 70 National Electrical Code (NEC).

B. 72 National Fire Alarm Code.

C. 90A Installation of Air Conditioning and Ventilating systems.

3.0 Underwriters' Laboratories (UL): Construct all fire alarm and fire detection equipment in accordance with the following publications:

A. 268 Smoke detectors for Fire protective Signaling Systems.

B. Fire Protection Equipment Directory.

C. Electrical Construction Materials Directory.

D. 38 Manually Actuated Signaling Boxes for Use with Fire-Protective Signaling Systems.

E. 464 Audible Signal Appliances.

F. 521 Heat Detectors for Fire Protective Signaling Systems.

G. National Electrical Manufacturers Association (NEMA): SB4.

H. Factory Mutual (FM) System: Approval Guide.

I. Local Fire Codes – City of Philadelphia Fire Protection Code.

J. Americans With Disabilities Act.

4.0 Quality Assurance:

A. Existing systems: All items of the fire alarm system shall be listed as a product of

the same manufacturer as the existing system. Substitutes will not be accepted.

B. New System: All items of the fire alarm system shall be listed as a product of a single fire alarm system manufacturer under the appropriate category by Underwriters Laboratories, Inc. and shall bear the "UL" label. All control equipment to be listed under UL as a single control system.

5.0 System Description:

A. General: Operation shall be such that actuation of any initiating device (manual station, automatic sprinkler system, automatic smoke detector, heat detector, etc.) shall cause the system to enter alarm mode. The system shall be electrically supervised for all initiating circuits, alarm signal sounding circuits and power supply circuits.

B. Operation: The actuation of any manual or automatic device shall cause a signal to sound at OCC (Operations Control Center) Penn Com, University's Monitoring System. General evacuation shall be initiated automatically.

1. Initiating devices shall provide the appropriate pre-alarm, supervisory, or trouble signals.

C. All alarm initiating devices shall indicate individually on each alphanumeric display. Devices will have a descriptive message and condition message, and will identify the area causing an alarm or trouble condition, geographically by floor.

6.0 Alarm Zones: Each manual pull station, area or duct smoke detector, heat detector, sprinkler system water flow switch, and tamper switch shall annunciate as an individual point.

7.0 Coordination: Submit design to Factory Mutual for review and approval prior to bidding documents.

A. At no time shall an existing fire alarm system be put out of service without notifying the University and the Insurance Underwriter. Either a firewatch shall be maintained when an existing system is shut down, or a temporary system installed. The Operations Control Center will notify Factory Mutual and University Police will notify the Philadelphia Fire Department.

B. The fire alarm system shall be tied into the University’s monitoring system at OCC (Operations Control Center) in the Franklin Building. This connection shall include all work (surge suppression devices, wiring, control modules, programming, etc.) to tie into the existing Digitize 3000 System Campus Reporting System via dedicated

(dry) telephone line.

8.0 Products: Manufacturer all system components shall be the standard product of FCI (Fire Control Instruments) or Gamewell. Alternates will not be accepted.

A. Fire Alarm Control Panel:

1. The fire alarm control panel shall be FCI 7200 Series, or Gamewell.

B. The FACP shall be of the addressable type and come equipped with features necessary to perform required functions and as specified as follows:

1. 80 character, backlit liquid crystal display.
2. Individual red system alarm LED.
3. Individual yellow supervisory service LED.
4. Individual yellow trouble LED.
5. Green "power on" LED.
6. Alarm Acknowledge Key.
7. Supervisory Acknowledge Key.
8. Trouble Acknowledge Key.
9. Alarm Silence Key.
10. System Reset Key.
11. LED testing.
12. Alarm verification functions.
13. Alarm trouble and abnormal condition listing.
14. Enabling and disabling of each monitor point separately.

C. Control Panel shall comply with all the applicable requirements of UL 864. The loss of primary power or the sequence of applying primary or emergency power, shall not affect the transmission of alarm supervisory or trouble signals.

9.0 Addressable Devices:

A. Communicationwith Addressable Devices: The system must provide communication with all initiating and control devices individually. All of these devices are to be individually annunciated at the control panel and the remote annunciator. Annunciation shall include the following conditions for each point.

1. Alarm.
2. Open.
3. Short.
4. Ground.

5. Device fail/or incorrect device.

B. All addressable devices shall have the capability of being disabled or enabled individually.

C. Identification of Addressable Devices:

1. Each addressable device shall be uniquely identified by an address code. The use of jumpers to set address will not be acceptable due to the potential of vibration and poor contact. Device identification schemes that do not use uniquely set addresses but rely on electrical position along the communication channel are unacceptable. The system shall accommodate the addition of an addressable device between existing devices and shall not require reprogramming existing devices.

10.0 Manual Pull Stations:

A. The stations will be red with painted white, raised lettering. The station will mechanically latch upon operation and remain so until manually reset by opening with a key common to all system locks. Pull stations will be double action.

B. The front of the station is to be hinged to a backplate assembly and must be opened with a key to reset the station. The key shall be common with the control panels. Stations which use allen wrenches or special tools to reset, will not be accepted.

C. Each pull station shall be identified with the following sign: "IN CASE OF FIRE SOUND ALARM AND CALL FIRE DEPARTMENT" and shall be provided by the installing Contractor.

D. ADA Strobe: Strobes shall be of the synchronized type. Candela ratings shall be in accordance with ADA, UL 1971 and NFPA-72 requirements.

E. Horns shall provide a sound of 96 dBA at 10'. In residential units, the sound level shall be a minimum of 70 dBA at the pillow and field testing shall confirm sound levels prior to installation horns.

11.0 System Expansion:

A. Provide audible and visual circuit loading such that all devices receive full power and such that no circuit contains more than 60 percent of the manufacturer's rated capacity of devices.

B. Provide addressable circuit loading such that no addressable circuit or loop contains more than 75 percent of the manufacturer's rated capacity of devices.

12.0 Emergency Power Supply: Power Requirements:

A. Provide sufficient standby battery capacity to operate the entire system upon loss of normal power for a period of 24 hours in a standby mode plus 10 minutes in alarm mode. In addition, provide an additional 20 percent spare standby battery capacity. All battery charging and recharging operations shall be automatic. Batteries shall be brought from fully discharged to fully charged condition within 48 hours.

B. Batteries: Storage batteries shall be sealed, lead calcium type requiring no additional water.

C. Battery charger shall be completely automated with high/low charging rate. Charger shall be located in FACP.

D. Power supply shall be connected to the building's emergency circuits.

13.0 Heat Detectors: Automatic heat detectors shall be of the analog addressable type with fixed temperature/rate-of-rise sensors as required by application.

14.0 Smoke Detector: Ceiling mounted smoke detector shall be of the analog addressable photoelectric type with plug-in base and auxiliary relay contacts.

15.0 Remote Annunciator: Alphanumeric liquid crystal display (LCD) type.

16.0 Identification and Labeling - Conductors:

A. All circuit conductors shall be identified within each enclosure where a tap, splice or termination is made.

B. Each cable shall be identified as to service within each enclosure, pull box and junction box.

C. Conductor and cable identification shall be by single piece, plastic coated self-laminating printed markers, or by heat-shrink type sleeves. Markers shall be attached in a manner that will not permit accidental detachment.

D. All cables shall be installed in conduit.

17.0 Training:

A. Training sessions shall be held for University employees. All training shall be held in a classroom type atmosphere. The amount of training and the duration of each training session shall be coordinated with the University. Training manuals shall be provided for all attendees.

18.0 Testing - General:

A. Testing of the fire alarm system shall meet the requirements set forth in NFPA 72. Testing shall be performed in the presence of N-Tech Company and the University of Pennsylvania.

B. Each portion of the fire alarm system shall be tested prior to being placed into service.

C. At the conclusion of the work and prior to final payment, a complete system acceptance test shall be conducted. Tests shall include interfaces from the fire alarm system to the elevator system, door interlocks, and other interconnected systems. The system shall not be accepted until all testing is complete and the entire system is fully functional.

19.0 Software: Three (3) copies of the software shall be given to the University representatives to distribute to OCC, University Engineering Office, and operating personnel.

A. Locations of devices: According to NFPA 72 and other applicable codes and standards.

B. In mechanical rooms no smoke detectors shall be installed. Provide only heat detectors and horn strobes..

C. Minimum amount of smoke detectors required by code. Only photoelectric smoke detectors are permitted in University Buildings.

D. All devices shall be accessible in lobbies or high reach areas. Beam detectors shall be installed in areas where area smoke detectors cannot be easily reached for service and maintenance.

E. Horn strobes must be audible or visible in all parts of building including mechanical rooms, etc. The use of horns should be limited in exit stairwells, especially in high rise buildings where building occupants must remain in the stairwells while existing during an emergency. Strobes should be considered as an alternate.

F. Performance testing is the responsibility of the installer and will be witnessed by the Department of Fire and Emergency Service (OFES). The installer shall provide all equipment required for testing and provide three (3) copies of the point list and set of location plans to OFES.

G. When connecting to an existing system:

1. During the design process advice and permission shall be obtained from the University Engineering Office.
2. Recertification and testing of the entire building's fire alarm system will be required by the City of Philadelphia.

END OF SECTION

SECTION 16741 – "DATA, VOICE AND VIDEO PATHWAYS"

1.0 The design shall provide and document all pathways required for data, voice, and video systems. The system design shall be based on the University of Pennsylvania's "Construction Specifications for Data, Voice, and Video Communication Networks at the University of Pennsylvania".

2.0 All design pathways shall be closely coordinated with the University's ISC Networking Group and the Telecommunications Group and approved by same.

3.0 The design shall document service entrance raceways, raceways and pathways within the building. Wiring and devices will be provided by the University.

4.0 Pathways shall include 1-inch conduit drops from above accessible ceiling to outlets. Provide cable trays above suspended ceilings and in telephone switch rooms for backbone cabling and horizontal distribution.. Cable trays shall be ladder type with both siderails supported. Center hung tray is unacceptable.

5.0 Cable trays shall be sized to allow for 100 percent expansion of telephone/data wiring.

END OF SECTION

SECTION 16911 – "ELECTRICAL MONITORING & CONTROL SYSTEM"

1.0 System design shall include all components, system software, system hardware, testing, training, supervision of installation, and connection to University Comdale (BAC) system.

2.0 System Monitoring Functions:

A. The system shall be capable of monitoring the following functions:

1. Secondary Substation:
   a. Main 480 volt circuit breaker(s) position.
   b. Main breaker(s) instantaneous amperes

2. UPS System:
   a. UPS common trouble alarm point.

3. Generator:
   a. Generator common trouble.
   b. Fuel tank low level alarm points.
   c. Run Status: Run selector switch in automatic and Generator Supplying Load.

4. ATS Status:
   a. Switch connected to Normal Source.
   b. Switch connected to Emergency/Standby Source.

END OF SECTION