DIVISION 16 - ELECTRICAL

16000 GENERAL

A. Design Considerations

1. All drawing, specifications and construction shall conform to the following:

   National Electrical Code
   National Electrical Safety Code
   National Fire Protection Association Codes
   N. J. Uniform Construction Code
   Occupational Safety and Health Administration Regulations
   Factory Mutual Regulations

2. Equipment and materials shall conform to:

   Underwriters Laboratories listed
   National Electrical Code
   American National Standards Institute
   National Electrical Manufacturers Association
   Institute of Electrical & Electronics Engineers
   Insulated Cable Engineers Association

3. Three copies of the following shop drawings should be requested from the Contractor for review by Rutgers, in addition to the normal A/E review:

   a. High Voltage Transformers

   b. High Voltage Switchgear

B. Special Documentation Requirements

RESERVED

C. Materials and Methods of Construction

RESERVED

16055 OVERCURRENT PROTECTIVE DEVICE COORDINATION

A. Design Considerations

1. Overcurrent protective device coordination must be performed for all electrical projects by the design engineer, using the latest computer software

B. Special Documentation Requirements

1. The engineer of record shall provide a Short Circuit and Protective Device Coordination Study.

C. Materials and Methods of Construction

RESERVED

16060 GROUNDING AND BONDING

A. Design Considerations

1. Service grounding electrode shall be on the street side of cold water valve and also provide a made grounding system. A reference only to the National Electrical Code and/or specifying requirements only by referencing the code are not acceptable.

2. Buildings with sensitive electronic equipment associated with high technology research shall have a building ground ring. This should be established and discussed with Rutgers.

3. Building's grounding system must have one test well installed.

4. An isolated ground shall be provided where required for designated sensitive electronic equipment in any facility. An isolated ground bus must be provided in the source panel and connected back to the service ground point by an insulated ground conductor.

5. A system ground shall be provided for each separately derived system including service entrance, each voltage level, and generators.

B. Special Documentation Requirements

1. Drawings shall show ground systems, protective conduit sizes, and relative locations. Specifications and drawings shall include detailed requirements of the grounding system. A reference only to the National Electrical Code and/or specifying requirements only be referencing the code are not acceptable.

C: Materials and Methods of Construction

1. Ground connections shall be made by the exothermic process to form solid metal joints.

2. Provide an equipment-grounding conductor in each of the following conduits and connect to the grounding system at each end:

   a. In each run of non-metallic and metallic conduit.

   b. In each feeder from main panelboard to each panelboard.

   c. In each run of metallic conduit that includes a section of flexible or liquid-tight conduit.

3. Each circuit shall have a dedicated ground. Sharing of grounds will not be allowed.

4. Grounding conductor in metallic conduits shall be 600 volt green insulated copper conductor sized per NEC code. Where a shock hazard to personnel may exist by the frequent and continued contact with machines or equipment (fixed or portable), a wire equipment ground shall be installed in the branch circuit conduits and be grounded to the cabinet of the panelboard by an uninsulated ground bus. The neutral bar of the panel shall not be used for equipment grounds.

5. The complete electrical installation shall be permanently and effectively grounded per code. This includes switchboards, panelboards, cabinets, transformer neutral, transformer ground pad, motor frames, motor starters, lighting fixtures, lightning arresters, conduit systems, and all non-current carrying metal parts of electrical equipment. Steel frame buildings shall be grounded through a low resistance ground system.

6. Convenience outlets shall have a wired ground for continuity of ground path from the device-grounding pole.

7. Provide a driven ground rod at outdoor lighting poles for equipment grounding, and provide an equipment ground wire in PVC underground conduits to the poles.

8. A system ground shall be provided for each separately derived system including service entrance, each voltage level, and generators.

16071 SEISMIC CONTROLS FOR ELECTRICAL WORK

RESERVED

16072 ELECTRICAL SUPPORTS AND SEISMIC RESTRAINTS

RESERVED

16075 ELECTRICAL IDENTIFICATION

RESERVED

16080 ELECTRICAL TESTING

A. Design Considerations

1. In addition to requirements specified elsewhere, report the following:

   a. Manufacturer's written testing and inspecting instructions.

   b. Calibration and adjustment settings of adjustable and interchangeable devices involved in tests.

   c. Tabulation of expected measurement results made before measurements.

   d. Tabulation of "as-found" and "as-left" measurement and observation.

B. Special Documentation Requirements

1. Provide three (3) certified copies of all test reports, completed by the independent testing agency.

C: Materials and Methods of Construction

1. Testing Agency Qualifications: As specified in each Section containing electrical testing requirements and in subparagraph and associated subparagraph below.

    a. Independent Testing Agencies: Independent of manufacturers, suppliers, and installers of components to be tested or inspected.

    b. Testing Agency's Field Supervisor for Power Component Testing: Person currently certified by the International Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Division 16 power component Sections.

2. Test Equipment Suitability: Comply with NETA ATS, Section 5.2.

3. Test Equipment Calibration: Comply with NETA ATS, Section 5.3.

4. General Tests and Inspections: Prepare systems, equipment, and components for tests and inspections, and perform preliminary tests to ensure that systems, equipment, and components are ready for independent agency testing. Include the following minimum preparations as appropriate:

    a. Perform insulation-resistance tests.

    b. Perform high potential testing.

    c. Perform continuity tests.

    d. Perform rotation test (for motors to be tested).

    e. Provide a stable source of single-phase, 208/120-V electrical power for test instrumentation at each test location.

16115 ELECTRICAL SERVICE AND UNDERGROUND RUNS

A. Design Considerations

1. In all cases, Rutgers University High Voltage Engineer shall be consulted regarding source of power.

B. Special Documentation Requirements

1. The Engineer of Record shall provide the Rutgers University High Voltage Engineer with a detail breakdown of all electrical loads in the building and future expansion.

C. Materials and Methods of Construction

1. The primary or main distribution service voltage utilized at various Rutgers installations are as follows:

   a. Busch Campus: 13,200 volt 3 phase 60 Hz dual loop feed underground distribution from a 26,400 to 13,200 volt Rutgers grounded system. The 26.4 KV service is provided by Public Service Electric and Gas Co. Building unit substations transforms and distributes power within each building.

   b. Cook/Douglass Campus: Depending on actual location, the source can be from a Rutgers 13,200 volt 3 phase loop feed underground distribution system, or a 13,200 volt Public Service Electric & Gas Co. overhead system in which case low voltage service would be requested from the utility.

   c. College Avenue Campus: Source is from a Rutgers 4160 volt 3 phase radial or loop underground system supplied from a 26,400 to 4160 volt grounded system. The 26.4 KV service is provided by Public Service Electric & Gas Co. Building unit substations transform and distribute power within each building.

   d. Livingston Campus: Source is from a Rutgers 13,200 volt 3 phase loop, or a Rutgers 4160 volt 3 phase radial system on poles. Power originates from Busch Campus system.

   e. Camden Campus: 4160 volt 3 phase underground radial distribution Rutgers system. PSE&G Co. supplies the 4160 volt service to Rutgers.

   f. Newark Campus: Source is from a PSE&G Co. 265/460 volt 3 phase 4 wire network system. Distribution is

underground, and Rutgers and the utility company shall be consulted regarding power source location.

g. Other Remote Locations: Rutgers and the utility company shall be consulted regarding power source, location and characteristics.

2. Service runs from existing manholes and/or buildings to new buildings shall be run in duct banks. Duct banks shall use 4" minimum PVC schedule 40 ducts supported on approved spacers and encased in red concrete, and located a minimum of 30" below grade to top of bank. Runs under traffic areas shall be reinforced. Duct bank runs shall be no greater than 300 feet long, unless otherwise approved, and run into manholes as needed to serve the facility.

3. Service runs to outdoor or indoor building unit substations shall be underground conduits two 4" schedule 40 PVC runs minimum; use four 4" PVC if for loop feed service; and encase in red concrete. Low voltage service runs to buildings shall be sized per load being served and shall include a minimum of 2 spare ducts.

4. Duct run terminations shall be made using rigid galvanized steel conduit. Slope duct runs into manholes to drain, and runs shall be essentially straight between manholes. Ducts shall be run below gas lines, and where ducts cross high temperature water lines a minimum separation of 3 feet shall be maintained, and a minimum of 6" thick foamglass type insulation extending at least 4 feet in both directions of crossing shall be used.

5. Manholes:

a. Construction: Electric manholes shall be a minimum of 8 feet square and 8 feet deep at the inside dimensions. Telephone/Communication manholes dimensions shall be per Section 16700. Hardware shall include pulling eyes and inserts, and plastic cable racks. Concrete shall be 4000 psi at 28 days, with re-bar reinforcement. Precast manholes are preferred.

b. Drains: Manholes shall be provided with a drain to the storm sewer that will not backwash and shall have a sump cast into the floor next to the ladder into which a portable sump pump can be installed. Floor shall slope to sump.

c. Covers: Manhole covers shall be round, having a standard manhole frame and cover. The cover shall be 30" in diameter and have the word ELECTRIC or TELEPHONE cast into it. Install frame and cover assembly on at least 4 courses of brick or precast concrete rings to allow adjustments to surrounding finish grade. Manholes shall be labeled as confined spaces.

d. Ground: A copperweld ground rod shall be installed in each manhole for bonding of hardware and cable sheaths.

16120 WIRE AND CABLE

A. Design Considerations

1. All electrical circuits will have dedicated grounds and neutrals.

B. Special Documentation Requirements

RESERVED

C. Materials and Methods of Construction

1. Secondary Distribution:

a. Wire for low voltage (600 volts and below) circuits shall be single conductor stranded copper of not less than 98% conductivity with 600 volt, Type THHN/THWN insulation. Type XHHW may be used for sizes #2AWG and larger.

b. Metal-Clad cable Type "MC" with THHN insulation rated 600 volts & with an insulated grounding conductor shall be permitted for power and lighting branch circuits on the normal and standby systems where concealed above hung ceilings or in walls. The insulated grounding conductor and the cable sheath shall be bonded to the supplying panelboard and each receptacle or lighting fixture connected to the circuit.

c. Wire and cable shall be No. 12 AWG and smaller, shall be made with approved insulated indentation or spring insert type pressure connectors. Connections and splices in low voltage wire, No. 8 AWG and larger, shall be made with approved insulated spring insert type pressure connectors or bolted or compression-crimped type pressure connectors

covered with an insulating filler tape, "Scotch-fil", or approved equal, and two half-lap servings of vinyl electrical tape, Scotch #33 or approved equal. All taped connections exposed to weather or moisture shall be given two coats of weatherproof insulating paint, Okonite, or approved equal.

d. All conductors shall be color-coded throughout and numbered and tagged to each junction box, pull box, panel and device with suitable fireproof tags or adhesive identification bands. Color-coding of conductors for power and branch circuits shall be as follows:

For 120/208 Volt System	For 277/480 volt System
Phase "A": Black	Phase "A": Brown
Phase "B": Red	Phase "B": Yellow
Phase "C": Blue	Phase "C": Orange
Neutral: White	Neutral: White
Ground: Green	Ground: Green

e. Branch Circuit Feeders: The design shall be for acceptable voltage drop and capacity for 20% load growth above initial design.

f. Branch Circuits: These circuits shall not be loaded to more than 80% of panel breaker ratings. Not more than six unassigned general use duplex convenience outlets shall be on any one 20 ampere branch circuit.

g. Feeder sizes and protections shall not be such a large percentage of the main that coordination of devices cannot be achieved.

h. Use two wire circuits with individual neutral and grounding conductors for all branch receptacle circuits in administrative, office, computer laboratory and classrooms, and general laboratory areas.

2. Primary Distribution:

a. All high voltage cable shall conform in material, construction and tests to all applicable requirements of the Insulated Cable Engineers' Association.

b. All cable for primary service and distribution circuits shall be single conductor, copper conductor, copper tape shielded type with a solid dielectric, vulcanized, rubber-like, elastomeric, thermosetting insulation, ozone-moisture-corona resistant, rated 105° C., and PVC sheath, as manufactured by the Kerite Co. or with an extruded semi-conducting strand screen, okoguard insulation extruded semi-conducting insulation screen, copper tape shield and okolon jacket as manufactured by the Okonite Co., or equivalent as approved by the Rutgers University high-voltage engineer. Cable shall be rated 5KV, or 15 KV depending on distribution system at campus location, and shall have 133% insulation level. Cable shall be UL listed as Type MV-105.

c. All cable in manholes shall be wrapped in two "opposing layers" of fireproofing tape secured in place with glass-cloth binder type. Slack cable shall be provided in manholes by routing the cables by the longest path possible through the manholes.

d. All cables in manholes shall be properly supported on nonconductive cable supports a minimum of every 36". Provide new cable supports in existing manholes as required for proper support of both the new and existing cables.

e. High voltage cables shall be terminated in accordance with the cable manufacturer's recommendations using terminators specifically recommended by the type of cable specified.

f. Terminations and splices shall be performed by a certified experienced cable splicer. Taped "T" splices are not permitted; they shall be made using elastimold, or approved equal, disconnectable fittings.

g. Primary cables shall be color coded at all terminations and in manholes with colored tape:

Phase A: Black

Phase B: Red

Phase C: Blue

h. Cables shall be identified in manholes as to source and destination.

i. Tests: High voltage DC proof tests shall be specified on all primary cable installations in accordance with the cable manufacturer's recommendation and written report shall be supplied to Rutgers.

16122 UNDERCARPET CABLES

RESERVED

16124 MEDIUM-VOLATAGE CABLES

RESERVED

16130 RACEWAYS AND BOXES

A. Design Considerations

1. MC cable is only permitted after a junction box located above the acoustical ceiling (near the area being served) or on the circuit and for flexible connection to recessed or chain hung fixture

2. Underground primary and/or secondary service ductbank must be encased in red concrete, rigid galvanized steel elbows shall be used where the conduit are run through concrete slab

B. Special Documentation Requirements

RESERVED

C. Materials and Methods of Construction

1. Galvanized rigid steel conduit shall be hot-dipped galvanized steel inside and outside comply with UL Standard 6, Federal Specification WW-C-581-D and ANSI C 80.1. Galvanized rigid steel conduit shall be used for the following:

    a. Buried raceways in concrete slabs (except for main services which shall be PVC conduit concrete encased ductbank) or in the ground. Where directly buried, two coats of asphaltic compound shall be applied. Provide approved electrically conductive corrosion resistant compound on all threads.

    b. Interior high voltage runs.

    c. Exposed exterior raceways.

    d. Any raceway in hazardous areas.

    e. Termination of ductbank runs through concrete and into equipment or indoor areas.

2. Electro-Galvanized Steel Metallic Tubing (EMT) shall comply with UL Standard 797, Federal Specification WW-C-563 and ANSI C 80.3. EMT shall be used for the following:

    a. Interior branch circuits exposed, concealed in hung ceilings and wall partitions, in masonry or concrete.

    b. Interior feeders, exposed or concealed.

    c. Interior motor circuit wiring.

    d. Interior control, signal and sound wiring exposed, concealed in hung ceilings and wall partitions.

3. Rigid Plastic Conduit, Schedule 40 PVC, shall be used for the following:

    a. Underground primary or secondary service ductbank encased in red concrete, rigid galvanized steel elbows shall be used where the conduit is run through concrete slab. Also a separate grounding conductor with green insulation shall be provided in these runs.

b. Underground telephone service ductbank encased in concrete.

c. Lightning protection down leads, and individual ground conductors.

d. Buried raceways in concrete slabs.

4. Underground ductbank runs shall be installed minimum of 30" below grade to top of bank, wherever possible. If 30" is not possible, concrete encased ducts may be installed to minimum burial depth stipulated in NEC. Underground runs cable markers shall be installed for all direct-buried cables and cables in non-metallic and metallic raceways. Marker shall be located directly over buried lines at 8 to 10 inches below finished grade. Marker tape shall be standard metallic lined, permanent, bright red colored continuous printed plastic tape for direct burial service, not less than 6 inches wide by 4 mils thick, and printed, "caution electric line buried below."

5. When conduits pass through the buildings exterior walls there shall be a complete link-seal modular seal assembly. A completely assembly shall consist but not be limited to the following:

a. Wall opening (i.e. steel sleeve, thermoplastic sleeve, cored hole).

b. Sufficient quantity and type of Link-Seal modular seals required to effectively provide a hydrostatic and fire rated seal.

c. Each individual link shall be conspicuously and permanently identified with the name of the manufacture and model number.

6. Liquid-Tight Flexible galvanized steel conduit with continuous copper bonding conductor shall be used for connection, not exceeding 18" in length, to all motors, heating and ventilating controls, and at other locations where vibration, movement, moisture, or oil-vapor atmosphere are encountered.

7. Hot-Dipped galvanized, single strip flexible steel conduit, not exceeding 6' in length shall be used for connections to recessed and chain hung lighting fixtures.

8. Metal-clad cable type "MC" with THHN insulation rated 600 volts and with an insulated grounding conductor shall be permitted for

branch circuits where concealed above hung ceilings or in furred partitions where permitted by code. MC is only permitted after a junction box located above the acoustical ceiling (near the area being served) or on the circuit and for flexible connection to recessed or chain hung fixture. Only EMT conduit shall be allowed to terminate in the electrical panels. All MC cable must be properly supported and run in a neat workman-like manner.

9. Plastic jacketed rigid steel galvanized conduit shall be used in corrosive atmospheres.

10. Rigid aluminum conduit may be used in lieu of rigid steel conduit, except where in contact with or in earth, concrete or masonry.

11. Conduit shall be 3/4" size minimum. Flexible steel conduit of 1/2" diameter may be used for connections to recessed and chain hung lighting fixtures.

12. Where empty conduits are required to be installed, provide a continuous #12 nylon draw line with identification tag securely attached to both ends.

13. Suitable expansion and deflection fittings with grounding continuity shall be provided in each conduit run at each point where the conduit run crosses a building expansion joint.

14. All wiring shall be installed concealed in ceilings, walls, slabs, pipe chases and furred spaces whenever possible. Conduit may be installed exposed only in Mechanical Room, Electrical Room and Janitors Closets. Concealed conduit shall be installed in a direct line, with bends as long as practicable. Exposed conduit shall be installed parallel to or at right angles with the lines of the Building, as closely as possible to walls, ceilings, columns and other structural parts, consistent with proper space for access to boxes and so as to occupy a minimum of space. Where exposed conduits are grouped, they shall be run parallel and equally spaced.

15. Surface metal raceways with snap-on covers shall be used for exposed runs in finished areas, for counter and workbench power and data outlets where required. Acceptable manufacturers are Wiremold, Mono-Systems and Isoduct.

16. All outdoor boxes to be NEMA3R with MYERS HUBS. Conduit penetrations shall be limited to the sides and/or bottom. Conduits shall **not** enter the top of the boxes without prior approval.

16138 UNDERFLOOR RACEWAYS

RESERVED

16139 CABLE TRAYS

RESERVED

16140 WIRING DEVICES

A. Design Considerations

RESERVED

B. Special Documentation Requirements

RESERVED

C. Materials and Methods of Construction

1. Local wall switches shall be heavy duty specification grade, toggle, quiet type, ivory, fully enclosed in composition cases, rated 20 amp. 120/277 volt AC; Hubbell #1221 Series, or approved equal.

2. Receptacles generally shall be duplex, specification grade, 2 pole, 3 wire grounding type conforming to latest NEMA standards for 20 amp, 125 volt with back and side wiring, ivory; Hubbell #5362, or approved equal.

3. Receptacles for use with specific equipment, special applications, etc. shall be suitable for the load to be served and of proper configuration for the mating plug.

4. Switches and receptacles for wet hazardous areas shall be an approved type for the environment served.

5. Receptacles fed from emergency power upon failure of normal power shall have cover of steel with red baked enamel and word "EMERGENCY" engraved in white letters on cover.

6. Ground fault interrupter type receptacles shall be duplex 120V. AC 15 or 20 amp as required, Class A.

7. Device plates, telephone outlet plates, and blank plates in finished areas shall be .04 gauge 302 stainless steel with brushed finish.

8. Surface mounted multi-outlet system:

   a. Multi-outlet systems shall consist of surface mounted metal raceways for use with number and type of wiring devices as required. Systems shall be complete with all fittings, etc. and shall be equal to Wiremold 2000 and G-3000.

   b. Systems requiring combination power and telephone/communication multi-outlet with divider shall be equal to Wiremold G-4000 and G-6000 as required.

9. Provide 20 amp duplex outlets at each floor landing of each stair. Provide at least one 20 amp duplex outlet in corridors and space such outlets at 75 feet on center in all corridors.

10. All receptacles shall have engraved nameplates fastened to the cover plate, stating the panel and circuit number.

11. All receptacles protected by a Ground Fault Interrupter shall have engraved nameplates fastened to the cover plate, stating that a Ground Fault Interrupter protects the circuit.

16145 LIGHTING CONTROL DEVICES

A. Design Considerations

RESERVED

B. Special Documentation Requirements

RESERVED

C. Materials and Methods of Construction

1. Timers and photo-electric control shall be used for all entrance site lighting.

2. Occupancy sensors and daylight harvesting shall be utilized for interior lighting control for energy conservation that produce a payback in 7 years or less. The designer shall review the application of the required sensors for the various areas throughout a facility. Sensors shall not be used in areas such as corridors, stairwells, laboratories, public areas, lobbies, mechanical &

electrical rooms, and any other area where a safety hazard may be created by lights going off automatically.

3. The use of multiple switching shall be evaluated for each space and condition. Where possible, switching shall be used to effectively reduce artificial lighting near window, permit light reduction for non-critical tasks and during partial occupancy, and reduced lighting for custodial activity.

4. All exterior and security lighting shall be powered from one location in the building - namely, the main electrical room.

5. Where dimming control is required, it shall be normally used to control incandescent lighting only. Dimmable fluorescent or H.I.D. lighting must be approved by Rutgers Project Manager before design of the system. Fluorescent or H.I.D. lighting shall be provided as the primary lighting source with the dimmable incandescent system as secondary.

6. Remote switching by means of central control shall be evaluated for special areas.

7. All switches shall have engraved nameplates fastened to the coverplate stating the panel and circuit number.

16211 ELECTRICITY METERING

A. Design Considerations

RESERVED

B. Special Documentation Requirements

1. Provide the University Electrical Engineer with certified documentation from Square “D” verifying the meter was commissioned and calibrated to the manufacturer’s specifications.

C. Materials and Methods of Construction

1. The main distribution equipment shall be equipped with Owner's metering section with Digital SQUARE “D” POWERLOGIC CM3350 meter or latest version (no substitutions). Meter to be equipped with a communicated module wired to the building’s

telecommunications closet. Coordinate the telecommunication wiring with RUNET personnel.

16215 ELECTRICAL POWER MONITORING AND CONTROL

RESERVED

16231 PACKAGED ENGINE GENERATORS

A. Design Considerations

RESERVED

B. Special Documentation Requirements

1. Specifications on any proposed fuel burning emergency generator must be provided to REHS for State permitting prior to installation.

C. Materials and Methods of Construction

1. Emergency Light and Power:

   a. During the design development phase of any facility, the extent of emergency lighting and power required shall be determined in order to establish the alternate power source. The total requirement shall dictate the use of engine generator, local battery or central battery stand-by sources. Location of exhaust outlet must not be located where it would affect building occupants.

   b. Buildings requiring only emergency lighting should be handled through emergency generator, local battery, central battery system based on type of construction and economics of system:

      1) New Construction: Emergency Generator ONLY. Acceptable manufacturer is Caterpillar. No substitution will be accepted.

      2) Renovation Project: Emergency generator, local battery, or central battery system, based on economics of system and prior approval from Vice

President of Facilities Maintenance and University Architect.

c. Buildings requiring operation of motor driven equipment, and/or elevator, as well as emergency lighting, shall use engine generator unit as the standby source.

d. Emergency generator drives shall be natural gas fuel where available at site and shall be equipped with heat exchanger for city water cooling. If natural gas is not already available near site, then diesel fueled type with minimum of 8 hour operation fuel tank built into base of unit, wherever possible. When diesel fueled generators are used, a fuel containment pad must be designed per all State and Federal regulations.

e. Emergency system wiring shall be in separate conduits, and its distribution through separate panelboards and motor control centers, etc., as required for a complete system to serve exit lights, safety lighting in corridors and stairwells, in general assembly areas, and Mechanical Equipment Rooms and electrical rooms, for essential loads, for security systems, fire alarm, and as required.

f. All emergency system wiring, conduits, panelboards and equipment/fixtures shall be labeled.

g. Emergency lighting shall be provided in toilet areas, outdoors at all egress doors, in all lecture halls and in laboratory areas.

h. Emergency and Exit lights shall be connected to the engine generator when a generator exists in the building.

2. Electrical provisions for elevators:

a. Power wiring shall be run to the elevator line terminals and a circuit breaker line switch provided adjacent to elevator controller.

b. An emergency circuit to mid-point of the hoistway shall be provided in each elevator pit.

c. A light, light switch, and convenience duplex GFI receptacle shall be provided in each elevator pit.

3. Cathodic Protection: When such protection is determined to be required for underground piping systems, see mechanical section for protection method.

16264 STATIC UNINTERRUPTIBLE POWER SUPPLY

RESERVED

16265 CENTRAL BATTERY INVERTERS

RESERVED

16269 VARIABLE FREQUENCY CONTROLLERS

RESERVED

16271 MEDIUM-VOLTAGE TRANSFORMERS

RESERVED

16280 POWER FACTOR CORRECTION CAPACITORS

RESERVED

16300 UNIT SUBSTATIONS

A. Design Considerations

1. Buildings and their equipment shall be served by unit substations, where applicable, as required for the load. Generally substations shall be single ended type, and the secondary or building distribution system voltage shall be as follows:

   a. 480Y/277 volt 3 phase 4 wire 60 HZ for buildings with large power loads utilizing 277 volt for most lighting, and small 480 to 120/208 volt transformer for receptacles, lighting and small equipment loads as required.

   b. 208Y/120 volt 3 phase 4 wire 60 HZ for buildings with small power loads that can be readily served by this voltage.

c. Buildings requiring almost equal quantities of both a. and b. above should be served by two unit substations, one for each low voltage service.

d. Double-ended substations may be used to serve buildings and their equipment when associated with high technology research facilities. This should be established and discussed with Rutgers.

B. Special Documentation Requirements

1. The engineer of record shall perform a coordination study and a short circuit analysis of the new electrical distribution system.

C. Materials and Methods of Construction

1. Type and Location of Building Substations:

a. Outdoor compartmental type pad mounted, completely enclosed, liquid filled (Envirotemp FR3 oil) power transformer with load break primary disconnect, or two "on-off" load break disconnects for loop feed service where required by campus distribution, primary fuses, and lightning arresters may be used to serve the building. This shall be located close to building electrical equipment room to keep secondary runs from outdoor transformer to indoor main distribution switchboard as short as possible. Main power distribution switchboard shall be located in building electrical room, NEMA 1 construction. The secondary power distribution switchboard shall be similar to that below for indoor units.

b. Indoor unit substation shall consist of a load break primary disconnect, or two "on-off" load break disconnects for loop feed service where required by campus distribution system, primary fuses, primary lighting arresters; dry type ventilated power transformer; and main secondary power distribution switchboard. Unit substations shall be provided as a completely enclosed, integrated and coordinated line-up by the manufacturer. The two primary "on-off" load interrupter switches for loop feed shall be in individual vertical section connected together on the load side and key interlocked to prevent both incoming circuits from being connected to transformer at the same time. Primary sections shall be equipped with copper ground bus. Incoming primary service shall be underground wherever possible. Primary fuses shall be disconnect type S & C type SM5, or

approved equal. Dry-type ventilated transformer to have maximum temperature rise of 80^{o} C. maximum ambient, to be equipped with provisions for forced cooling, to have 4 - 2-1/2 full capacity taps in high voltage winding 2 above and 2 below normal, and ground pad. Main secondary switchboard shall be front accessible, with vertical sections as required bolted together to form one metal enclosed rigid switchboard constructed to NEMA PB-2 and UL 891 standards. It shall be equipped with Owner's metering section with digital SQUARE "D" POWERLOGIC CM3350 meter or latest version (no substitutions). Unit shall have a main circuit breaker, and feeder branch circuit breakers as required to serve loads plus two spare feeder breakers. Rating of main bus, circuit breakers, etc. shall be determined based on building transformer rating and building distribution system to serve loads. Interrupting capacity shall be determined and noted on system one line diagram main buses and equipment. Provide a ground copper bus in switchboard for its entire length firmly secured to each vertical section. Provide 20% space for future breakers. Incoming secondary service shall be underground wherever possible. Breaker loading shall be maximum of 80% of its rating unless breakers are specified and available as fully rated units for switchboard service. Each breaker on the switchboard assembly shall have an engraved lamacoid nameplate to designate load served.

c. Selection of a. or b. above will depend on site location of new facility, indoor space availability for mechanical and electrical equipment, etc. and shall be determined by discussions with Rutgers.

2. Secondary Distribution Systems: Due to the increasing use of solid state devices for personal computers, data processing units, electronic ballasts, and variable speed drives in a facility, the building electrical system in a facility must be designed to accommodate these non-linear loads. Where these loads are prevalent, the design must include transformers designed for non-linear load application, and oversizing of distribution panel neutrals as well as the neutral conductors of the system feeding these panels.

16442 PANELBOARDS

A. Design Considerations

1. Provide all electrical panels with a main breaker. 100 Amp. Bus minimum.

2. No riser panels allowed without the University's prior approval.

3. Designed with 20% spare capacity minimum per panel.

4. Provide all electrical closets with two (2) 4" sleeves on every floor down to the main electrical room.

B. Special Documentation Requirements

1. The Engineer-of-Record shall perform a coordination study, a short circuit analysis and an arc flash hazard analysis of the new electrical distribution system.

2. Hazard Labeling for electrical shock and arc-flash:

   a. Switchboards, panelboards, industrial control panels, and motor control centers in other than dwelling occupancies, which are likely to require examination, adjustment, servicing, or maintenance while energized, shall be field marked to warn qualified persons of potential electric arc flash hazards and electrical shock. The marking shall be located so as to be clearly visible to qualified persons before examination, adjustment, servicing, or maintenance of the equipment.

   b. The specific additional information that should be added to the label includes:

      1) Available Short-Circuit Current;

      2) Flash Protection Boundary;

      3) Incident energy at 18 inches expressed in cal/cm2;

      4) PPE required;

      5) Voltage shock hazard;

      6) Limited shock approach boundary;

7) Restricted shock approach boundary;

8) Prohibited shock approach boundary.

C. Materials and Methods of Construction

1. All panelboards shall be rated for the intended voltage and shall be in accordance with Underwriter's Laboratories, Inc., standards for panelboards and standards for cabinets. Panelboard boxes shall be so labeled.

2. Construction:

a. Panels shall consist of factory completed dead-front assemblies of sheet steel cabinets, main buses, over-current and switching units and sheet steel trim and panel doors.

b. Boxes shall be 20 inches wide and fabricated from unpainted, galvanized code gauge sheet steel having multiple knockouts with lapped and screwed or welded corner construction. Boxes shall be of sufficient size to provide a minimum gutter space in accordance with NEC Tables 373-6(a) and (b), but not less than four inches at the side and six inches at top and bottom. Multi-section panelboards shall be provided with a minimum top and bottom gutter space of 8 inches. Where feeder cables supplying a panel are carried through its box to supply other panels the box shall be provided with a separate barriered side gutter. Cables shall be bundled, routed and supported within the gutters. This wiring space shall be in addition to the minimum gutter space specified above. A minimum of four interior mounting studs shall be provided.

c. Trims shall be fabricated from code gauge galvanized sheet steel. Trims shall be fastened to cabinets by means of machine screws with captive nuts or clamps and shall be self-supporting on the cabinet after trim holding screws have been removed. Trim for flush panels shall overlap its respective box by at least 3/4 inch all around. Surface trim shall have the same width and height as its respective box. Doors and trims shall each be in one piece so designed that door will close without a rabbet.

d. Panel doors shall be fabricated from the same material as the panel trim and shall be fastened thereto by continuous concealed hinges. Doors shall be so installed that no live

parts are exposed when the door is opened. Doors shall be complete with flush type combination lock and catch with keys. Doors over 48 inches high shall be provided with vault handle, built-in locks and three point catch fastening door at top, bottom and centers. All panels shall be keyed alike. Doors shall be provided for access to contactors, time clocks, relays, and similar devices as required.

e. Panels shall be equipped with hinged 1-piece door.

f. Backbox interiors, inside trim, door and exterior shall be treated with a rust inhibiting phosphatized coating after pickling and finished in ANSI-61 gray enamel. A typewritten directory, eight inches by ten inches, with metal frame and clear plastic face shall be furnished and installed upon the inside of the door of each panelboard, indicating the room or area and the service controlled by each circuit.

g. Bus bars shall be hard drawn copper and extend the full height of the panel without reduction. Buses shall be arranged for sequence phasing of branch circuits. Circuit loading shall be distributed evenly over all phases. The neutral bus shall have a suitable lug for each outgoing branch circuit requiring a neutral connection. Neutral bus shall be full size and electrically isolated from the cabinet. Ground bar shall be bare, uninsulated, and suitably bolted to the cabinet for equipment grounding. Busing shall be braced throughout to conform to industry standard practice governing short circuit stresses in panelboards. Bracing shall be equivalent to, or compatible with, the rated interrupting capacity of the smallest overcurrent device in that panelboard. Spaces for future devices shall be bussed for the maximum device that can be fitted into them with suitable insulation and bracing to maintain proper short circuit rating. All provisions shall be made for ready insertion of future protective devices. Provide an isolated ground bus where required by special sensitive equipment.

h. All interiors shall be completely factory assembled with switching and protective devices, connectors, etc. They shall be so designed that switching and protective devices can be replaced without disturbing adjacent units and without removing the main bus connectors and shall be so designed that circuits may be changed without machining, drilling or tapping. Branch circuits shall be arranged using double row construction.

i. Multiple section panels shall have feed-thru lugs with full capacity taps to adjacent panel sections.

j. Lighting and power panels for 480Y/277 volt system, and receptacle, appliance and power panels for 208Y/120 volt system, shall be of the bolted circuit breaker type with single, two and three pole branches of quantity and trip setting as required. Panelboards shall be furnished with main overcurrent interrupting devices consisting of circuit breakers of size and capacity as required.

k. Multiple cable lugs for incoming feeder cables shall be furnished where required. Lugs shall be secured to bus by stud bolts. Where several panels are fed by one feeder, solid tap connections shall be made in separate side gutters as required with tap connectors. Suitable lugs or connectors shall be provided for connecting feeders. Tap connections to multiple lug feeders shall be made to all lugs at each tap joint.

l. When lighting circuits are switched in groups, these circuits shall be controlled by contactors mounted under a separate door in the lighting panel.

3. Circuit Breakers:

a. Circuit breakers shall be of the molded case, bolted in type consisting of the number of poles and ampere ratings as required. Two and three pole breakers shall be of the common trip type. Handle extensions providing manual operation will not be accepted.

b. Circuit breakers shall be of the indicating type providing "on", "off" and "tripped" position of the operating handle. When the breaker is tripped the handle shall assume a position between "on" and "off" positions. Breakers shall be of the quick-make and quick-break type toggle mechanism with inverse time trip characteristics. Automatic release shall be secured by a bimetallic thermal element releasing the mechanism latch. In addition, a magnetic armature shall be provided to trip the breaker instantaneously for short circuit currents above the overload range.

c. Circuit breakers shall be rated for the voltage of the circuit on which they are used. Circuit breakers with 225 ampere or larger frame sizes shall have interchangeable trips.

d. Locking tabs shall be provided on all circuit breakers serving emergency lighting, fire alarm system, security systems and other emergency or critical equipment.

e. Interrupting capacity of breakers shall be suitable for the power system. Available short circuit currents shall be noted on single line diagram on all major system buses and on panel schedules.

f. Circuit breakers feeding 120 volt lighting circuits that are not controlled by local wall switches shall be approved type "SWD" circuit breakers.

4. Panelboards shall be initially designed to that they are not loaded more than 75%. Provide spare breakers and spare space.

16443 MOTOR CONTROL CENTERS

A. Design Considerations

RESERVED

B. Special Documentation Requirements

RESERVED

C. Materials and Methods of Construction

1. Motor Voltages: Motors 1/2 HP and larger shall be 3 phase 60 Hz, 208 volt or 460 volt based on system secondary distribution. Motors under 1/2 HP shall be single phase 60 Hz, 115 volt or 208 volt.

2. Motor Control: A motor control center shall be provided to handle 3 phase motors in a given area. Single phase motors can be fed from lighting and/or power panels. Motor control circuits shall be 120 volt 60 Hz.

3. Motor starters (Individual), Magnetic Type:

a. Starter units for three phase motors shall be the combination full voltage type, consisting of a magnetic starter containing three manual reset thermal bimetallic overloads and low voltage protection. Each starter unit shall include a circuit breaker (MCP) disconnect for short circuit protection and provisions for locking switch, handle in the "on" and "off" positions. Each starter unit shall be complete with 2 extra normally open interlock contacts. Starters shall be mounted in NEMA 1 enclosure indoors and NEMA 4 outdoors. Minimum size shall be NEMA 1.

b. Units shall be equipped with individual 120 volt secondary control transformers, as required, with two primary and one secondary control fuse. The other secondary lead shall be grounded. Where indicating lights, solenoid valves and additional control components are energized from the control transformer, the capacity of the control transformer shall be proportionally increased.

c. Starter shall have "Hand-Off-Auto" selector switches and indicating red "run" light mounted on the starter. Control units shall be of the heavy duty oil tight type. Lights shall be 120/6 volt type with lamp voltage rated 150% of normal voltage and of the miniature bayonet type only.

4. Manual motor starters for single phase motors shall be 2 pole, have a quick-break, quick-make toggle mechanism that can be locked in "off" position, with a neon pilot light to indicate when motor is running, with thermal overload units as required. Enclosure shall be NEMA 1 for indoors, NEMA 4 for outdoors, or NEMA 7-9 for hazardous areas.

a. Motor control centers shall be NEMA Class 1, Type B wiring. The 480V motor control centers shall consist of independent vertical sections, free standing on 4" channel iron sills, with sections bolted together to make up the center. The section shall be 90" overall height, including the mounting sills. The width of each section shall be 20" (except large starters or other special panels which may be 30" in width). Structure depth shall be 20" and designed to mount starters in the front only. A maximum of six starter units shall be stacked in one vertical section. Terminal blocks for wiring shall be mounted within each starter unit and shall be factory wired. Each section shall be dead front, and rear access shall not be necessary for connections. Removable rear plates shall, however, be employed on the rear of the structure. Pan type doors shall be used for all

units and future spaces. Doors shall be hinged to the structure with a concealed hinge and fastened with pressure type fasteners. The top of each section shall have removable plates for access to the horizontal feeder bus and for conduit entry. A minimum of 12 gauge steel shall be used throughout the structure, including all doors and plates. All painted steelwork shall be treated with a primer coat and a finish coat.

b. The top of each section shall contain horizontal feeder bus bars of tin plated aluminum or copper which shall run continuously through the center from section to section. Provisions shall be made for easy addition and connection to adjacent sections. The horizontal bus shall be sized as required by the load, but in no case less than 600 amperes. The horizontal bus shall be braced to withstand the maximum fault current available at that point. The bus supports shall be formed of high dielectric strength, low moisture absorbing, high impact material with ample creepage distance between bus bars. Each section shall contain 3 vertical bus bars running the full working height of the section and connected to the horizontal feeder bus bars. The vertical bus bars shall be braced to withstand the maximum fault current available at that point. The bus support shall be formed of high dielectric strength, low moisture absorbing, high impact material with ample creepage distance between bus bars. Vertical bus shall be sized as required by the load, but in no case less than 300 amps.

c. Each section shall have a top horizontal wiring trough in front of the main horizontal bus. This wiring trough shall be protected from the horizontal bus bars by means of a steel barrier plate. The wiring trough shall be equipped with cable supports and the structure shall have a cutout in the end for continuous cable runs through the motor control center. A vertical wiring trough shall run the full working height of each section and shall be equipped with cable tie clamps. This vertical wiring trough shall be designed so as to allow installation wiring to the units with the unit doors open, but with the units in place.

d. Motor starter units shall be of the combination type with motor circuit protectors coordinated with motor overload relays. The interrupting rating assigned to the complete combination motor starters shall exceed the system short

circuit capacity at the starter terminals. Starter units shall meet the requirements specified above.

e. A magnetic trip-only molded case circuit breaker which serves as a main disconnect shall be provided where required. A horizontal copper ground bus 1/4" x 1" shall be provided with lugs for termination of the feeder and branch circuit ground conductors. Motor starter units shall connect to the vertical bus bar in each section with stab-on connectors, shall be free-flowing silver plated clips, self-aligning and backed up with steel springs. Units shall be capable of being withdrawn from the structure with a minimum of difficulty. Unit support brackets shall be provided in the structure to properly align the units. Cam latch fasteners shall be employed on each unit to latch the unit in one of two positions in the structure.

1) The engaged position - Stabbed on the vertical bus.

2) The test position - With units withdrawn from the vertical bus, but still supported by the structure. In the test position, the pull-apart terminal block must still be capable of being engaged for electrical testing purposes.

f. In either engaged or test positions, the cam latching mechanism on the unit must be capable of being padlocked to prevent unauthorized movement of the unit. Units shall have complete steel top and bottom plates to provide maximum isolation between units. Units shall be of modular dimensions so that it is possible to readily interchange units of the same size without modifications in the structure.

g. Motor disconnect switch operating handles shall be interlocked with the door so that the door cannot be opened with the switch in the "on" position, except through a hidden release mechanism. The operating handle shall be arranged for padlocking in the "off" position with up to three padlocks. Motor starters shall be built, tested, and sized in accordance with NEMA Standards for Industrial Control, except that no smaller than NEMA Size 1 starters shall be employed in any unit. Motor overload protection shall be effected by three element overload relays with adjustable heater element positions.

h. Engraved nameplates shall be provided for each unit of the motor control center as well as the assembly.

6. Motor Disconnect Switch: Provide a motor disconnect switch for all motors. Switch shall be horsepower rated, heavy duty type, switch blades fully visible in off position when door is open, quick-made and quick-break mechanism, handle positions shall indicate and be lockable in "on" and "off" positions. Enclosures shall be NEMA 1 indoors, and NEMA 4 outdoors. The motor disconnect switch shall be located at or near the motor.

SECTION 16461 - DRY-TYPE TRANSFORMERS (600 V AND LESS)

A. Design Considerations

1. Insulation Class: UL-component-recognized insulation system with a maximum of 80deg C rise.

2. Install floor-mounting transformers level on concrete bases. Construct concrete bases of dimensions indicated, but not less than 4 inches larger in both directions than supported unit and 4 inches high.

3. In areas with large numbers of computers or electronic equipment, K-Factor Rating Transformers shall be used.

4. High efficient copper core transformer shall be used with no exceptions

B. Special Documentation Requirements

RESERVED

C. Materials and Methods of Construction

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Acme Electric Corporation; Power Distribution Products Division.

   b. Challenger Electrical Equipment Corp.; a division of Eaton Corp.

   c. Computer Power Inc.

d. Controlled Power Co.

e. Cutler-Hammer.

f. Federal Pacific Transformer Company; Division of Electro-Mechanical Corp.

g. GE Electrical Distribution & Control.

h. Hammond Co.; Matra Electric, Inc.

i. Jefferson Electric, Inc.

j. Micron Industries Corp.

k. Siemens Energy & Automation, Inc.

l. Sola/Hevi-Duty Electric.

m. Square D/Groupe Schneider NA.

2. Description: Factory-assembled and –tested, air-cooled units for 60-Hz service.

3. Cores: Grain-oriented, non-aging silicon steel.

4. Coils: Continuous windings without splices, except for taps.

   a. Internal Coil Connections: Brazed or pressure type.

5. Comply with NEMA ST 20, and list and label as complying with UL 1561.

6. Provide transformers that are internally braced to withstand seismic forces specified in Division 16 Section "Seismic Controls for Electrical Work."

7. Cores: One leg per phase.

8. Enclosure: Ventilated, NEMA 250, Type 2.

9. Enclosure: Ventilated, drip proof, NEMA 250, Type 2.

10. Enclosure: Ventilated, rain tight, NEMA 250, Type 3R .

11. Enclosure: Totally enclosed, nonventilated, with lifting eyes, NEMA 250, Type 3, 3R.

    a. Core and coil shall be encapsulated within resin compound, sealing out moisture and air.

12. Transformer Enclosure Finish: Comply with NEMA 250 for "Indoor and Outdoor Corrosion Protection."

    a. Finish Color: Gray.

13. Taps for Transformers Smaller than 3 kVA: One 5 percent tap above normal full capacity.

14. Taps for Transformers 7.5 to 24 kVA: Two 5 percent taps below rated voltage.

15. Taps for Transformers 25 kVA and Larger: Two 2.5 percent taps above and four 2.5 percent taps below normal full capacity.

16. K-Factor Rating: Transformers indicated to be K-factor rated shall comply with UL 1561 requirements for nonsinusoidal load current-handling capability to the degree defined by designated K-factor.

    a. Unit shall not overheat when carrying full-load current with harmonic distortion corresponding to designated K-factor.

    b. Indicate value of K-factor on transformer nameplate.

17. Electrostatic Shielding: Each winding shall have an independent, single, full-width copper electrostatic shield arranged to minimize interwinding capacitance.

    a. Arrange coil leads and terminal strips to minimize capacitive coupling between input and output terminals.

    b. Include special terminal for grounding the shield.

    c. Shield Effectiveness:

        1) Capacitance between Primary and Secondary Windings: Not to exceed 33 picofarads over a frequency range of 20 Hz to 1 MHz.

2) Common-Mode Noise Attenuation: Minus 120 dBA minimum at 0.5 to 1.5 kHz; minus 65 dBA minimum at 1.5 to 100 kHz.

3) Normal-Mode Noise Attenuation: Minus 52 dBA minimum at 1.5 to 10 kHz.

18. Wall Brackets: Manufacturer's standard brackets.

19. Fungus Proofing: Permanent fungicidal treatment for coil and core.

20. Low-Sound-Level Requirements: Minimum of 3 dBA less than NEMA ST 20 standard sound levels when factory tested according to IEEE C57.12.91.

16511 INTERIOR LIGHTING

A. Design Considerations

1. See Section 16145 Lighting Control Devices.

2. The following illumination levels are recommended by Rutgers. Illumination levels referenced are maintained levels measured at a 30" height from the floor or at an actual work surface and represent an average level for the area.

Area / Room Name	Maintained Foot Candles
Offices & Secretarial Areas	55 -60
Laboratories	75 - 80
Study Areas & Classrooms	50 - 60
Conference Rooms & Meeting Rooms	40 - 50
Lecture Hall Auditorium / Multi Purpose	35 - 50
Corridors & Stairwells	15 - 20
Reception / Lobby, Lounge	30 - 35

Mechanical, Electrical Rooms	25
Telephone & Elevator Machine Rooms	25
Receiving Areas	30
Storage Areas	10 - 15
Rest & Locker Rooms	25 - 30
Critical Work areas such as tissue labs, culture plate areas, Instrument Rooms, etc.	90 - 100
Temporary site lighting for security purposes	1 - 3
Walkways for pedestrian Safety	2 - 2.5
Parking Lots	1 - 1.5
Parking Decks	5
Fitness Areas	30

B. Special Documentation Requirements

RESERVED

C. Materials and Methods of Construction

1. Fluorescent fixtures are generally preferred. Use of the more efficient H.I.D. fixtures is encouraged only where practical indoors. Incandescent lighting may be used only for special effect architectural lighting or for limited dimming applications.

2. Fluorescent fixtures of the static recessed type shall be used for most hung ceiling applications. They shall be 2' x 4', 1' x 4', or 2' x 2' based on ceiling grid, size of room or area, and architectural arrangement. Generally, lenses shall be plastic injection molded prismatic type of 100% virgin acrylic. In areas requiring low brightness, numerous CRT's, or similar equipment, parabolic type louvered fixtures shall be used. Commercial fluorescent fixtures shall be used, where applicable, for surface or stem mounted fixtures, of metal with hinged shielding lens of 100% virgin acrylic, prismatic type. Industrial type fluorescent fixtures with

reflector but no lens shall be used in Mechanical Equipment Rooms, Storage and Receiving areas, and similar spaces.

3. Fluorescent ballasts shall be dimming type with following features:

   a. High frequency solid state electronic;

   b. High power factor (90% or higher);

   c. Class P thermally protected;

   d. Have a harmonic distortion of less than 10% and comply with all current ANSI standards;

   e. Super - quiet operating sound level of 2 dB above a 16 dB ambient;

   f. Meet FCC requirements governing electromagnetic and radio frequency interference;

   g. Comply with all applicable State & Federal ballast efficiency standards;

   h. Listed & Approved by U. L.;

   i. Designed for use with T8 OCTIC type (265 ma) rapid start lamps.

   Ballast manufacturer to be Osram Sylvania, Bodine, Universal or EBT.

4. Fluorescent lamps shall be T8 rapid-start Sylvania Octron F032/835 for 4 ft. units, and Sylvania Octron Curvalume FB031/835 (for 1 5/8" leg spacing) or FBO32/835/6 (for 6" leg spacing) for 2' x 2' fixtures, CRI 80 (minimum) 3500K color temperature, or equivalent by G. E. or Philips.

5. Incandescent lamps must be approved for use by Rutgers. If approved for use, they shall be rated 130 volt for 120 volt circuits.

6. Stairwells in buildings shall have sufficient fixtures so that loss of one lamp or ballast will not leave the area dark.

7. Emergency exit signs shall be Hubbell led exits, models LED-1EM RB or LED-2EM RB or approved equal with light emitting diodes as the light source.

16521 EXTERIOR LIGHTING

A. Design Considerations

1. See Section 16145 Lighting Control Devices.

2. The following illumination levels are recommended by Rutgers. Illumination levels referenced are maintained levels measured at the surface. Values represent an average level for the area.

Area / Room Name	Maintained Foot Candles
Temporary site lighting for security purposes	1 - 3
Walkways, for pedestrian safety	2 - 2.5
Parking Lots	1 - 1.5
Parking Decks	5
Fitness Areas	30

B. Special Documentation Requirements

RESERVED

C. MATERIALS AND METHODS

1. Lighting for the entire site development of a building shall be included in the building contract documents.

2. High Intensity Discharge (H.I.D) fixtures shall be used for exterior lighting of parking lots, walkways, roadways, and building perimeter security lighting. These fixtures shall be mounted on suitable standards and/or building for site lighting. Walkways, pathways, and sidewalks shall use metal halide fixtures.

3. Lighting Standards: Consult with Office of the University Architect.

4. Mounting height for roadway lighting is 25'; walkways and pathways, 12'; and parking lots will vary depending upon application.

5. Lens control shall be provided on all exterior lighting fixtures. Vandal proof fixtures shall be used if fixtures are mounted 10' or less off the ground.

6. Fixtures shall be located so that dark voids and excessive glare in windows are eliminated. Accessibility for servicing and spillage onto adjacent facilities must be considered.

7. For covered walkways use metal halide or mercury vapor H.I.D. downlights or wall mounted type fixtures depending on application.

8. Include temporary security site lighting of the construction area.

16715 VOICE AND DATA COMMUNICATIONS SYSTEMS

A. Design Considerations

RESERVED

B. Special Documentation Requirements

RESERVED

C. Materials and Methods of Construction

1. Telecommunications Service Entrance:

   a. Identify communications manhole to be used on the building plans. Telecommunications Staff will specify. Provide new manhole and underground path to the building if the existing manhole is not available. Distance between manholes should not exceed 600'. The total number of bends in a conduit run shall not exceed two 90^{o} bends or equivalent of sweeps and radius bends. Each bend will have a minimum radius in accordance with existing standards (10 times the I.D. minimum for the bend radius).

   b. Install four (4) four inch diameter polyvinyl chloride (PVC) Schedule 40 conduits from existing and/or new manholes to

the building shear line. The conduits will be installed at a minimum depth of 30" and backfilled with select material. An orange warning tape will be placed in conduit trench approximately 12” below the surface. Encase conduits in concrete (2,500 PSI), except when terminating at a pole. When terminating at a pole, clamp the conduit(s) rigidly to the field side of the pole at a 90° separation from power.

c. Galvanized steel conduits should be used from the inside of the, building to undisturbed earth to prevent a "shearing point" at the building edge. Conduits terminating inside a building will be installed so that the conduit extends four (4) inches beyond the surface from which it emanates. Conduits shall be plugged with inserts to ensure that foreign matter does not enter the building. The ends of metallic conduit shall be reamed, bushed and grounded according to the National Electric Code. All conduits are to be installed with a minimum 200 lb. test noncorrosive graduated pull tape.

(* Minimize routing of conduits under the building foundation.)

d. Provide and install the 6’W X 12'L X 7’D in-line manholes allowing two splicing bays and 7’W X 9'L X 7’D auxiliary manholes as needed. Prefabricated manholes preferred whenever possible. Manholes should be equipped with cable racks, pulling irons, 8” sump hole, frame, cover and ladder. A 6’-6” galvanized straight steel ladder is required when the chimney height is 12 inches or less. When the chimney height is 12 inches or more, a hooked ladder is required and manhole steps are to be provided at 12 inch intervals. The frame shall have a nominal opening of 27 inches and the cover is to be marked with a "C"; "Communications", or "T"; “Telephone”.

e. Terminating Space for the service entrance shall have a ¾ inch trade size A-C plywood, 8 ft. High X 4’ Wide. The terminating space shall include a two 11O V, 20 -amp AC power outlets and lighting equivalent to 50 foot-candles 3 feet above the floor. A #6 ground should be provided at the terminating space.

2. Telecommunications Closet:

a. Telecommunications closets should be centrally located away from building corners and in close proximity to

electrical service. Limiting the distance between these facilities will include designing an optimal grounding arrangement and minimize intersystem grounding disturbances. A #6 ground should be provided in all telecommunications closets.

b. Size Requirements are based on distributing telecommunications service to one individual work area per 100 sq. ft. of occupied floor space. Minimum telecommunications closet sizes are shown in the table below:

IF THE SERVING AREA IS:	THEN THE CLOSET MUST BE AT LEAST
Less than 5,000 sq. ft.	10 ft. x 7 ft.
Between 5,000 sq. ft. and 8,000 sq. ft.	10 ft x 9 ft.
Larger than 8,000 sq. ft.	10 ft. x 11 ft.

c. All walls of the closet shall be lined with rigidly installed wall-to-wall framing of ¾" trade size A-C plywood, 8 ft. high. Backboards shall be rigidly installed and painted with a nonconductive fire-retardant overcoat.

d. The temperature of the room shall be kept between 64°F and 75°F.

e. The telecommunications room shall be kept between 30% and 55% relative humidity.

f. Floors shall be static free (using asphalt / linoleum tile).

g. Lighting intensity shall be at least 50 foot candles at 30" above the floor.

h. Emergency lighting shall be provided.

i. The rated distributed floor loading shall be greater that 250 psf.

j. The rated concentrated floor loading shall be greater that 1000 lbs.

k. Telecommunications closets shall not have door sills or center posts. The door shall be 7' H X 3' W.

l. Sleeves or dam walls around floor slots shall extend 4 inches AFF.

m. Conduits and cable trays located in ceilings shall protrude 2" into the closet.

n. Ventilation shall accomplish one air change per hour (minimum).

o. Closets shall include a minimum of 2 dedicated 110 V AC 20 ampere quad outlets on separate branch circuits.

p. Each floor of the building should have at least one centrally located closet. These closets should be vertically stacked and connected with four - 4" sleeves for a clear cable pull without offsets extending 2" AFF and below ceiling level on the lower floor. Conduits, reamed and bushed at both ends are to be installed with a minimum 200 lb. test pullwire and no more than two 90o bends without a pull box being placed (See the attached diagram for pullbox installations. Bends are to be 10 times the I.D. for all conduits. The sizing and placing of pull or splice boxes shall not be used in place of 90o bends.

3. Cabling:

a. Location and number of telephone / data outlets will vary and must be determined by consultation with building occupants. Typically one telephone / data outlet consists of a double gang outlet box with a reducer plate and a one (l) inch conduit extended to a location above the hung ceiling. Poke through outlets should be avoided. In addition to this, a separate data outlet with a double gang outlet box and a reducer plate with a blank cover plate should be provided for future use with coaxial video or fiber optic cable.

b. Labs and other heavily wired locations require proper sizing of conduits feeding computer workstation clusters.

c. No more that three (3) outlet boxes in any conduit run will be allowed. If multiple boxes are chained together, then the conduit size must be increased accordingly.

d. Cable paths to modular furniture or workstations must be enclosed and secure. Raceways between ceilings and floor or furniture must be avoided.

e. In a building with a suspended ceiling, each telephone / data outlet should be provisioned with a 1" conduit that extends from the wall outlet to 8" above the ceiling. All conduits should have a pull line.

f. Cable trays should be provisioned above ceilings for orderly horizontal distribution of telephone and data cabling.

4. Telecommunications Grounding, Bonding and Electrical Protection:

a. The telecommunications grounding system shall be directly attached to the closest point in the building's electrical service grounding electrode system.

b. Bonding conductors shall be routed with a minimum number of bends. The bends placed in the conductor should be sweeping.

c. Make all bonding connection with listed bolts, crimp pressure connectors, clamps, or lugs. Exothermic welding may be used.

d. Multiple busbars placed in a building shall be directly bonded with a #6 AWG copper conductor.

16925 ENERGY MANAGEMENT SYSTEMS

A. Design Considerations

RESERVED

B. Special Documentation Requirements

RESERVED

C. Materials and Methods of Construction

1. All buildings larger than 5,000 sq. ft., or containing research equipment or other mechanical/electrical gear operating on a continuous basis must be equipped with an energy management system that ties into the existing campus EMS system (Honeywell on Newark and New Brunswick Campuses, and Andover on Camden). This system shall have the capability of monitoring the

conditions of the environment within the building for temperature, humidity, and movement; determining the operating status of all environmental control equipment in the building; and changing the status of the equipment to effect changes in the environment inside the building.

2. In general, the system shall include an electrical or electronic processing unit receiving information on the status of various sensors in the building and comparing this information with standard instructions relayed from a central processor. The local unit then makes changes required according to programming already present in its memory or overridden by the central processor.

    a. The building controller also receives alarms concerning off standard environmental conditions or emergencies such as fire and relays the alarms to the central processor for further action. This system should operate electronically using 1-5 volts or 4-20 milliamp signals although the final control device may be powered by a pneumatic system with clean, dry air with a 20 psi system pressure. Final control devices will consist of valves and damper positioners. No control functions (PID) are to be done with pneumatics. If devices are used that require air then provisions must be made in the design that detail a separate air compressor, air dryer and receiver, including all other associated appurtenances required for compressed air supply to these devices.

3. The building control system shall be capable of operating the building utility systems independently, but must also be constructed to accept signals from the campus EMS without extensive interconnecting equipment. The building control device must also be able to communicate data concerning building status to the central processor upon demand. The design must detail method of tie-into existing EMS system (i.e. telephone line, fiber optic, etc.) and must detail how the connection is to be made. The design must also detail what programming has to be done to main EMS system in order to accept new signals. The cost to hook-up and reprogram the EMS system must be included in the cost of the project.

    a. The design engineer should determine the campus system being used at the location of the building being designed before beginning design work. This information will be available through the Project Manager.