

DIVISION 26 - ELECTRICAL

26 00 00 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
FM Global loss prevention data sheets

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

26 01 26 MAINTENANCE TESTING OF ELECTRICAL SYSTEMS

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.

26 05 13 MEDIUM-VOLATAGE CABLES

A. Design Considerations

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

B. Special Documentation Requirements

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

C. Materials and Methods of Construction

3. 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 transform and distribute 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.
4. 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.
5. 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.
6. 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.

7. 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. 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.
- c. Ground: A copperweld ground rod shall be installed in each manhole for bonding of hardware and cable sheaths.

26 05 19 LOW VOLTAGE ELECTRIC POWER CONDUCTORS AND CABLES

A. Design Considerations

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

B. Special Documentation Requirements

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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. See section 26.05.33 on limited use of MC Cable. 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": Orange
Phase "C": Blue	Phase "C": Yellow
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 105⁰ 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.

26 05 19.13 UNDERCARPET ELECTRICAL POWER CABLES

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26 05 26 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.

26 05 29 HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

RESERVED

26 05 33 RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS

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 conduits 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. PVC coated Galvanized rigid steel conduit "ROBROY" shall be used in corrosive environments and to terminate conduit runs through concrete into equipment, enclosures and/or indoor areas.
 3. 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.
 - e. Generally use mechanical dual set-screw type on EMT conduit on interior conduit runs. Use threaded steel compression type within mechanical rooms, kitchens and damp/wet locations.
 4. 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.
 5. 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."

6. When conduits pass through the buildings exterior walls there shall be a complete link-seal modular seal assembly. A complete 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.
 - d. Concrete encased ductbank to be pinned to building foundation wall.
7. 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.
8. 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.
9. 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.
10. Plastic jacketed rigid steel galvanized conduit shall be used in corrosive atmospheres.

11. Rigid aluminum conduit may be used in lieu of rigid steel conduit, except where in contact with or in earth, concrete or masonry.
12. Conduit shall be 3/4" size minimum. MC cable of 1/2" diameter may be used for connections to recessed and chain hung lighting fixtures.
13. Where empty conduits are required to be installed, provide a continuous #12 nylon draw line with identification tag securely attached to both ends.
14. 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.
15. 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.
16. 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.
17. 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.

26 05 36 CABLE TRAYS FOR ELECTRICAL SYSTEMS

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26 05 39 UNDERFLOOR RACEWAYS FOR ELECTRICAL SYSTEMS

RESERVED

26 05 48 VIBRATION and SEISMIC CONTROLS OF ELECTRICAL SYSTEMS

RESERVED

26 05 53 IDENTIFICATION FOR ELECTRICAL SYSTEMS

RESERVED

26 05 73 OVERCURRENT PROTECTIVE DEVICE COORDINATION STUDY

A. Design Considerations

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

B. Special Documentation Requirements

2. The engineer of record shall provide a Short Circuit and Protective Device Coordination Study hard copy form and ETAP computer file.

C. Materials and Methods of Construction

RESERVED

26 09 13 ELECTRICAL POWER MONITORING

RESERVED

26 09 23 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 that produce a payback in 7 years or less shall be utilized for interior lighting control for energy conservation. 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, labs, 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. Provide a dedicated lighting contactor with bypass switch controlled via a photocell.
5. Where dimming control is required, it shall be normally used to control LED 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 source panel and circuit number.

26 11 00 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° 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 CM4000 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.

26 12 00 MEDIUM-VOLTAGE TRANSFORMERS

RESERVED

26 12 16.30. SUBSTATION TRANSFORMERS

A. Design Considerations

RESERVED

B. Special Documentation Requirements

RESERVED

C. Materials and Methods of Construction

1. The transformer(s) shall be the substation type with sidewall mounted primary and secondary terminations.
2. Transformer(s) shall be of solid-cast, dry-type construction, mounted in a suitable, ventilated enclosure.
3. The average temperature rise of the transformer windings shall not exceed 80 °C when the transformer is operated at full nameplate AA and FA rating. The transformer(s) shall be capable of carrying 100% of nameplate kVA rating in a 40° C maximum, 30° C average ambient as defined by IEEE C57.12.01™.
4. Terminations shall be side-wall mounted for: [close-coupling to high and low voltage switchgear sections] [close-coupling to high voltage switchgear on the primary side and terminating in an air-filled terminal chamber for cable connections to the low voltage side] [close-coupling to low voltage switchgear on the secondary side and termination in an air-filled terminal compartment on the primary side for cable entrance] [terminations within air-filled terminal chambers on both high voltage and low voltage side for cable entrance and exit][cover mounted for top entry/exit].
5. Primary and secondary locations shall be as follows: [primary: ANSI Segment 2, i.e. to observer's left when facing the transformer front; secondary: ANSI Segment 4, i.e. to observer's right when facing the transformer front] [primary: ANSI Segment 4, i.e. to observer's right when facing the transformer front; secondary: ANSI Segment 2, i.e. to observer's left when facing the transformer front].

6. The transformer(s) shall be rated kVA AA. Primary voltage volts delta. Secondary voltage volts wye, 4-wire, 60 Hz with two 2-1/2% full capacity above normal and two 2-1/2% full capacity below normal primary taps. Impedance shall be manufacturer's standard impedance, $\pm 7-1/2\%$. Sound level shall not exceed the maximum specified by NEMA TR-1, for the applicable kVA size of dry-type transformer.
7. Forced air-cooling shall increase the allowable full-load kVA by 50%.
8. Both high and low voltage windings shall be of copper conductors. High and low voltage windings shall each be separately cast as one rigid tubular coil, and arranged coaxially. Each cast coil shall be reinforced with glass mat. The casting process shall provide complete, void-free resin impregnation throughout the entire insulation system. The coil supports shall maintain constant pressure during thermal expansion and contraction of the coils. There shall be no rigid mechanical connection between high and low voltage coils.
9. The windings must not absorb moisture, and shall be suitable for both storage and operation in adverse environments, including prolonged storage in 100% humidity at temperature from -30°C to 40°C and shall be capable of immediately being switched on after such storage without predrying.
10. The impulse rating of the high voltage windings must be at least equal to the basic impulse level specified by IEEE C57.12.00™ for liquid-filled transformers of the same voltage class, without the use of supplemental surge arresters.
11. The transformer core shall be constructed of high grade, grain-oriented silicone steel laminations, with high magnetic permeability. Magnetic flux density is to be kept well below the saturation point. The core shall be cruciform in shape, with mitered joints to keep core losses, excitation current and noise level at a minimum. The outside surfaces of the core shall be protected against corrosion by painting with a suitable coating after assembly. Core dipping is not acceptable.
12. The enclosure(s) shall be constructed of heavy-gauge sheet steel. All ventilating openings shall be in accordance with NEMA and NEC standards for ventilated enclosures. The cabinet shall have a minimum of four hinged doors complete with door handles.
13. The base(s) shall be constructed to permit rolling or skidding in any direction, and shall be equipped with jacking pads designed to be flush with the transformer enclosure.

14. Fan cooling equipment shall include multi-phase electronic temperature monitor controlled automatically by sensors placed in the LV air ducts. The temperature monitor must contain yellow and red indicating lights. The yellow lamp indicates fan power, while the red lamps signal that alarm and trip contacts have been activated. A 0-1 milliampere output is required for remote indication. Alarm contacts shall be provided for fans, alarm, and trip function. An audible alarm must sound when the highest phase temperature exceeds a preset point. The fans must be able to operate in either manual or automatic mode. A fan exerciser circuit must operate the cooling fans for approximately one minute every six days [Minimum six fans shall be provided; each fan must have a 6-inch diameter blade and develop a minimum 350 CFM at 1500 RPM] [Minimum six "squirrel cage" centrifugal blowers shall be required; each blower must develop a minimum 800 CFM at 1500 RPM] and shall be controlled automatically by sensors placed in the LV air ducts. Forced air cooling system shall include: fans, control wiring, controller with test switch, current limiting fuses in the power supply to the controller, indication lights, alarm silencing relay, and necessary push buttons to properly control the system. Fan controller must be POWERLOGIC ® system compatible.
15. The transformer shall be pre-wired for TRANSPARENT READY web enabled communication for communication to Square D Powerlogic monitoring system.
16. Provision for future forced air cooling equipment shall include mounting provision for fans, bussing sized to the fan-cooled rating and provisions for mounting the fan control system.
17. Low voltage bus shall be silver flash plated copper throughout.
18. The transformer shall comply with all applicable portions of NEMA TR 1, and IEEE C57.12.01™.
19. The transformer shall be UL listed
20. Testing - Testing shall be done in accordance with IEEE C57.12.91™ and shall include, as the minimum, the following tests:
 1. Ratio
 2. Polarity
 3. Phase Rotation
 4. No-Load Loss
 5. Excitation Current
 6. Impedance Voltage
 7. Load Loss

8. Applied Potential
9. Induced Potential
10. The transformer windings must be free of partial discharge up to at least 1.2 times the rated line-to-ground voltage. All coils shall be subjected to a partial discharge test to verify its partial discharge.

26 12 19 PAD-MOUNTED, LIQUID-FILLED TRANSFORMERS

A. Design Considerations

1. Except where noted the Transformers shall conform to the latest applicable standards and requirements of IEEE, NFPA 70, ANSI C57.12.22 and NEMA, Units also must be combination UL listed and classified and shall be suitable for outdoor installation as manufactured by COPPER POWER SYSTEMS, SQUARE D, GENERAL ELECTRIC or approved equal.
2. All external surfaces of the transformers shall be cleaned, bonderized (or equal treatment), primed and finished with outdoor munsell green 7GY3.29/1.5 paint, proposal shall describe manufacturer's standard painting procedure.
3. The equipment shall be detailed as in this specification and attachments, and any exception there to shall be stated in vendor's proposal.
4. All equipment and component parts shall be guaranteed by the manufacturer against faults in design, defective or improper materials, poor workmanship, and failure from normal usage for one year after being placed in specified service, but not to exceed eighteen (18) months after date of shipment. If any defects or mal-performance occurs during the guarantee period, the manufacturer shall make all necessary alterations, repairs, and replacements free of charge
5. Unit shall be carefully inspected after assembly, connections checked to insure correctness of same.
6. The transformer shall be tested in accordance with the latest IEEE and NEMA standards. Tests shall include, but not be limited to the following: ratio test at rated voltage connection guaranteed no load loss in watts at 100% voltage, Resistance measurements for all windings at the rated voltage connections in Ohms at 85 Deg. C ° guaranteed percent impedance, primary to secondary windings at rated KVA high voltage test, induced potential test, ETC percent excitation current at rated voltage load loss at rated current at rated voltage connections.
7. Transformers shall be shipped with a nitrogen blanket over oil with a positive 3 PSIG pressure reading at 60 degrees C. before leaving the factory.

B. Special Documentation Requirements

1. One (1) 8 ½ x 11 inch reproducible drawing shall be furnished with each submittal.
2. Manufacturer's drawing and production schedule shall be submitted immediately after placement of order.
3. The manufacturer shall submit within ten business days, drawings in a AutoCAD 2014 dwg format and PDF format for review, and two business days after review; certified correct wiring diagrams, elementary diagrams, nameplate diagrams, foundation measurements and outlines and any other pertinent drawings. These shall show the arrangements, mounting details, and locations of various equipment and accessories. Locations and sizes of conduits, fittings, knockouts, ETC for connection by others shall be indicated. Complete data on the equipment furnished shall be shown on drawings. The manufacturer shall furnish six (6) copies of each instruction book, spare parts recommendations and test certificates.
4. Delivery time, allowing (14) days for purchase approval of drawings.
5. Sketch indicating the general arrangement of equipment, major dimensions and weight. Dimensioned locations of space allocations for conduit entry from above and below.
6. Time required from date of order for manufacturer to submit all drawings for review.
7. Manufacturer shall supply two copies of certified test reports as covered in applicable IEEE standard

C. Materials and Methods of Construction

1. Transformers shall be shipped with a nitrogen blanket over oil with a positive 3 PSIG pressure reading at 60 degrees C. before leaving the factory.
2. Transformers shall be 3 phase FR-3 Fluid filled 65degree rise copper wound both primary and secondary windings, rated 13,200 V delta 208Y/120 +/- 2 (2.5%) Taps. VOLTAGE MUST BE VERIFIED WITH THE RUTGERS UNIVERSITY'S HIGH VOLTAGE ENGINEER.
3. Units to be loop feed, dead front, and integral non load break 600amp bushings with dual sensing bayonet fuses. Low voltage terminals shall have four additional holes exceeding ANSI C57.12.22
4. Transformers will have (2) 2 position / padlock able under oil 630amp line loop switches plus (1) 300amp under oil switch for transformer, CT/PT mounting brackets, 2 ground lugs, high voltage door and steel low barrier. Switches shall be operable with a standard switching pole.

Primary door shall be independently lockable and capable of accepting a university lock.

5. The 28.5” minimum deep compartments shall have 30” hinged doors equipped for latching in the open position. The high voltage compartment door shall have a padlock able fastening device which is accessible only through the low voltage compartment. The hinge assemblies shall be made of corrosion resistant materials. Stainless steel hinge pins shall be provided and both compartment doors must be capable of being secured with a single padlock. Lifting provisions in accordance with ANSI standards shall be provided as well as cabinet jacking provisions.
6. Transformer tank shall be sealed tank construction with a welded main cover. A bolted tamper resistant manhole shall be provided in the tank cover for access to internal connections. Cabinet to have sufficient depth to accommodate 600amp elbows with adapters and arresters.
7. Provisions for tank grounding shall be supplied in both high voltage and low voltage compartments. The low voltage neutral shall be connected internally and brought out through a bushing located in the secondary compartment.
8. A tap changing mechanism shall be provided without opening the transformer tank the tap changer shall be externally operated and shall be for de-energized operation only.
9. The transformer tank and compartment shall be assembled as an integral unit for mounting on a pad. There shall be no exposed screws, bolts or other fastening devices which are externally removable. There shall be no openings which might allow sticks, rods or wires to contact live parts. The construction shall provide a tamper-resistant weather protected unit.
10. No parking stands for HV dead front terminals.
11. ACCESSORIES: Transformers shall be equipped with standard NEMA accessories Including, but not limited to the following:
 - a. (6EA) Primary fault indicators, Schweitzer 3ARU30Y2 or equal (indicators supplied loose) NOTE: Primary fault indicators to be supplied unmounted
 - b. (3EA) 18KV external distribution class elbow arresters with 200 to 600 amp bushing adapters (supplied loose)
 - c. (1EA)Pressure relief valve
 - d. (1EA) Cover mounted pressure relief device
 - e. (1EA)Drain valve with sampler accessible in high voltage

- compartment between H3A and H3B
- f. (1EA) Liquid level gauge
 - g. (1EA) Pressure vacuum gauge
 - h. (1EA) Temperature gauge
 - i. (1EA) Engraved nameplate
 - j. (1EA) Removable tank inspection hatch
 - k. Fluid protected with bayonet fuses in series with partial range C.L. fuse

26 22 00 - 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-9 Factor Rating Transformers shall be used.
4. The US Department of Energy (2016) 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.
 - h. Siemens Energy & Automation, Inc.
 - i. Sola/Hevi-Duty Electric.

- j. 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-9 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.

26 24 16 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.
5. Mount panels to unistrut support. Support to be attached to the building's structural members not the buildings finishes.
6. **NO FOREIGN SYSTEMS (I.E. PIPING, DUCT WORK, ETC.) WILL BE ALLOWED ABOVE ANY ELECTRICAL EQUIPMENT (PANELS, TRANSFORMERS, DISCONNECTS, VFD, ETC.) THE SPACE MUST BE CLEARED FROM THE TOP OF THE PANEL TO THE STRUCTURAL CEILING. A DROP CEILING IS NOT CONSIDERED A STRUCTURAL CEILING. DRIP PANS WILL NOT BE ALLOWED.**

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. **ALL ELECTRICAL EQUIPMENT SHALL BE DESIGNED WITH A MAX. CATEGORY II ARC FLASH HAZARD.**
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. Method to Reduce Clearing Time:

- (1) Zone-selective interlocking or
- (2) Differential relaying or
- (3) Energy-reducing maintenance switching with local status indicator or
- (4) Energy-reducing active arc flash mitigation system or
- (5) An approved equivalent means

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 liveparts 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 door-in-door piano hinged 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.

26 24 19 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 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 shortcircuit 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.

26 27 13 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 CM4000 meter or latest version (no substitutions). Meter to be equipped with a display, and communicated module wired to the building’s telecommunications closet. Coordinate the telecommunication wiring with RUNET personnel.

26 27 26 WIRING DEVICES

B. Design Considerations

RESERVED

C. Special Documentation Requirements

RESERVED

D. 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. USB Charger receptacles shall be heavy duty specification grade 20A, 120V, class 2, 5V DC-5A. Shall be installed in all lounge areas and gathering spaces. Acceptable manufactures Hubbell, & Legrand

3. 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.
4. 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.
5. Switches and receptacles for wet hazardous areas shall be an approved type for the environment served.
6. Receptacles fed from emergency power upon failure of normal power shall be RED and have cover of steel with red baked enamel and word "EMERGENCY" engraved in white letters on cover.
7. Ground fault interrupter type receptacles shall be duplex 120V. AC 15 or 20 amp as required, Class A.
8. Device plates, telephone outlet plates, and blank plates in finished areas shall be .04 gauge 302 stainless steel with brushed finish.
9. 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.
10. 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.
11. All receptacles shall have engraved nameplates fastened to the cover plate, stating the source panel and circuit number.
12. 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.

26 29 23 VARIABLE-FREQUENCY MOTOR CONTROLLERS

RESERVED

26 32 13 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 manufacturers are Caterpillar, Cummins, and MTU. No substitution will be accepted.
 - 2) Renovation Project: Emergency generator, or central battery system.
 - c. Buildings shall have the following equipment elevator, fire pump, telecommunications room, emergency lighting, as well as any special equipment requested by the end users, connected to the emergency generator via separate transfer switches.

- 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 24 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.
 - i. When commissioning the generator provide a 4 hour field 100% load bank test.
 - j. When diesel generators are used a permanently static load bank (50% of generator rating) shall be installed.
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.

26 33 23 CENTRAL BATTERY INVERTERS

RESERVED

26 33 53 STATIC UNINTERRUPTIBLE POWER SUPPLY

RESERVED

26 35 33 POWER FACTOR CORRECTION EQUIPMENT

RESERVED

26 41 00 FACILITY LIGHTNING PROTECTION

A. Design Considerations

1. Lightning Protection: Each building shall be considered individually to determine the necessity for lightning protection. The building location, height, proximity and height of surrounding facilities, etc. should be analyzed in determining the need for this protection. If lightning protection is to be provided, it shall be designed and specified to comply with NFPA 780 "Lightning Protection Code".
2. The completed system and its installation must have a U.L. master label.

B. Special Documentation Requirements

RESERVED

C. Materials and methods of Construction

RESERVED

26 51 00 INTERIOR LIGHTING

A. Design Considerations

1. See Section 26 09 23, 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:

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. LED dimming fixtures are preferred. All LED lighting to be commercial grade and meet the Design Lights Consortium Premium Rating. The LEDs must be tested to LM-80 standards. The manufacturer must also warranty the entire fixture for 5 years.
2. The Designer shall meet with Project Manager, Design Architect and End User to develop lighting types for all spaces. During this time, the Designer is encouraged to investigate emerging technologies of fixtures, lamps and lighting methods. Generally, full scale mock-ups of emerging technology fixture selections require input and approval by the University Office of Design and Construction Technology. These prototypes will be previewed for color rendition, energy consumption, light output, aesthetic appeal, lamp maintenance and established manufacturers, along with conformance with applicable local ordinances.
3. Lighting fixture types should be reviewed on a case-by-case basis. When suspended ceilings (10'-0" or above) can be utilized, pendant mounted indirect/direct fixtures are preferred.
4. In Academic/Administrative Buildings with low ceilings (10'-0" or below), or no ceilings, direct lighting is preferred.
5. Designer will be required to provide light level calculations and energy efficiency as it relates to typical spaces for review and compliance with Rutgers standards of light level quality. Coordinate any dimming requirements with end user.
6. Preferred type of Room lighting (where applicable):
 - a) Classrooms – Pendant mounted Indirect/Direct energy efficient fixture when ceiling height allows.
 - b) Administrative Areas and Offices – Pendant mounted Indirect/Direct energy efficient fixture or recessed energy efficient fixture. Consider accent lighting. Accent lighting on perimeter walls should be considered.
 - c) Student Dormitory Rooms (Studies and Bedrooms) – Indirect energy efficient wall sconce. See Appendix 3.5.3.
 - d) Laboratory Rooms – Pendant mounted Indirect/direct energy efficient fixture. Where possible at bench locations, under cabinet/shelf task lighting is preferable.

- e) Mechanical Spaces – Linear industrial protected reflector energy efficient fixture
- f) Public Spaces –Energy efficient /Decorative based on use of space, quantity and configuration.

26 56 00 EXTERIOR LIGHTING

A. Design Considerations

- 1. See Section 26 09 23, 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. LED fixtures shall be used for all exterior lighting (i.e. parking lots, walkways, roadways, and building perimeter security lighting etc). These fixtures shall be mounted on suitable standards and/or building for site lighting.
- 3. All light poles & concrete bases must be designed to withstand

120M.P.H wind loads with two (2)-2'X4' banner arms

4. Lighting Standards: Consult with Office of the University Architect.
5. Mounting height for roadway and parking lot lighting is 25' above finished grade; walkways and pathways 12' above finished grade.
6. 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.
7. 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.
8. Include temporary security site lighting of the construction area.
9. All parking lot lighting must be installed on a concrete base 3'-0" above finish grade.
10. All lighting to be connected via a dedicated junction box. Junction box to be quartzite tier 22 rating open bottom with 24" crushed stone. Lid to have "electric" logo.