

SECTION 2
DIVISION 26
ELECTRICAL

DIVISION 26 - ELECTRICAL

Note: This is a guide for Designers only. Contents shall not be used in lieu of specifications as part of the Designer’s contract documents

SECTION 26 0100 - ELECTRICAL GENERAL

PART 1 - GENERAL ELECTRICAL DESIGN

This guideline is based upon the 2011 North Carolina State Construction Office (SCO) Electrical Guidelines and Policies. It is the designer responsibility to be knowledgeable and proficient in application of the current referenced guideline. The more stringent of the NEC, SCO or University guideline will be enforced unless exception is given by Authority Having Jurisdiction.

1.1 GENERAL REQUIREMENTS

- A. Design for Safety.
- B. Design for Maintainability. Electrical systems shall be durable and easy to maintain and access. The Consultant shall incorporate into equipment and system design sufficient access and clearance for maintenance, repairs and replacement. Electrical Rooms shall be a minimum of 100 SF and as close to square as possible (i.e. avoid rectangular or irregularly shaped rooms).
- C. Design for Reliability and Redundancy. Ensure electrical rooms have the proper ventilation.
- D. Design for Energy Efficiency. Designing energy efficient building systems to meet State mandated energy goals is an essential part of the University’s design philosophy. Any new project shall be designed with state of the art energy efficiency. Design standards published by the American Institute of Architecture (AIA), American Society of Heating Refrigeration and Air Conditioning Engineers (ASHRAE) and the State of North Carolina shall be met or exceeded.
- E. Major energy consuming systems and equipment shall be specified and purchased based on a Life Cycle Cost Analysis. Careful evaluation of energy conservation measures shall begin early in the design phase and continue throughout the design process.
- F. It is the responsibility of the designer to provide concise, detailed, comprehensive drawings and specifications suitable for the project.
- G. Coordinate with the University Project Manager and Facilities Engineer for any question and/or discrepancies with this guide.
- H. The design engineer shall provide a short-circuit study and shall ensure that coordination study is performed between the main protective devices for the system, feeder protective devices for the system, and all downstream protective devices. Reference North Carolina State Construction Office Electrical Guidelines and Policies – 2011.

1.2 ELECTRICAL DESIGN PROVISIONS

- A. **The electrical design shall be in complete compliance with the current edition of the North Carolina State Construction Office Electrical Guidelines and Policies. In addition, the following provisions shall be incorporated into the contract documents:**
 - 1. RESIDENCE LIFE PROJECTS HAVE ELECTRICAL VARIANCES GRANTED BY THE STATE CONSTRUCTION OFFICE. Verify applicability prior to beginning design.
 - 2. All materials shall be new, with required UL label, and manufacturer's label or nameplate giving complete electrical data. Where a manufacturer's catalog number is used, all parts shall be furnished to make it complete and fit the construction intended.

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3. The Contractor shall be responsible for the security and storage of all materials and equipment.
4. Current editions of the National Electrical Code and the North Carolina State Building Code shall be met.
5. The Contractor shall secure and pay for all permits, fees, inspections, and licenses required. Upon completion of the job he shall present to the Engineer a certificate of inspection and approval from the inspection authorities.
6. The Contractor shall coordinate all necessary power outages with the University and Duke Power as required by giving a 30 day written notice to each agency. No power shall be reinstated to any facilities or equipment until an inspection and certificate is obtained from the NC State Construction Office of the Electrical Inspector.
7. The Contractor shall notify Piedmont Natural Gas and Time Warner for location of gas and TV cable prior to digging. Contractor shall notify University for location of all other underground utilities prior to digging.
8. Required excavation for installation of all electrical work shall be provided by the Electrical Contractor and replacement and compaction shall be performed according to other specifications relating to the particular type of work. All excavations must comply with OSHA guidelines.
9. In unfinished areas, such as equipment rooms, etc., exposed equipment shall be furnished with suitable factory applied finishes, i.e. standard gray enamel finish for panelboards, etc. Equipment furnished in finishes such as stainless steel, brushed aluminum, etc. shall not be painted.
10. The electrical drawings shall be diagrammatic only, and are intended to explain system function and define quality of materials and installation. They are not intended to define construction methods.
11. The Contractor shall not scale drawings for outlet and equipment locations. Unless specifically dimensioned on drawings or defined in specifications, outlets and equipment shall be located as evidently intended or as detailed on Architectural drawings. Lighting outlets are to be centered or spaced symmetrically unless they are dimensioned. Any dimensions shown on the drawings shall be verified in the field by the contractor prior to roughing. All outlet and equipment locations shall be coordinated with the other trades.
12. **Medium voltage conductor separable connectors (T-body) for splices in underground vaults are approved by State Construction Office (SCO) for UNCC installation. TEE TAPS ARE NOT ALLOWED.** Communication from SCO available on request.

SECTION 26 0200 – SEISMIC REQUIREMENTS FOR ELECTRICAL EQUIPMENT

PART 1 - GENERAL

1.1 REQUIREMENTS

- A. Electrical installation shall meet the seismic requirements as specified by the North Carolina State Building Code (hereinafter referred to as the State Building Code).

PART 2 - PRODUCTS

2.1 MATERIALS

- A. All free standing electrical equipment such as switchboards, motor control centers, transformers, generators, etc., shall be mounted on 4 inch housekeeping pads mechanically connected to the structural floor.

SECTION 26 0501 – ARC FLASH ANALYSIS

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PART 1 - GENERAL

1.1 REQUIREMENTS

- A. For all new buildings and services the electrical equipment manufacturer shall provide an arc flash analysis per NFPA 70E. Analysis shall include providing all labels. The electrical contractor shall install labels in the field. Electrical contractor shall set breakers to match the associated coordination study. Provide an arc flash analysis report for review by the engineer.
- B. Review arc flash requirements with owner when adding electrical equipment to existing facilities.

SECTION 26 0502 – ELECTRICAL TESTING

PART 1 - GENERAL

1.1 FEEDER INSULATION RESISTANCE

- A. All current-carrying phase conductors and neutrals shall be tested as installed, and before connections are made, for insulation resistance and accidental grounds. Each fixture and item of equipment for connection under the Contract shall be tested for insulation resistance from its conductors to its grounded surface or contact. These tests shall be done with a 500 volt (minimum) high voltage "megger."
 - 1. Minimum readings shall be one million (1,000,000) or more ohms for #6 AWG and smaller wire, 250,000 ohms or more for #4 AWG and larger wire, between conductors and between conductor and the grounding conductor.
 - 2. The contractor shall send a letter to the engineer and the State Construction Office certifying that the above has been done and showing the tabulation of the megger readings for each panel or feeder. This shall be done at least four (4) days prior to final walk-through by engineer and the State Construction Office (SOC).
 - 3. At final walk-through by the engineer and the SCO, the contractor shall furnish a megger and demonstrate that the panels comply with the above requirements. He shall also furnish a clamp-on type ammeter and a voltmeter to take current and voltage readings as directed by the engineer or the SCO representatives.

1.2 GROUND SYSTEM TESTING

Upon completion of installation of the electrical grounding and bonding systems, the ground resistance shall be tested with a ground resistance tester. Where tests show resistance-to-ground is over 25 ohms, appropriate action should be taken to reduce the resistance to 25 ohms, or less, by driving additional ground rods. (The compliance should be demonstrated by retesting.)

1.3 THERMOGRAPHIC IMAGING

- A. A thermographic imaging survey shall be required for the following equipment installations:
 - 1. Medium Voltage Cable terminations.
 - 2. Pad Mount Transformer connections (primary and secondary).
 - 3. Service Entrance Switchboard Connections.
 - 4. Emergency Generator Connections.
 - 5. Automatic Transfer Switch Connections.
- B. The thermographic imaging survey shall be performed by a thermographic imaging contractor who is a level III certified Thermographer and who has received accreditation through a NETA accredited Thermography training program. The imaging contractor shall have an equipment

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calibration program that is traceable to the National Institute of Standards and Technology (NIST). Imaging equipment must be calibrated within the last six months. Imaging equipment shall include a Forward Looking InfraRed camera able to detect emitted thermal infrared radiation and convert the detected emissions into a visual image. The imaging contractor shall provide a test report to the engineer and owner. Deficiencies shall be addressed by the Electrical Contractor.

1.4 CIRCUIT BREAKERS TESTS

- A. The following tests shall be performed on the service entrance breaker and distribution circuit breakers in the service switchboard and in service and distribution panelboards rated 1000A or higher. Tests shall be performed by a qualified factory technician at the job site. All results shall be recorded and presented to the engineer.
1. Phase tripping tolerance (within 20% of UL requirements).
 2. Trip time (per phase) in seconds (delay).
 3. Instantaneous trip (amps) per phase (pickup).
 4. Insulation resistance (megaohms) at 100-volts (phase-to-phase, and line-to-load).
 5. Set final trip functions to match the engineers approved overcurrent protection device coordination and arc flash study.
 6. Ground fault protection on circuit breakers shall be tested in the field in accordance with the NEC and properly calibrated and set to match the coordination and arc flash studies.
 7. List all breakers settings on the as-built drawings.

SECTION 26 0519 – CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 REQUIREMENTS

- A. All material shall be Third Party listed and shall be installed in conformance with the National Electrical Code.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Normal trade standard "Building Wire" of copper. Aluminum conductors shall not be installed. Each conductor shall bear easily readable markings along entire length, indicating size and insulation type.
- B. Conductors #10 AWG and smaller shall be solid. #8 AWG and larger shall be stranded.
- C. All wire shall be new, manufactured within the last 6 months.
- D. Insulation on conductors #6 AWG and smaller shall be suitable colored in manufacturing. Conductors #4 and larger may be identified with bands of proper color plastic tape near each termination and in each junction box.
- E. Conductor insulation shall be as follows:
1. Insulation on service and feeder conductor shall be 600 volt type XHHW or THHN/THWN.
 2. Branch circuit conductors shall be minimum #12 AWG, with 600 volt THHN/THWN insulation. Circuit wires carried through rows of fluorescent fixtures shall be at least Type RHHW or THHN.
 3. Conductors in any location subject to abnormal temperature shall be furnished with an insulation type suitable for temperature encountered as designated by the NEC.

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- F. Type MC Cable shall not be used.
- G. Fire alarm and control wiring shall have stranded copper conductors.
- H. All wiring lugs including, but not limited to, breakers, panelboard / switchboard lugs, safety switch lugs, and transformers lugs, shall be rated for use with 75°C conductors.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. All wiring shall be color coded:
 - 1. On 120/208 volt, 3 phase, 4 wire systems - phase A, black; phase B, red; phase C, blue; neutral, white. On 277/480 volt, 3 phase, 4 wire systems - phase A, brown; phase B, orange; phase C, yellow; neutral, light gray. Ground conductor on all systems shall be green.
 - 2. Unless noted or accepted otherwise, busses in panels and switchgear shall be considered "A", "B", and "C" from left to right, top to bottom, or front to back when facing equipment.
 - 3. Control wiring shall not use black, red, or blue; but shall use white for neutrals and green for grounding. Any other colors may be used but the coding shall provide same color between any two terminals being joined.
 - 4. Switch legs, including "travelers" in 3-way and 4-way switching systems, shall be same color as phase leg.
 - 5. Conductors shall be labeled within all junction boxes, etc. using plastic "punch" tape, identifying the conductors according to circuit numbers.
 - 6. Wires within panel boards, terminal cabinets, and similar equipment shall be neatly squared and "bunched" together and held with plastic ties.

3.2 MEDIUM VOLTAGE CABLE TESTS AND GUARANTEES

- A. The cable shall be tested at the factory. The contractor shall be required to furnish a Certified Manufacturer's Test Report for the "Master Reel" of each cable length shipped, for approval by the Engineer. The test report shall include:
 - 1. A high voltage test (AC).
 - 2. Insulation resistance values.
 - 3. Corona test.
 - 4. Leakage current curves submitted for each minute up to 10 minutes at test voltage.
- B. The manufacturer's test report shall be sent to the Engineer and Owner.
 - 1. After installation, but prior to energizing the system, the contractor shall also high spot the system in accordance with the Design Engineer's specified testing procedure, as witnessed and "signed-off" by the Design Engineer. Copies of this test report shall be sent to the Owner, to the Engineer, and to the State Construction Office, attention Design/Review Section.

SECTION 26 0526 – GROUNDING AND BONDING

PART 1 - GENERAL

1.1 SPECIFIC REQUIREMENTS

- A. All systems and equipment shall be grounded in accordance with NEC Article 250.
- B. All grounding conductors shall be contained within a raceway, unless specifically noted otherwise.

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- C. The raceway system shall not be relied on for ground continuity. A green grounding conductor, properly sized per the NEC shall be run in ALL raceways less than 600 volts except for telecommunications, and data raceways.
- D. All systems above 600 volts shall have grounding systems.

PART 2 - PRODUCTS

2.1 GROUND RODS

- A. Provide made grounding electrode in compliance with NEC.
- B. Ground rods shall be copper clad 10 foot minimum length, 3/4" in diameter.

2.2 GROUNDING CONDUCTORS

- A. Grounding conductors shall be sized in accordance with the requirements of the NEC.
- B. Grounding conductors for branch circuits shall be copper Type THHN/THWN.
- C. Bonding shall be done with insulated bonding bushings and lugs.

2.3 GROUND CLAMPS

- A. Clamps for attachment of grounding conductors to water pipes, etc. shall be of bronze or brass, with conduit hub with insulated bonding bushings and compression type lugs.
- B. Where available on the premises, bond together the following:
 - 1. Metal water pipe.
 - 2. Building metal frame
- C. Where required by NEC Article 250, provide "made" grounding electrodes to supplement the above. Bond together all available and made electrodes.
- D. Service ground clamps shall be attached to cold water mains at an accessible point and before its size is reduced. Clamp shall be accessible after construction is complete. Grounding conductor shall be without splice into the service enclosure where it shall be connected to main service ground buss, and interconnected with system neutral.

PART 3 - EXECUTION

3.1 PAD MOUNT TRANSFORMERS, VAULTS, MANHOLES, MV SWITCHES

- A. Pad mounted transformers and medium voltage switches shall be connected to ground rods with copper grounding conductors. Ground rod clamps shall be accessible after construction is complete. Grounding conductors shall be continuous without a splice.
- B. Each manhole, hand hole and underground vault shall have a ground rod(s) installed in bottom. Ground rod and copper grounding conductor shall bond all metallic parts inside manhole, hand hole and vault. Ground rod clamps shall be accessible after construction is complete. Grounding conductors shall be shall be continuous without a splice.
- C. Upon completion of installation of the ground rods and bonding system for pad mounted transformers, medium voltage switches, manholes, hand holes and underground vaults, the ground resistance shall be tested with a ground resistance tester. Resistance to ground shall be less than 25 ohms. If test indicates a greater resistance, appropriate measures shall be taken, including driving additional ground rods, to reduce the resistance to less than 25 ohms. Contractor shall send a letter to the engineer and owner certifying that the ground resistance

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test has been performed and stating the resistance measured at each for pad mounted transformer, medium voltage switch, manhole, hand hole and underground vault.

- D. Bushings shall be used wherever metallic conduits stub into transformer cabinets. The bonding jumper shall be sized by NEC Section 250 and lugged to the box.
- E. Provide new grounding bushings and grounding conductors on the existing secondary conduits turning up into new pad mounted transformers

3.2 EQUIPMENT GROUNDING, ETC

- A. Ground all fixed and portable appliances and equipment connected under the project with a green grounding conductor. This wire shall be carried inside the raceway and flex from equipment to nearest grounding portion of raceway system. Connect at both ends with suitable lugs.
- B. Each grounding type receptacle shall be grounded. Grounding may not be through the grounding yoke.
- C. Any feeder raceway anywhere in the system which enters a box or cabinet through part of a concentric knockout shall be fitted with a bonding bushing and jumper. The jumper shall be lugged to the box.

3.3 DRY TYPE TRANSFORMER SECONDARY GROUNDING

- A. Equipment on the secondary side of transformers shall be considered "service" and be bonded and separately grounded directly to the main service ground bus or electrode. Grounding conductor may be run in feeder raceways back to main service enclosure.
- B. In addition, transformer secondaries shall be provided with a local grounding electrode consisting of a clamp on a local 3/4" (minimum) copper cold water pipe or a grounded member. Grounding conductor shall be sized as shown on plans.
- C. All grounding system tests shall be fully documented as to time of day, weather condition, ground moisture, "megger" readings, etc. Submit a report in writing to Owner and Engineer.

SECTION 26 0529 – HANGARS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SPECIFIC REQUIREMENTS

- A. Full and proper support shall be provided for all items of electrical equipment, raceways, etc. All materials, whether exposed or concealed, shall be firmly and adequately held in place. Fastening and support shall afford safety factor of three or higher.
- B. All fixtures, raceways, and equipment shall be supported from the structure. Nothing may be supported from suspended ceilings or HVAC ducts.

1.2 MATERIALS

- A. Recessed fixtures shall be supported with 10 gauge steel wire or with the same type of wire used to support the lay-in ceiling track if heavier/stronger than 10 gauge steel wire adjusted as necessary to level fixture. Fixture shall be supported at the two opposite ends of the fixture to the building structural frame. Attach one end of the support wire to one corner of the luminaries and the other end to the building's structural system. The lay-in luminaire shall be screwed to the main runners of the lay-in ceiling track at all four corners using sheet metal screws.

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- B. Recessed ceiling speakers, where specified with an enclosure, shall have the enclosure - supported directly from the structure with a minimum of two 10 gauge wires run perpendicular to the ceiling and not pulling to one side. If recessed ceiling speaker is specified without an enclosure and is mounted in a suspended ceiling, the speaker shall be supported using T -Bar bridges such as Soundolier No. 81-8, or other device specifically designed for such support. In addition, each of the four corners of the ceiling grid block enclosing the speaker shall be supported from the structure using 10 gauge steel wire run perpendicular to the ceiling plane.
- C. Other devices using octagonal or 4" square ceiling boxes, such as smoke detectors, dome lights, exit signs, etc., where installed in suspended ceilings shall be attached to the ceiling system using Caddy, or other, hangers specifically designed for such support. In addition, each of the four comers of the grid block enclosing the box shall be supported from the structure using 10 gauge steel wires run perpendicular to the ceiling plane.

SECTION 26 0533 - RACEWAYS AND BOXES

PART 1 - GENERAL

1.1 REQUIREMENTS

- A. All material shall be U.L. listed and shall be installed in conformance with the National Electrical Code.

PART 2 - PRODUCTS

2.1 OUTLET AND JUNCTION BOXES

- A. Galvanized or aluminum of gauge required by NEC.

2.2 RACEWAYS

- A. Rigid metal conduit (RMC) shall be used for feeders leaving all freestanding switchboards, switchgears, and all panel feeders. Raceways used in service entrance concrete duct banks shall be PVC Schedule 40, except for the stub-ups which shall be RMC. RMC shall be used for feeder or branch circuits exposed to weather. RMC shall be used in all mechanical rooms. Use RMC anywhere conduit is exposed and subject to damage below 8 feet above finished floor.
- B. Electric metallic tubing (EMT) may be used for general branch circuits. EMT shall not be installed in any location where exposed and subject to severe physical damage, severe corrosive influence, outdoors, underground, in below slab-on-grade or in earth.
- C. EMT couplings and connectors shall be compression-gland type of malleable steel, galvanized or sherardized. Connectors shall be insulated-throat type. Set screw, indentor, or cast type fittings are not acceptable.
- D. PVC conduit may be used under slab and underground. No exposed PVC allowed. Fittings for PVC shall be U.L. listed for the use, and shall be installed per the manufacturer's instructions. Under slab PVC conduit runs shall utilize RMC elbows and RMC up through slab, and transition to EMT or RMC in masonry walls. PVC may be used for underground outdoor branch circuits and under slab branch circuits. Bends in PVC shall be made by methods approved by the manufacturer and the NEC.

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- E. Galvanized "flex" in dry and "sealtite" in wet locations shall be used for connection to mechanical equipment or transformers, or for lighting fixture whips. Green ground wire shall be installed and NEC followed. Flex runs shall be no greater than six feet in length.

2.3 FASTENINGS AND SUPPORTS

- A. Galvanized Steel or other non-corroding material.

PART 3 - EXECUTION

3.1 RACEWAY INSTALLATION

- A. 1/2" minimum lighting fixture whips are acceptable, otherwise minimum raceway size shall be 3/4".
- B. All runs of empty conduit only shall have a 100# nylon pull rope installed in the conduit.
- C. Rigid metal conduit shall be made up with full threads.
- D. Underground runs, except under concrete floor slabs, shall have a minimum of 24" cover. Backfill shall be made in 6" layers – tamping each layer to a density of 95% of maximum possible.
- E. Raceways run external to building foundation walls, with the exception of branch circuit raceways, shall be encased with a minimum of 3" of concrete on all sides. Encased raceways shall have a minimum cover of 18", except for raceways containing circuits with voltages above 600 volts, which shall have a minimum cover of 30".
- F. Branch circuit raceways run underground external to building foundation shall be run in raceways installed in accordance with the NEC, and shall be of a type approved by the NEC as "suitable for direct burial". Minimum raceway size shall be 3/4".
- G. All underground raceways shall be identified by underground line marking tape located directly above the raceway at 6" to 8" below finished grade. Tape shall be permanent, bright colored, continuous printed, metal compounded for direct burial not less than 6" wide and 4 mils thick. Printed legend on tape shall indicate general type of underground line below.
- H. Where underground raceways are required to turn up to cabinets, equipment, etc., and on to poles, the elbow required and the stub-up through the slab or earth to equipment shall be of rigid steel conduit.
- I. Grounding type insulated bushings shall be used where raceway enters boxes with concentric or oversized knockouts. These bushings shall also be used wherever conduits stub into switchboards or transformer cabinets. Grounding type insulated bushings shall always be used on both ends of conduits feeding panelboards.
- J. Provide suitable fittings where raceway crosses building expansion joints.
- K. Run concealed in finished areas.
- L. All PVC conduits, except those installed for services, shall contain green grounding conductor.
- M. All runs exposed and all runs above accessible ceilings shall be neat and square with building structure such as walls and ceiling/roof structures. Multiple parallel runs shall use trapeze supports where possible.
- N. The use of "LB's" shall be limited as much as possible.

3.2 BOX INSTALLATION

- A. Outlet boxes shall be sized in accord with NEC. All lighting outlet boxes shall have fixture studs. Device boxes shall be sectional type or 4" square equipped with plaster rings as required to

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mount the device. Set edge flush with finished surface. Boxes may be installed at top or bottom of a masonry course.

- B. Where installed in metal stud partitions, wall boxes shall be supported from two adjacent studs. Support on a single stud is not acceptable.
- C. Ensure all devices meet ADA requirements and specific project requirements regarding mounting heights and locations. Coordinate questions with Architect and Project Manager:
- D. The following are standard mounting heights:
 - 1. Switch boxes 46" from finished floor to center. Boxes beside doors shall be mounted so edge of trim plate is 2" from edge of door trim on strike side.
 - 2. Telephone boxes 18" from finished floor to center and vertical. Boxes for wall phones shall be 46" from finished floor and vertical.
 - 3. Panel cans 6' - 4" (\pm 4" in concrete block construction) from finished floor to top of can.
 - 4. Fire alarm pulls stations 46" from finished floor to center.
 - 5. Fire alarm chimes, horns, flashing lights, etc., 80" to bottom above finished floor or 6" below finished ceiling, whichever is lower, to comply with ADA requirements.
- E. Mount boxes for receptacles to receive device in a vertical position and locate:
 - 1. Centered 18" above finished floor.
 - 2. Centered 6" above counters, shelves, or cabinets where apparently intended to be so placed.
 - 3. Centered 4" above high edge of backsplashes.
 - 4. Where devices are to be ganged, provide boxes to receive devices trimmed with a gang plate.
- F. As soon as installed, all raceway openings shall be closed with plastic inserts to prevent entrance of foreign matter during construction. All enclosures shall be kept clean of any foreign matter.
- G. All outlet boxes, junction boxes and pull boxes shall have their covers and exterior visible surfaces painted with colors to match color scheme outlined in Section 260553. This includes covers on boxes above all type ceilings. In addition, the box cover shall be labeled using a permanent, black marking pen to identify circuits or systems in box.

SECTION 26 0543-UNDERGROUND DUCT BANK SYSTEM

PART 1 - GENERAL

1.1 GENERAL REQUIREMENTS

- A. System shall consist of single, round bore conduit encased in concrete. The minimum number and size of ducts shall be indicated on the drawings. Changes in direction of runs exceeding 10 degrees shall be accomplished by using special couplings or bends manufactured for this purpose. Duct lines shall be installed so that the top of concrete or future concrete as shown is not less than 30 inches below finished grade or finished paving at any point.
- B. Ducts should be pitched to drain toward manholes and away from buildings and equipment. Minimum slope shall be 4-inches in 100-feet. Where necessary to achieve this between manholes, ducts should be sloped from a high point in the run to drain in both directions.
- C. Concrete encased non-metallic duct shall be supported on plastic separators coordinated with duct size and spacing. Separators shall be spaced close enough to prevent sagging and deforming of ducts. Separators to the earth and to ducts should be secured to prevent floating during placement of concrete. Steel or tie wires should not be used in such a way as to form conductive or magnetic loops around ducts or duct groups.
- D. Where duct lines enter manholes or pull boxes, the conduits shall terminate in end bells. Conduit shall be thoroughly cleaned before laying. During construction and after the duct line is

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completed, the ends of the conduit shall be plugged to prevent water washing mud into the conduits.

- E. All underground raceways shall be identified by underground line marking tape located directly above the raceway at 6 to 8 inches below finished grade. Tape shall be permanent, bright-colored, continuous printed, metallic tape compounded for direct burial not less than 6 inches wide and 4 mils thick. Printed legend shall be indicative of general type of underground line below. Where it is necessary to cut a tapered end of a piece of conduit at the site, the cut shall be made with a tool or lathe designed to cut a taper to match the taper of the particular conduit to be used.
- F. All ducts should be sealed at terminations, using sealing compound and plugs, as required to withstand 15 psi hydrostatic pressure.
- G. After the duct line has been completed, a mandrel not less than 12 inches long, having across section approximately one-fourth inch less than the inside cross section of the conduit shall be pulled through each conduit after which a brush with stiff bristles shall be pulled through to make certain that no particles of earth, sand, or gravel have been left in the lines.
- H. The conduit furnished shall be concrete encased plastic. Concrete shall be colored red for all MV Cable Duct Banks.
- I. Installation of duct banks comprising multiple single conduits: each single conduit shall be completely encased in concrete with a minimum of 3" between conduits and a minimum thickness of concrete encasement of 3" which may be increased to fit the actual shape of the trench. Spacing assembly shall be made of non-metallic, non-decaying material. Joints in conduits shall be staggered at least 6". Ducts shall be securely anchored to prevent movement during the placement of concrete.
- J. Waterproof, 130 pound tensile test marking cord shall be installed (marked at least every foot), in all ducts, including spares, after thoroughly rodding, clearing and swabbing all lines free of any and all obstructions.
- K. Installation of single conduit shall be completely encased in concrete. The thickness of concrete shall be not less than 3" on the sides, bottom and top of conduit.
- L. Concrete: Concrete shall be 3000 psi class. Where a connection is made to an existing duct line, the concrete encasement shall be well bonded to the existing encasement. Use 1/2" diameter stainless steel rod minimum doweled in existing duct bank for cold joints, 2' - 0" into old envelope and 2' - 0" beyond.
- M. Connections to New Manholes: Concrete encased duct lines connecting to underground structures shall be constructed to have a flared section adjacent to the manhole to provide shear strength. Underground structures shall be constructed to provide for keying the concrete envelope of the duct line into the wall of the structure. Vibrators shall be used when this portion of the envelope is poured to assure a seal between the envelope and the wall of the structure.
- N. Connections to Existing Manholes: For duct line connections to existing structures, break the structure wall out to the dimensions required and preserve the steel in the structure wall. Cut the steel and bend it out to tie into the reinforcing of the duct line envelope. Chip out the structure wall to form a key for the duct line envelope.
- O. Design for spare ducts in each power duct bank as follows:
 - 1. 1-3 occupied ducts requires (1) additional spare duct, 4 or more occupied ducts requires (2) spare ducts minimum.
- P. Coordinate number of ducts and associated spares for Telecom duct bank with the University Telecommunications Department.

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PART 2 - PRODUCTS

2.1 MANHOLES/VAULTS:

- A. Underground structures shall be poured in place or may be of precast construction. Horizontal concrete surface of floors shall have a smooth trowel finish. Concrete shall be cured by applying two coats of white pigmented membrane forming-curing compound in strict accordance with the manufacturer's printed instructions, except that precast concrete may be steam cured. Curing compound shall conform to ASTM C 309. Duct entrances and windows shall be located near the corners of structures to facilitate cable racking. Covers shall fit the frames without undue play. Steel and iron shall be formed to shape and size with sharp lines and angles. Casting shall be free from warp and blow holes that may impair their strength or appearance. Exposed metal shall have a smooth finish and sharp lines and arises. Provide all necessary lugs, rabbets and brackets. Set pulling-in irons and other built-in items in place before depositing concrete. The words "electric" and "telephone" shall be cast in the top face of all power and telephone manhole covers, respectively.
- B. Medium Voltage Switch vaults shall have spring assist lids for access to termination and switching compartments.
- C. Optional Precast Concrete Construction: In lieu of poured-in-place concrete manholes and hand holds, the Contractor may, at his option, provide precast concrete structures subject to the requirements specified below. Precast units shall be the product of a manufacturer regularly engaged in the manufacture of precast concrete products, including precast manholes and handholds.
- D. General: Precast concrete structures shall have the same accessories and facilities as required for poured-in-place structures. Likewise, they shall have plan area and clear heights not less than those of poured-in-place structures. Concrete materials and methods of construction shall be the same as for poured-in-place concrete construction, as modified herein. Slope in floor may be omitted provided precast sections are poured in reinforced steel forms. Concrete for precast work shall have an ultimate 28-day compressive strength of not less than 4000 pounds per square inch. Structures may be precast to the design and details shown for poured-in-place construction, precast monolithically and placed as a unit; or, they may be of assembled sections, designed and produced by the manufacturer in accordance with the requirements specified. All structures shall be identified with the manufacturer's name embedded in, or otherwise permanently attached to, an interior wall face.
- E. Structure top and bottom shall be designed for full dead, superimposed dead and live load including impact. Structure sidewalls shall be designed for lateral earth and hydrostatic pressures plus live load (H20 Truck) adjacent to structure. Tops and walls of structures shall be designed for AASHTO standard H20 highway loading, with 30 percent loading added for impact and with design load being that which produces maximum shear and moment. All dead and live loads, as well as impact loading, shall be considered in design. Walls shall be designed to withstand all soil pressures, taking into consideration the soil to be encountered and ground water level present at the site and assuming that the H20 design vehicle will operate on surfaces adjacent to the structure. Ground water level shall be assumed to be three feet below ground surface unless a higher water table is indicated in the boring logs. Design shall also take into consideration stresses induced in handling units. Lifting devices shall be provided for properly handling units. Calculations and shop drawings shall be submitted covering the design and manufacture of precast units and shall bear the seal of registered professional engineer.
- F. Joints: Mating edges of precast components shall be provided with tongue and grooved joints. Joints shall be designed to firmly interlock adjoining components and to provide waterproof junctions. Joints shall be sealed watertight using preformed plastic strip conforming to AASHTO M 198, Type B. Sealing material shall be installed in strict accordance with the sealant manufacturer's printed instructions. Provisions shall be made for waterproofing cable entrances into structures and at covers in the top slab.

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- G. Pulling-in irons shall be steel bars bent as indicated on drawings, and cast in the walls and floors. In the floor they shall be centered under the cover, and in the wall they shall be not less than 6 inches above or below, and opposite the conduits entering the structure. Pulling-in irons shall be projected into the structure approximately 4 inches. Irons shall be zinc-coated after fabrication.
- H. Cable racks, including arms shall be made from 50% glass-reinforced nylon or a non-metallic material having equal mechanical strength, thermal resistance, chemical resistance and dielectric physical properties. Cable racks, including rack arms and insulators, shall be sufficient to accommodate the cables. Racks in power manholes shall be spaced not more than 3 feet apart and each manhole wall shall be provided with a minimum of 2 racks.
 - 1. Provide stainless steel hardware for mounting fasteners. Coat threads of anchor bolts with anti-seize compound immediately prior to installing nuts.
 - 2. Rack arms shall be 8", removable type, and rated capable of supporting 450 lbs working load and 1,000 lbs short term rated.
 - 3. Rack arms shall have slots or holes for securing cables with non-metallic cable wire ties.
- I. Precast Manhole/Vault Installation: Commercial precast assembly shall be set on 6 inches of level, 90 percent compacted granular fill, 3/4 inch to one inch size extending 12 inches beyond the manhole on each side. Granular fill shall be compacted by a minimum of four passes with a plate type vibrator. Drain sumps shall be provided for all precast structures.
- J. Coordinate requirement for sump pumps in manholes and vaults with Project Manager.
- K. Install 1/0 bars copper ground conduct around inside perimeter of manhole. Connect to 3/4" x 10' - 0" ground rod inside manhole. Bond with #6 bare copper from ring to manhole cover frame, sump covers, etc.

SECTION 26 0553-EQUIPMENT IDENTIFICATION LABELS

PART 1 - GENERAL

1.1 NAMEPLATES

- A. Furnish and install engraved laminated phenolic nameplates for all safety switches, panel boards, transformers, switchboards, motor control centers, low voltage systems and other electrical equipment supplied for the project for identification of equipment controlled or served, phase, voltage, etc.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Nameplate material colors shall be:
 - 1. Blue surface with white core for 120/280 volt equipment.
 - 2. Black surface with white core for 227/480 volt equipment.
 - 3. Bright red surface with white core for all equipment related to fire alarm system.
 - 4. Dark red (burgundy) surface with white core for all equipment related to security systems.
 - 5. Green surface with white core for all equipment related to "Emergency" systems.
 - 6. Orange surface with white core for all equipment related to telephone systems.
 - 7. Brown surface with white core for all equipment related to data systems.
 - 8. White surface with black core for all equipment related to paging systems.
 - 9. Purple surface with white core for all equipment related to television systems.
- B. All empty conduit runs and conduit with conductors for future use shall be identified for use and shall indicate where they terminate. Identification shall be by phenolic tags with wire attached to conduit or outlet.

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- C. All outlet boxes, junction boxes and pull boxes shall have their covers and exterior visible surfaces painted with colors to match color scheme outlined above. This includes covers on boxes above all type ceilings.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Nameplates shall be securely attached to equipment with self-tapping stainless steel screws, and shall identify equipment controlled, attached, etc. Letters shall be 1/2 inch high minimum. Embossed, self-adhesive plastic tape is NOT acceptable for marking equipment and shall not be used.

SECTION 23 0800 – BUILDING COMMISSIONING SERVICES

PART 1 - GENERAL

1.1 GENERAL REQUIREMENTS

- A. North Carolina General Statute 143-135.37(d) requires commissioning of major projects.
- B. Performance Verification. In order to be able to verify performance of a building component or an electrical system component, the construction contract shall include provisions that require each building component and each electrical system component to be commissioned, and these provisions shall be included at the earliest phase of the construction process as possible and in no case later than the schematic design phase of the project. Such commissioning shall continue through the initial operation of the building. **The project design and construction teams and the public agency shall jointly determine what level of commissioning is appropriate for the size and complexity of the building or its electrical system components.**
- C. Design for Commissioning. The electrical designer will be responsible for ensuring and developing "... a systematic process of assuring that a building (*mechanical, electrical and plumbing systems*) performs in accordance with the design intent and the owner's operational needs." The Owner considers the following elements as a minimum requirement for building acceptance and inherently integral to the Electrical Designer responsibilities, unless specifically notified otherwise by the Owner.
 - 1. Design Phase – Provide documentation to the commissioning agent for
 - a. Owner's project requirements and Basis of Design, to include single line drawings for Design Narrative.
 - b. Commissioning reviews of design documents.
 - c. Verification that operations and maintenance staff training through the mechanical contractor is specified.
 - d. Building load data files and energy analysis data for Measurement and Verification requirement.
 - e. Metering and sub metering to accomplish analysis of annual energy consumption versus projected energy consumption.
 - 2. Construction Phase
 - a. NOTE: Commissioning shall in no way reduce the designer scope and responsibility for Construction Administration to include verifying quality of system installation
 - b. Attend the commissioning scoping meeting and selected commissioning team meetings.

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- c. Installation Verification.
 - d. Coordinate resolution of system deficiencies identified during commissioning, according to the contract documents.
 - e. Perform normal submittal review, construction observation, as-built drawing preparation, etc., as contracted. On site observations should be completed just prior to system startup.
 - f. The designers shall continue to assist (along with the contractors) in clarifying the operation and control of commissioned equipment in areas where the specifications, drawings or equipment documentation is not sufficient for writing detailed testing procedures.
 - g. Startup and Checkout.
 - h. From the Contractor's red-line drawings, edit and update one-line diagrams developed as part of the design narrative documentation and those provided by the vendor as shop drawings for the fire alarm, normal power distribution and emergency power distribution systems.
 - i. Prepare and submit the final as-built design intent and operating parameters documentation for inclusion in the O&M manuals. Review and approve the O&M manuals.
3. Post Construction Phase
- a. Designer will provide classroom overview to university operations staff to include Basis of Design, standard power riser, emergency and standby power riser, and metering.
 - b. M&V. Assist in reconciling discrepancies between actual electrical energy usage and the submitted projection model.
- D. The Designer will include in bid documents the specific support and documentation required of the General Contractor, Mechanical Contractor, Electrical Contractor, Plumbing Contractor, Controls Contractor, Designer, Owner and others as applicable to ensure acceptable commissioning. Reference Division 01 General Requirements for commissioning guidelines. Guidelines will be modified as appropriate for each project.

SECTION 26 1313 – MEDIUM VOLTAGE SWITCHES

PART 1 - GENERAL

1.1 MEDIUM VOLTAGE SWITCHGEAR

- A. Switchgear shall be multiple way, manually operated switches with circuit interrupters.
- B. Switchgear shall consist of a gas-tight tank containing SF6 gas, load interrupter switches with visible open gaps and integral visible grounds. Manual operating mechanisms and viewing windows shall be located on the opposite side of the tank from the bushings and bushing wells so that operating personnel shall not be required to perform any routine operations in close proximity to high-voltage elbows and cables.
- C. Switchgear shall include microprocessor-based overcurrent control to initiate fault interruption on designated ways.
- D. Switchgear shall be suitable for sub-surface installation.
- E. Switchgear may be installed either as a pad mount or vault configuration depending on the location and visibility. Coordinate requirement with Project Managers.
- F. The University prefers S&C brand Medium Voltage Switchgear. S&C brand shall be bid as a preferred alternate.

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- G. Design for each medium voltage switch to be loop fed such that each switch has two independent source feeds.
- H. Pad mount switches shall be mounted on fibercrete box pads engineered and manufactured to support the particular switch.

SECTION 26 1200-DRY-TYPE TRANSFORMERS

PART 1 - GENERAL

1.1 MATERIALS

- A. Transformers shall be furnished in accordance with the following:
 - 1. For 60Hz service.
 - 2. Built in accordance with NEMA Standards.
 - 3. Insulation shall conform to NEMA ST 20 standards for 2200 C UL system. Transformers 25KV A and larger shall be rated for 1150 C temperature rise over 400 C ambient, provided case temperature rise shall not exceed 450 C over 400 C ambient. The transformer overload capability shall be in accordance with IEEE C57.96 for standard transformers.
 - 4. Transformers shall have been rated for sound level in accordance with American Standards Association Standard ASA- C89.1-latest edition. Sound rating shall be same as, or less than, maximum decibel rating recommended by the standard for transformer size and type specified. This information shall be indicated on transformer nameplate.
 - 5. Primary winding shall be rated 480 volts for use on a 3-phase, 4-wire system and connected Y. Furnish with full KVA rated taps of the manufacturer's standard, but not less than two - 2 1/2% above rated voltage and 4 - 2 1/2% below rated voltage. After load is applied, set taps to deliver as near 120/208 volts as possible.
 - 6. The designer shall evaluate the need for K-rated transformers on case-by-case basis. Coordinate with Project Manager.

1.2 MOUNTING

- A. Transformers over 15 KVA shall be floor mounted. Four vibration dampeners per transformer shall be employed as necessary to avoid transmitting vibration to building structure.
- B. Transformers 15 KVA and under may be wall mounted.
- C. Installation shall meet seismic requirements of Section 260200 of these guidelines.

1.3 CONDUIT CONNECTIONS

- A. No conduits shall be attached directly to transformer housing.
- B. Where construction permits, stub conduits up into transformer housing from beneath. Stubs shall be fitted with fiber-throated grounding bushing with suitable lug. Stubs shall be bonded together and to transformer case with ground wire of size required by N .E.C.
- C. Where connection must be made to housing, provide vibration dampening assembly consisting of:
 - 1. Female hub-type liquid-tight connector.
 - 2. Male hub-type liquid-tight connector.
 - 3. Short length (approximately 6") liquid-tight flexible conduit.
 - 4. Bonding jumper of NEC size on inside of assembly. Bond from lug to transformer case panel or switch can.

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- D. All transformers, in addition to having the secondary neutral grounded to the system grounding conductor, shall also have the secondary neutral grounded to a local grounding electrode as required by NEC.

SECTION 26 2413-SWITCHBOARDS

PART 1 - GENERAL

1.1 GENERAL

- A. Switchboard shall be provided with painted "schematic" bus on front of enclosure to depict actual bus arrangement inside cubicles.
- B. Provide a laminated drawing of the building electrical riser next to each switchboard in the main electrical room framed and mounted under glass.

1.2 BUSSING

- A. All busing shall be silver-plated copper.
- B. Switchboards shall have a 100% neutral bus of the same material as the main bus. A copper ground bus shall be provided in each section

1.3 METERING

- A. Main section shall be equipped with a GE Power Management Power Quality Meter or equivalent device. The intent is to be able to connect to a central monitoring station PC. The Power Meter shall provide for readouts of A, V, VA, W, var, kWh, kvarh, kVAh, PF, Hz, demand W, demand var, demand A, demand VA. Values shall be in true RMS. The Power Meter shall have (4) output relays, (4) isolated analog outputs that can replace transducers.
- B. The Power Meter shall be able to perform Harmonic Analysis with trigger trace memory, waveform capture, event recorder and data logger.
- C. The Power Meter shall have built-in data communications to allow Multi-point communication to multiple computer workstations, programmable controllers, and other host devices, at a minimum data rate of 9600 baud. The Power Meter shall be able to communicate with the Owners Tridium Niagara Software through the Network Area Controller, NAC, Panel for building management and/or other monitoring functions. The Power Meter shall be compatible with Modbus RTU Communications.

1.4 CIRCUIT BREAKERS

- A. Each circuit breaker is to be furnished with an externally operable mechanical means to trip the circuit breaker, enabling maintenance personnel to verify the ability of the circuit breaker trip mechanism to operate, as well as exercise the circuit breaker operating mechanisms.
- B. Feeder breakers shall be thermal magnetic with trip ratings as shown on plans. Feeder breakers shall be bolt-in.
- C. Evaluate main service breaker for applicability of rack-out type breaker. Coordinate with Project Manager.

1.5 TESTING

- A. Perform the following tests on the service circuit breaker. Testing shall be performed by a qualified factory technician at the job site. All readings shall be tabulated:
 - 1. Phase tripping tolerance (within 20% of U.L. requirements).

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2. Trip time (per phase) in seconds.
 3. Instantaneous trip (amps) per phase.
 4. Insulation resistance (in mega ohms) at 100 volts (phase to phase, and line to load).
 5. Ground fault protection on the main breaker shall be performance tested in the field and properly calibrated and set in accordance with the coordination study.
- B. All tests specified shall be completely documented indicating time of day, date, temperature and all pertinent test information.
- C. All required documentation of readings indicated above shall be submitted to the engineer prior to, and as one of the prerequisites for, final acceptance of the project.

SECTION 26 2416 – DISTRIBUTION AND BRANCH CIRCUIT PANELBOARDS

PART 1 - GENERAL

1.1 SPECIFIC REQUIREMENTS:

- A. Equipment shall be built to NEMA Standards where such standards exist

PART 2 - PRODUCTS

2.1 MATERIALS

- A. The Designer shall design all new panels to have 20 percent blank breaker spaces. The Designer shall require that the Contractor install 10 percent unassigned spare breakers in each new panel.
- B. Panels shall be marked with their maximum short circuit current rating at the supply voltage and shall be Third Party listed and bear the Third Party label. When required, panels shall be suitable for use as service equipment.
- C. Distribution and branch circuit panelboards shall be bolt-on type.

2.2 CABLE CONNECTIONS

- A. Circuit breakers shall be equipped with individually insulated, braced and protected connectors. The front faces of all circuit breakers shall be flush with each other. Large, permanent, individual circuit numbers shall be affixed to each breaker in a uniform position.

2.3 CIRCUIT BREAKERS

- A. Panel Board Circuit Breakers
1. Minimum interrupting capacity rating of any panel assembly shall be 10,000 amps.
 2. Branch circuit breakers shall be bolt-on, thermal-magnetic, molded case. Single pole, 15 and 20 ampere breakers intended to switch fluorescent lighting loads on a regular basis shall carry the SWD marking.
 3. Following the NEC requirement, AFCI are only required in bedrooms with permanent cooking appliances.
- B. Distribution Board Circuit Breakers
1. Distribution Board Breakers shall be one, two, or three pole molded case circuit breakers rated 600VAC. Breakers shall be high interrupting construction.
 2. Breakers with frame sizes greater than 100 amperes shall have variable magnetic trip elements which are set by a single adjustment (to assure uniform tripping characteristics in each pole). A push-to-trip button shall be provided on the cover for mechanically

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tripping the breaker. The breaker shall have reverse connection capability and be suitable for mounting and operating in any position.

3. Circuit breakers shall have removable lugs. Lugs shall be UL listed for copper conductors only, rated 75 degrees C. Breakers shall be UL listed for installation of mechanical type lugs.

2.4 CONSTRUCTION FEATURES

- A. Panels shall be sized so that they will pass through door openings and hatch openings, be assembled if required within the room that they are located/mounted, installed to meet NEC clearance requirements and installed for maintainability.
- B. Top or bottom gutter space shall be increased six inches where feeder loops through panel. End plates shall be galvanized Code gauge (minimum) and shall be supplied without knockouts.
- C. Covers shall be constructed of high grade flat sheet steel of Code gauge minimum with the following:
 1. Door flush with face and closed against a full inside trim stop. Hinges shall be inside type.
 2. A combination flush latch and Yale, Corbin or equivalent, tumbler-type lock, so panel door may be held closed without being locked. All such locks on same job shall be keyed alike. Plastic lock type trims are not acceptable.
 3. Finish of manufacturer's standard color of top-grade enamel over a phosphatized or other approved rust inhibitor treatment and prime coat.
 4. Four or more cover fasteners of a type which will permit mounting plumb on box. Cover shall also have inside support studs to rest on lower edge of can while being fastened.
 5. Distribution and lighting type panelboards shall be furnished with covers hinged to backbox. Hinge shall be continuous "piano" hinge type permanently spot welded to the panelboard cover. Hinge shall in turn bolt securely to the backbox.
- D. For lighting panels, breakers shall be "Quicklag" type bolted to the supply bus. Plug-in types are not acceptable.
- E. Supply lugs shall be installed on busses and neutral bar so they may be readily and securely tightened from the front with panel in place and wired. A suitable arrangement shall limit their movement out of plumb. It shall not be possible to move the lugs so that metal parts between phases are closer than 3/8".
- F. All panels shall have copper busses, with substantial connections where breakers bolt to busses.
- G. All wiring lugs in panelboards and all breakers shall be rated for use with 75 degree conductors.
- H. All branch circuit panels shall be equipped with copper ground busses.
- I. Panelboards shall be equipped with directory cards mounted behind heavy clear plastic shields in substantial frames attached to inside face of doors. Cards shall be a minimum of three inches wide.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Installation shall be as follows
 1. All unused openings shall be closed.
 2. Only one solid wire is allowable under a screw. Provide an approved lug for connecting stranded wire or more than one solid conductor.
 3. Each lighting or branch circuit panelboard mounted flush in a wall shall have a minimum of five empty 3/4" conduits stubbed out into the ceiling space above panel for future use unless all circuits in a panel are assigned. Seal ends of conduit with caps or with U.L. approved fire stopping material.

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- B. Labeling shall be as follows
1. Label all equipment in conformance with documents.
 2. For branch circuit panels, directory cards shall be neatly typed to indicate load served by each breaker or fuse. Directory cards shall indicate circuits in a manner analogous to the physical circuit breaker arrangement (i.e. odd numbered circuits in one column, even numbered circuits in another). Mount cards behind heavy plastic. Panelboard directory card shall be neatly typed with circuits assigned as shown on schedules. Space typing on card so all is visible when inserted into frame. Use room names and numbers as provided by Owner, not those shown on schedule. Names and numbers on schedule relate to plans only for construction. Indicate spare breakers in pencil (not typed) so that owner can erase and change as necessary in the future.
 3. Next to each breaker within distribution panels, attach a label indicating load served. Wording shall be as shown on its diagram or schedule on the drawings. Labeling shall also be attached to separately-mounted breakers, switches, transformers, wiring gutters and controllers of all types.
 4. Centered above door on panel cover attach a label indicating panel designation-for example, "Panel A;-voltage- 120/208 VOLTS": and from where served - "FED FROM PANEL MDP".
 5. Interrupting capacities shall be as indicated on the panel schedules. All ratings are for fully rated panels and breakers; series ratings are not acceptable.

SECTION 26 2713 – ELECTRICITY METERING

PART 1 - GENERAL

1.1 SUMMARY

- A. All new buildings (and facilities with significant electrical consumption) shall have electric meters, to be provided and installed by the Prime Electrical Contractor. If there is no Electrical Prime Contractor, the contractor with the greatest contract dollar value shall provide and install the meter.
- B. All new service boards shall be equipped with electric meters.
- C. Power Monitoring Interface: The Power Measurement Interface (PMI) device shall include the appropriate current and potential (voltage) transformers. The PMI shall be certified under UL-3111. The PMI shall perform continuous true RMS measurement based on 32 samples-per-cycle sampling on all voltage and current signals. The PMI shall provide outputs to the BAS based on the measurement and calculation of the following parameters:
- Current for each phase and average of all three phases,
 - kW for each phase and total of all three phases,
 - power factor for each phase and all three phases,
 - Voltage for each phase and average of all three phases , and
 - Power consumption (kWH).

These output values shall be communicated to the BAS over the open-protocol LAN. Coordinate with electrical engineer to ensure electrical specifications require correct meter to accomplish power monitoring noted above.

Mount to allow manual reading without use of ladders.

1.2 SUB METERING

- A. The designer shall coordinate with the owner for sub metering requirements covering major mechanical equipment/systems and other tenant loads. Standby (generator) power must be sub metered.

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- B. Provide sub metering to enable measurement and verification requirements for building commissioning.

SECTION 26 2726 - WIRING DEVICES

PART 1 - GENERAL

1.1 SUMMARY

- A. New receptacles are to be installed with ground pin up.
- B. Specific Requirements:
 - 1. Where two or more devices are indicated for gang installation, they shall be trimmed with gang type plates.
 - 2. Ground each receptacle by means of a separate code size ground wire (#12 minimum) connecting the receptacle ground terminal to the ground bus in the distribution panel..
 - 3. Designer shall evaluate the need for isolated grounding systems. Isolated ground wires shall be installed continuous from IG receptacle to the isolated ground bus in the panel. In addition, a separate ground wire shall bond the box and conduit and run with the circuit conductors to the normal ground bus bonded to panel.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. All wiring devices of any one general type (i.e. all duplex receptacles, all wall switches, etc.) shall be of the same manufacturer, color and shall match throughout.
- B. All duplex receptacles shall be rated 20 Amp, NEMA 5-20R, unless otherwise noted.
- C. All safety switches shall be heavy duty.

2.2 WIRING METHOD FOR BRANCH CIRCUITS

- A. Although not prohibited by the NEC, conductors serving two separate power systems (i.e. 120/208 V and 277/480 V) shall not be mixed in the same raceway, pull box, or junction box. Exception is where control wiring is a different voltage than the power.
- B. Use dedicated neutrals in all designs. Sharing of neutrals is not allowed for single phase branch circuits.
- C. Three phase circuits shall be limited to one circuit per raceway (three [3] different phase wires and a neutral if needed).
- D. The neutral carrying all or any part of the current of any specific load or run shall be contained in the same raceway or enclosure with the phase wire or wires also carrying that current. No split neutrals permitted.
- E. Under the above requirements and with required color coding system, no feeder or branch circuit raceway will contain more than one wire of the same color, except for switch legs and control circuits.
- F. Conductors feeding lighting outlets shall not be combined in the same raceway with conduit serving convenience receptacles. Lighting outlets and convenience receptacles shall not be connected on the same circuit unless specifically intended.
- G. Outlets in the same general area shall be circuited together.
- H. The designer shall evaluate the need for dedicated neutrals (one dedicated neutral per phase) in each project.

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2.3 RECEPTACLES

- A. Ground-Fault Interrupters (GFI) shall be as follows:
 - 1. Where indicated, provide general-duty, duplex receptacles, ground-fault circuit interrupters: grounding type UL-rated Class A, Group 1, 20 Amperes rating, 120 Volts, 60 Hz: with solid-state ground-fault sensing and signaling: with 5 milliamperes ground-fault trip level. Within the extent of applicable codes, "feed-through" GFI's may be installed.

2.4 MISCELLANEOUS

- A. All receptacles on emergency or UPS power circuits shall be red in color. Do we want different colors for isolated ground and/or switched receptacles,
- B. Unless noted or specified otherwise, device trim plates shall be type 302 stainless steel to suit device. All plates in the job shall be same make and match throughout.
- C. Wiring devices shall be 20 amp minimum and shall be of the grounding type, with hex-head green grounding screw, to be connected to the green ground conductor. Self grounding type is not acceptable.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Devices shall be mounted tightly to boxes and be adjusted plumb and level.
- B. Two or more devices ganged shall be trimmed with gang plate.

SECTION 26 3000 - EMERGENCY POWER SUPPLY SYSTEM

PART 1 - GENERAL

1.1 WARRANTY

- A. The engine generator set shall be guaranteed against defective parts or workmanship for a period of five years from the date of final inspection and acceptance. Warranty conditions shall be included in submittals. Warranty shall include all parts and labor, including travel to and from the job site and expenses and equipment necessary to perform replacement and and/or repairs.

PART 2 - PRODUCTS

2.1 ENGINE/GENERATOR SET

- A. Engine generator set shall be Caterpillar, Cummins, Kohler, or approved equivalent.
- B. Packaged generator set shall be third party listed. UL2200 or CSA or both.
- C. The new engine generator shall be rated KW as required, continuous standby, 60 hertz, 0.8 power factor, 4-cycle diesel or natural gas. The generator, if its diesel, shall have a sub-base fuel tank unless otherwise approved by Facilities Mechanical Engineer.
- D. The generator set shall be capable of cranking and picking up the assigned loads, meeting the minimum frequency and voltage stability requirements of these specifications, within 10 seconds after loss of utility power.
- E. Engine shall be water cooled, solid-injection type, either vertical in-line or v-type. The engine shall be equipped with fuel filter, lube oil filter, intake air filter, lube oil cooler, service meter, gear-driven water pump, and instruments, including a fuel pressure gauge, water temperature

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gauge, lubricating oil pump and pressure gauge, battery charging ammeter, and engine hour meter.

- F. Engine shall be furnished with a 24 volt starting system with batteries. Batteries shall be industrial grade lead acid with current limiting battery charger. Batteries shall be oversized for proper starting in temperature extremes. The battery charging system shall be automatic, solid state, current limiting and float equalizing and shall maintain the battery at normal capacity, recharge battery after cranking and be capable of recharging a completely discharged battery within 8 hours. System shall be capable of automatically switching from one charging rate to another to meet the needs of the battery. The battery charging system shall have a 120 volt input and shall also be equipped with overload protection, voltage surge suppressors, D.C. ammeter, D.C. voltmeter, low D.C. voltage alarm relay, battery charger malfunction alarm contact and have a minimum continuous output of 10 amperes D.C. and be third party listed.
- G. Engine shall be equipped with one jacket water heater with recirculating pump, if available from the manufacturer. Heaters and pump shall be a single assembly with a single point power feed connection.
- H. Engine shall have radio frequency suppression.
- I. Air flow shall be away from engine. The radiator shall be protected by a strong grille or screen guard and the fan shall be provided with a screen guard.
- J. The Engine Generator must be able to meet Mecklenburg County emissions requirements (Tier 4).
- K. Engine shall be equipped with an institutional grade (critical) muffler-silencer. Critical grade silencer shall be provided to reduce engine exhaust noise to a maximum dBA level of 85 at a distance of 10 feet. The Contractor shall also furnish all necessary flexible and hard exhaust piping necessary for a satisfactory installation. Terminate exhaust piping using a hinged cap on top of pipe to keep out rain. Exhaust piping and silencer shall be stainless steel to prevent rusting or be internally mounted. Exhaust pipe size shall be such that exhaust back pressure does not exceed maximum limitation required by engine manufacturer. Silencer shall provide a minimum of 32 dBA attenuation.
- L. The generator set shall have a digital control panel mounted on the unit with LCD readout and controls listed by the manufacturer as standard as well as those specified herein. Controls shall provide for automatic shutdown in case of high water temperature, overspeed, overcrank, or low oil pressure. Include additional alarms for NFPA 110 and 99 compliance.
- M. The generator set shall be equipped with main line circuit breakers, as required, mounted on the unit. Circuit breakers shall be adjustable electronic trip type, molded case, rated as indicated on plans, and with shunt trip for engine shut down tripping. Furnish with auxiliary position contacts. Provide generator mounted circuit breakers, molded case or insulated case construction, 3 pole, NEMA 1 P22. Breakers shall utilize a 24 VDC shunt trip. The breaker shall be UL listed with shunt trip device connected to engine/generator safety shutdowns. Breaker shall be housed in an extension terminal box mounted on the side of the generator. Mechanical type lugs, sized for the circuit breaker feeders shown on drawing, shall be supplied on the load side of breaker.
- N. Provide generator set with battery-powered emergency lighting suitable for installation. The battery-powered emergency lighting shall be powered from the load side of the automatic transfer switch.
- O. Generator parameters (see 2.4 C) shall be able to be monitored through the Building Automation System (BAS) via LonWorks, Modbus, or approved equal.
- P. Engine shall be equipped with provision to connect Load Bank equipment to fully test generator under load per NFPA 110 standards. Reason for Update Request: ur preventive maintenance procedures are developing a more robust method for testing our generators on a regular basis.

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2.2 OUTDOOR ENCLOSURE

- A. Generator shall be housed in an outdoor enclosure intended for both weather protection as well as sound reduction. Housing shall be painted aluminum, 14 gauge minimum, with access doors with panic hardware. Doors shall provide full access for operation and servicing and be lockable via in-handle lock tumblers.
- B. Platforms are required for larger sized generators to enable accessibility for maintenance personnel. Evaluate need for platform with the Project Manager.
- C. Acoustic insulation shall reduce engine generator noise to an average of 79 dBA at 23 feet. Air intake and discharge inlets shall be supplied. Acoustic insulation material shall consist of sound absorbing material.
- D. Engine silencer shall be independently supported from the engine-generator.
- E. Engine shall be provided with oil and water drains to exterior of enclosure with a bronze body ball valve installed on engine and plumbed to exterior coupling with high quality hose. Fumes disposal shall be extended to radiator discharge using an oil resistant high quality hose.

2.3 CONCRETE PAD

- A. Contractor shall provide a separate concrete pad for generator enclosure. Pads shall be a minimum of 12" beyond base x 12" deep with No.6 rebar on 12" centers in a horizontal grid pattern. Rebar should clear surfaces by 3" minimum in all directions. Concrete mixture shall be a 1:2:3 mixture of cement, sand, and aggregate with maximum of 4" slump and 28-day compressive strength of 3000psi.

2.4 REMOTE MONITOR PANEL

- A. Provide and install a 16-light remote monitor panel for the emergency generator and a remote alarm indicator in a location(s) as directed by the University.
- B. Alarm panel shall be U.L. labeled and shall operate on 24 volts DC. Power shall be supplied from the generator starting batteries.
- C. The remote alarm panel shall be designed to contain all the alarm and monitor functions for the generator individually plus alarms and indicators to the emergency system. These alarms and indications shall comply with NFPA 110 and NEC Sections 700 and 701, and shall include the following as a minimum:
 - 1. For generator:
 - a. Battery charger malfunction
 - b. Low lubricating oil pressure
 - c. Low coolant temperature
 - d. High coolant temperature
 - e. Overcrank
 - f. Overspeed
 - g. Generator running
 - h. Generator Not in automatic
 - i. Alarm buzzer and silence switch (for all alarms)
 - j. Lamp test switch (for all lamps)
 - k. Utility power available
 - l. ATS in normal
 - m. ATS in emergency
 - n. Low gas pressure
 - o. Enclosure breach
 - p. Panel shall also include an emergency "STOP" button (mushroom type)
- D. The alarm panel shall contain an alarm light and signal with silence switch to give an indication of any of the alarm conditions above, but shall not indicate them separately. In addition, it shall

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indicate utility and/or emergency power "on" using a green lamp and red lamp respectively. A lamp test switch shall also be provided.

- E. Panels, alarms, meters, etc., shall be appropriately labeled using laminated plastic labels, red letters on white background, professionally engraved. Contractor shall submit a drawing for approval showing layout prior to purchase or fabrication.

2.5 AUTOMATIC TRANSFER SWITCHES

- A. Contractor shall furnish and install one NEMA 1 enclosed automatic transfer switch. Switch shall be 4 wire, 4 pole, 100% rated continuous. Acceptable switches are Russelectric RMTD, ASCO and Zenith. Features and functions shall be as follows:
 - 1. Shall be UL 1008 listed.
 - 2. Shall be capable of switching the load to either source under all conditions.
 - 3. Visual indication of switch positions.
 - 4. Complete engine starting capability.
 - 5. Adjustable time delay on transfer to emergency and retransfer to Utility, adjustable from 0-30 minutes.
 - 6. Adjustable time delay for engine cool-down after re-transfer to normal, adjustable from 0-30 minutes.
 - 7. Switches shall have complete engine starting capability with adjustable time delay for momentary utility power outages or dips.
 - 8. Each transfer switch shall be equipped with a U.L. listed manual operator in the event the electrical operator should become inoperative. The manual operator shall provide the same contact-to-contact transfer speed as the electrical operator to prevent flashover, and shall be arranged so that the transfer switch can be manually operated under load, without opening the enclosure door.
 - 9. All solid state control circuitry.
 - 10. Contacts shall be silver plated copper.
 - 11. Shall be rated for 42,000 amps withstand current, symmetrical.
 - 12. Switching shall incorporate a time adjustable transition neutral position where the load is disconnected from both power sources.
 - 13. Timed auxiliary contacts. Two individually timed N.O.-N.C. contacts.
 - 14. Controls shall be digital incorporating LCD backlit display visible while the enclosure door is closed.
 - 15. A selectable load/no-load digitally programmable exerciser shall be incorporated within ATS.
- B. Operation of transfer switch shall be as follows:
 - 1. The switch shall automatically transfer to the emergency source in less than 10 seconds upon loss of utility power.
 - 2. When the utility source returns, switch should automatically, after a time delay, return to the utility position.
 - 3. Loss of utility power on any phase, or reduction of voltage on any phase below 80%, the transfer switch shall cause generator start.
- C. Switch shall be equipped with overrides necessary to operate switch manually (by electric push buttons) under all conditions.
 - 1. Transfer switch shall be completely assembled, wired, and tested at the factory prior to shipping and installation

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Engine generator set shall be mounted on heavy structural steel base fastened to the concrete pad. Provide pad depth to accommodate the slope of the grade while keeping the pad a minimum of 6" above grade. Generator set shall be mounted using heavy duty, open, stable

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viscous vibration dampers of the type approved for seismic areas. Vibration dampers shall be mounted between the engine/generator and base frame.

- B. Supplier shall provide a competent factory trained service engineer\technician to coordinate the installation, check-out, and start-up and testing of the complete generator system.
- C. On-site testing in the presence of the owner shall include testing of all safety devices and shall include a four hour running test first at 50% load for 1 hour, then at 75% load for 1 hour and last at 100% load for 2 hours. Then, after the cool down period the generator shall be started and after 10 seconds be applied 100% load for 30 minutes. The capability of the system to pick up full standby service load within 10 seconds of power outage shall also be demonstrated. Supplier shall furnish load bank.
- D. Supplier shall provide complete on-site training in the operation of the systems for the Owner at times chosen by the Owner to include all work shifts.
- E. Supplier shall provide, upon completion of installation but before final acceptance by Owner, three complete sets of operating instructions, maintenance manuals, and drawings, showing full details for care and maintenance of each item of equipment. In addition, a simplified set of step-by-step operating instructions, encased in a suitable frame for placing at the generator location, shall be provided with the operation and maintenance manuals.

3.2 MISCELLANEOUS

- A. When applicable, power elevators from the engine generator. Coordinate requirements with the University.

SECTION 26 3353 UNINTERRUPTIBLE POWER SUPPLIES

PART 1 - GENERAL

1.1 REQUIREMENTS

- A. The designer shall evaluate the need for a UPS by project.
- B. UPS units in excess of 150 kVA shall have an external bypass.
- C. UPS units for large computer rooms shall be closed transition type.

SECTION 26 5000 - LIGHTING

PART 1 - GENERAL

1.1 GENERAL INTERIOR

- A. Daylighting
 - 1. Day lighting shall be considered in the design of new construction and where applicable in renovation. Some keys to successful day lighting include:
 - a. Maximize southern exposure (orient building on an east – west axis).
 - b. Concentrate on the most heavily used spaces.
 - c. Use roof monitors and light baffles to increase winter radiation, reduce summer radiation and eliminate glare from direct sunlight.
 - d. Use glass on the roof equal to 10% to 12% of the building floor area.
 - e. Provide day-lighting controls. (See SECTION 26 5000 Part 1.1 B Interior lighting Control)

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- f. All opaque interior surfaces in daylight areas shall have average visible light reflective greater than or equal to 80% for the ceiling, 40% for partitions higher than 60in. (1.5m), and 60% for walls.
- B. Interior lighting control
 - 1. Large Classrooms and Conference Rooms shall have dual technology motion detectors to control ceiling light fixtures when room is not occupied, unless room function dictates otherwise. Detectors shall have manual override.
- C. Suspended luminaires
 - 1. All pendent-style fixtures shall have screens or closed tops to prevent trash from being thrown into the light cavities. If the specified fixtures are not manufactured with this feature, the Designer shall provide the design for removable screens with maximum 1/8-inch mesh to be provided, assembled and installed by the Contractor who installs the fixtures. The contractor who installs the pendent fixtures shall install protective covers to prevent construction dust and debris from settling inside the fixtures. The light fixtures installer shall be responsible for cleaning dirty fixtures prior to University acceptance.
- D. Recessed lighting
 - 1. Recessed lighting shall be installed with minimum clearance above fixture equal to thickness of fixture to ensure maintainability and accessibility.

1.2 GENERAL EXTERIOR

- A. Parking, roadway, and walkway
 - 1. Appropriate light fixtures and poles shall be used in parking lots, streets and along pedestrian walkways. Contact Planning Department to coordinate pole lighting installation requirements and to obtain campus standard detail drawings.
 - a. Roadway Lighting – Single/double housings with LED lamps, as required to meet recommended lighting levels, mounted on 30' tall round tapered aluminum poles. Luminaires by GE (Evolve Series, 9100 lumens, Type II, 4000K) or approved equivalent. Poles by Lithonia (RTA Series), Lyte Poles or approved equivalent. Both luminaire and pole to be Malaga Green (RAL 6012).
 - b. Parking Lot Lighting – Single/double housings with LED lamps, as required to meet recommended lighting levels, mounted on 30' tall round tapered aluminum poles. Luminaires by GE (Evolve Series, 17100 lumens, Type IV, 4000K) or approved equivalent. Poles by Lithonia (RTA Series), Lyte Poles or approved equivalent. Both luminaire and pole to be Malaga Green (RAL 6012).
 - c. Walkway Lighting – Citadel luminaire with LED lamps mounted on decorative round tapered smooth aluminum pole. Luminaires by ANP Lighting (LA923 Series, 11227 lumens, Type V, 4000K) or approved equivalent. Poles by ANP Lighting (CB1609 Series), Hadco or approved equivalent. Both luminaire and pole to be Malaga Green (RAL 6012).
 - d. Walkway Lighting at Charlotte Research Institute (CRI) Campus – Citadel luminaire with LED lamps mounted on decorative round smooth aluminum pole. Luminaires by Antique Street Lamps (LTL30 Series, 32 LED array at 700 mA, Type V, 4000K) or approved equivalent. Poles by Antique Street Lamps (Washington Series, 4" diameter shaft, 12'-0" height) or approved equivalent. Both luminaire and pole to be Malaga Green (RAL 6012).

1.3 TEMPORARY LIGHTING

- A. The Electrical Contractor shall provide adequate temporary lighting at the Project site for other contractors. If there is no electrical contractor, the prime contractor with the greatest contract monetary value shall provide temporary lighting specified herein.

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PART 2 - PRODUCTS

2.1 LAMPS

- A. The Electrical Contractor shall provide all new lamps in all lighting fixtures at date of Beneficial Occupancy. In lieu of installing all new lamps at Beneficial Occupancy, the Contractor may elect to warranty all lamps (for labor and material) for a period of 2 years with the requirement that defective lamps be replaced within seven calendar days of notice. The Contractor shall provide a 5 percent "attic stock" of all types of lamps installed by the Contractor, delivered to the University within 14 days of Beneficial Occupancy. "Attic Stock" is not for the contractor's use during the 2 year Warranty Period.
- B. Solid State (LED) lighting is preferred for new construction and major renovation projects. Minor renovation projects should typically match the existing lighting. Efficient thermal management, without fans, is required to provide maximum LED life. To maintain the same quality of light, all LED's, for a given luminaire, shall be binned the same. Prefer replaceable LED arrays where possible. LED drivers shall be located for easy access and replacement.
- C. Ballasts for T-8 fluorescent lamps shall be electronic; shall be instant start (for areas with infrequent switching) and programmed start (for areas with frequent switching or occupancy/vacancy sensors); shall comply with FCC and NEMA limits governing electromagnetic and radio frequency interference and shall not interfere with normal operation of other electrical equipment; shall meet all applicable ANSI and IEEE standards; shall have a total harmonic distortion (THD) of less than 20% but not less than 10%; shall be equipped with surge protection; shall not be affected by lamp failure and shall yield normal lamp life; shall have power factor above 90%; ballast factor of .88 or .90; lamp current crest factor shall not exceed 1.7; and shall allow remaining lamp(s) to maintain full output if companion lamp(s) fail. The electronic ballasts shall be provided with end-of-life shutdown circuit. Provide with 5-year full replacement warranty for electronic ballast. Manufacturer shall have a 5-year minimum manufacturing experience. Motorola, Magnetek, Osram / Sylvania, EBT, or Advance.
- D. Lamps shall be G.E., Phillips, or Osram/Sylvania. Nominal 4000K with a CRI of at least 80.
- E. Unless noted otherwise, all fluorescent fixtures shall be provided with high power factor, U.L. approved and CBM-made Class "P" ballasts, "sound rated A" and meet or exceed ANSI C82.11 requirements. HID fixtures shall be provided with constant wattage high power factor ballasts. Ballast shall be provided for proper voltage based on circuit assignment indicated on plans.
- F. Ballast design shall withstand line transients per IEEE 587, Category A and shall meet FCC Rules and Regulations, Part 16.
- G. Other, or specialized, lighting technologies, including T-5 fluorescent and quartz/halogen, will be evaluated for each project.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Surface-mounted luminaires installed on combustible material shall be mounted at least 1-1/2" from the surface of the material; exception, luminaires U.L. labeled for mounting directly to such surfaces.
- B. Mount all luminaires plumb and square. All rows shall be in a straight line.