**DIVISION 26 ELECTRICAL**

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**DIVISION 26 ELECTRICAL**

**SECTION 26 00 00 GENERAL ELECTRICAL REQUIREMENTS**

**PART 1 – GENERAL**

**1.1 GENERAL REQUIREMENTS**

A. This section contains information which serves as general requirements for electrical design.

B. The performance standard, LEED, shall be implemented to the extent feasible and practicable in all new buildings and major renovation projects in existing buildings. Refer to LEED in Design Guidelines – General Section for more information.

C. In some instances, a product is named to represent a minimum acceptable quality standard as a basis for the A/E. The intent is for the A/E to specify/schedule not less than three manufactures/ models based on similar style, appearance & performance characteristics of the named product.

D. This guideline lists minimum material quality standards. Materials not contained here-in shall be selected by A/E based on application and where code allows.

E. Following guidelines shall be adhered to in their entirety without deviation/modification. Any deviation from or modification to the listed documents must be approved in writing by the ECU Project Manager

F. All equipment and material shall be Listed and Labeled by a Third party agency amongst those acceptable to the North Carolina Building Code Council (NCBCC) to Label Electrical & Mechanical Equipment.

G. All work specified by the A/E shall be compliant with the current State of North Carolina, Department of Administration, State Construction Office, Electrical Guidelines and Policies Manual.

H. See telecommunication design for all requirements and guidelines pertaining to the planning, design and construction of telecommunication systems.

I. See Division 33 for additional requirements related to Electrical Utilities

J. This Section includes general electrical requirements for all projects

K. The electrical systems shall be designed so that the Arc Flash Hazard at any point does not exceed an ARC Level 2 (8cal/$cm^2$)

L. Fault-Current Study: All projects shall include a fault current study pursuant section 260573.

M. Coordination Study: All projects shall include a coordination study for all overcurrent protection devices pursuant section 260573.

N. Arc-Flash Hazard Analysis: All projects shall include an arc-flash study on all new construction and major renovations that include electrical equipment additions pursuant 260573.

O. A one inch raceway, for future communications and or control wiring, shall be installed for all Emergency power generators, medium voltage sectionalizing switches, and medium voltage switchgear, located outside of a building structure. The raceway shall terminate in a junction box, inside the closest building structure and identified for future communications. To be coordinated with the ECU Project Manager.

P. All medium voltage, air insulated, distribution equipment not located inside a conditioned electrical room shall have thermostatically controlled heaters installed to control moisture. The heaters shall be supplied by a dedicated circuit.

Q. The A/E is responsible for field verification of all documentation provided by ECU.

R. Electrical rooms shall be any room designated for electrical or a mixture of electrical and mechanical equipment to include spaces containing fire alarm systems or elevator controls.

**1.2 DESIGN CRITERIA**

A. The A/E is responsible for developing, documenting, and promoting technical discussion of proposed systems early in the project design phase. Early submittals are to include narrative technical discussion of system types, materials, and controls; including options, advantages, disadvantages, relative costs, and architect/engineer recommendations.

B. The A/E shall ensure that all major decisions regarding system types, materials, and controls are determined and agreed to by owner/user by the end of design development phase; and documented in the design development submittal.

C. The A/E should attempt to minimize the use of custom or unique lighting fixtures that may become difficult to obtain replacement parts for.

D. The A/E shall carefully investigate the layout of benchtop, plug/cord connected, equipment and the placement of duplex receptacles or permanently install power strips, as the use of extension cords is prohibited

**1.3 SITE**

A. Excavations, not located within a secured (fenced) site, shall be backfilled completely to provide safe crossing by the end of workday or whenever the work zone becomes inactive.

B. To the extent possible, existing pedestrian/sidewalk lighting and roadway lighting shall remain operational during all phases of the construction until new lighting is energized, temporary lighting is installed, or an outage is coordinated.

C. Construction Sites: Provide protective barriers around primary switchgear (Vacuum switches and PME switchgear), transformers, electrical and communications manholes, and temporary services. ECU shall have clear vehicle access to these items at all times during construction.

D. Fenced Construction Sites: An access point agreed to by ECU Project Manager and ECU Facilities Services Department shall be provided to ECU. Chains shall have ECU Standard Maintenance Padlock and site contractor pad lock daisy chained. ECU is responsible to provide the ECU Standard Maintenance Padlock. The project manager will coordinate with ECU Project Manager and ECU Facilities Services Department.

**1.4 WARRANTY**

A. Require contractors to provide minimum 1 year warranty for all labor and materials, whether included or not included by equipment manufacturers. Require contractors to replace defective materials during the first year of warranty without additional compensation from ECU.

B. Manufacturer warranties greater than 1 year, or where lengthier warranties are required in ECU Construction Standards shall extend the standard 1 year warranty.

C. Warranty period shall begin on the date of final acceptance of the project.

D. Warranty periods greater than 1 year may be called for in other sections of Division 26 and will supersede the 1 year period noted here.

**1.5 MISCELLANEOUS**

A. Branch Circuits: Provide dedicated neutrals for multiwire branch circuits for compliance with NEC.

B. Design team for new construction and renovations or contractor for miscellaneous additions shall demonstrate via load summary or per NEC 220.87 Determining Existing Loads, that the service, switchboard, panel board, or equipment can accommodate the load being added.

C. Electrical Space Planning Guide

1. The following requirements are to be used by architects for electrical space planning considerations at the conceptual design level. Refinements and modifications will be considered upon evaluation of the specific requirements in the building, but as a minimum, allow space according the following guidelines:
2. Main Service Entrance room shall provide for adequate equipment and maintenance clearance.
3. Provide outside equipment access to MDP room where feasible.
4. Electrical rooms shall be centrally located and “stacked” so that feeder conduits and bus duct are run as straight and short as possible.
5. Doors shall swing out where possible and as required by the National Electrical Code (NEC).
6. Electrical rooms shall not share space with storage, telecommunications, controlled access systems, building automation control systems, janitor’s sinks and piping.
7. If possible, locate electric rooms away from outside walls, elevator shafts, stairwells, HVAC duct chases, trunk runs, and other utility avenues so that branch circuits can fan out in all directions. Making provisions for raceways to cross atriums, firewalls, etc.
8. Locate electrical room where it is not susceptible to flood from heavy rains, broken pipes, stopped drains, or fire hose deluge. Do not locate janitor’s closets or similar type rooms above electrical rooms where leaks or overflows of drains could flow down to the next level and enter electrical equipment. This include elevator equipment rooms.
9. Where feasible do not locate MDPs and IDFs below grade where ground water infiltration could migrate to equipment.
10. Electrical rooms shall be fully rated and not require use of water based fire suppression systems.
11. Electrical rooms must be located so that access to them is not required to pass through gender specific restrooms, offices, clinics or other similar areas. Electrical rooms should be accessed from service corridors.
12. Electrical rooms should be maintained at a reasonable ambient temperature. If supplementary heating or cooling is needed, the equipment shall be separate from those systems serving areas that may have setbacks for evenings and weekends. If the electrical room houses sensitive equipment or life safety equipment than it shall also be on standby power.
13. All Lighting in electrical rooms shall be on standby power.

**1.6 PROJECT CLOSE OUT**

A. Closeout documents shall include laminated full size electrical site plan and electrical riser diagrams in the main electrical room. Provide on a chain hook system adjacent to the main electrical room entrance.

B. Provide record documents (as-built) per ECU requirements. Coordinate with ECU Project Manager.

END OF SECTION 26 00 00

**DIVISION 26 ELECTRICAL**

**SECTION 26 01 00 OPERATION AND MAINTENANCE OF ELECTRICAL SYSTEMS**

**PART 1 – GENERAL**

**1.1 WORK INCLUDED**

A. Compile electrical product data and related information appropriate for ECU's operation and maintenance of products furnished under Contract. Prepare electrical operating and maintenance data as specified in this Section and as referenced in other sections of specifications.

B. Instruction of Owner's personnel in operation and maintenance of equipment and systems.

C. Submit 3 copies of complete manual in final form

**1.2 ELECTRICAL OPERATING AND MAINTENANCE MANUAL SUBMITTAL SCHEDULE**

A. Thirty (30) days after receipt of reviewed submittals bearing the Architect / Engineer's stamp of acceptance (including re-submittals), submit for review, 1 copy of the first draft of the Electrical Operating and Maintenance Manual. This copy shall contain as a minimum:
   1. Table of Contents for each element
   2. Contractor information
   3. All shop drawings, coordination drawings and product data, bearing the Architect / Engineer's stamp of acceptance.
   4. All parts and maintenance manuals for items of equipment
   5. Warranties (without starting dates)
   6. Certifications that have been completed; submit forms and outlines of certifications that have not been completed
   7. Operating and maintenance procedures.
   8. Owner's Training Program Syllabus (including times and dates)
   9. Control operations / equipment wiring diagrams
   10. Coordination Drawings
   11. Schedule of Lamps
   12. Schedule of Ballasts and Drivers
   13. Schedule of Fuses
   14. Other required operating and maintenance information that are complete.

B. Copy will be returned by ECU within 30 days with comments for corrections.

C. Submit the (3) completed manuals in final form to the Architect / Engineer.
   1. Prior to substantial completion for Owner's use after the Owner accepts facility maintenance.
   2. Include all specified data, test reports, drawings, dated warranty letters, certificates, along with other materials and information.

D. The Architect / Engineer shall review the manuals for completeness prior to submission to ECU for review.

E. The A/E shall notify the Contractor of any missing or omitted materials. The Manuals shall be reworked by the Contractor, as required, in the office of the Architect / Engineer. The manuals will not be retransmitted.

F. Three complete manuals shall be delivered to the Owner prior to substantial completion.

G. Maintenance activities that may be done infrequently (grater than once every 12 months) should be thoroughly documented. Providing step by step instructions that shall be supplemented with photographs and video as appropriate to refresh staff or educate new staff on the procedures.

H. Training for complex systems such as lighting controls, SCADAs, building automation systems, etc. shall be videoed. The video shall be turned over to the university for their use exclusively. The video will not be distributed or shared with outside entities. The university shall not be required to sign any nondisclosure statements unless approved in advance by the university's legal office. The fact that the university will not sign a nondisclosure statement shall not negate the responsibility of the project to provide the documented training. This requirement shall be closely evaluated by the A/E during the submittal process.

## PART 2 – PRODUCTS

### 2.1 BINDERS

A. When multiple binders are used, correlate the data into related groupings.

B. Label contents on spine and face of binder with full size insert. Label under plastic cover.

C. Contents must be legible, not photocopies

D. Contents must be specific to the products actually installed

E. The completed and approved O&M Manual shall be provided in digital format as well.

## PART 3 EXECUTION

### 3.1 ELECTRICAL OPERATION AND MAINTENANCE MANUAL

A. Form for Manuals:
   1. Prepare data in the form of an instructional manual for use by ECU's personnel.
   2. Format:
      a. Size: 8-1/2" x 11"
      b. Text: Manufacturer's printed data or neatly typewritten.
   3. Drawings:
      a. Provide reinforced punched binder tab and bind in text.
      b. Fold larger drawings to size of text pages.
   4. Provide flyleaf indexed tabs for each separate product or each piece of operating equipment.
   5. Cover: Identify each volume with typed or printed title "Operating and Maintenance Instructions". List:
      a. Title of Project
      b. Identity of separate structures as applicable
      c. Identity of general subject matter covered in the manual.
   6. Binder as specified

B. Content of Manual:

   1. Neatly typewritten Table of Contents for each volume arranged in systematic order as outlined in the specifications.
      a. Contractor, name of responsible principal, address, fax number and telephone number
      b. A list of each product required to be included, indexed to content of the volume.
      c. List with each product, name, address and telephone number of:
         1) Subcontractor or installer
         2) Warranty contractor as appropriate and all contact information
         3) Identify area of responsibility of each.
         4) Local source of supply for parts and replacement
      d. Identify each product-by-product name and other identifying symbols as set forth in Contract Documents.

   2. Product Data:

a. Include those sheets pertinent to the specific product.
b. Annotate each sheet to:
1) Identify specific product or part installed.
2) Identify data applicable to installation.
3) Delete references to inapplicable information.

3. Drawings:
a. Supplement product data with drawings as necessary to illustrate:
1) Relations of component parts of equipment and systems
2) Control and flow diagrams
b. Coordinate drawings with information in Project Record Documents to assure correct illustration of completed installation.
c. Do not use Project Record Documents as maintenance drawings.
4. Written text as required to supplement product data for the particular installation:
a. Organize in consistent format under separate headings for different procedures.
b. Provide logical sequence of instructions for each procedure.

5. Copy of each warranty, bond and service contract issued
a. Provide information sheet for Owner's personnel, giving:
1) Proper procedures in event of failure
2) Instances that might affect validity of warranties or bonds
6. Shop drawings, coordination drawings and product data as specified.

C. Sections for Equipment and Systems
1. Content for each unit of equipment and system as appropriate:
a. Description of unit and component parts:
1) Function, normal operating characteristics, and limiting conditions.
2) Performance curves, engineering data and tests.
3) Complete nomenclature and commercial number of replaceable parts.
b. Operating procedures:
1) Start up, break-in, routine / normal operating instructions
2) Regulation, control, stopping, shut down and emergency instructions
3) Summer and winter operating instructions
4) Special operating instructions
c. Maintenance procedures:
1) Routine operations
2) Guide to trouble-shooting
3) Disassembly, repair and reassembly
4) Alignment, adjusting and checking
5) Routine service based on operating hours
d. Servicing and lubrication schedule:
1) List of lubricants required
e. Manufacturer's printed operating and maintenance instructions.
f. Copies of typed circuit directories of panel board to reflect actual room graphics numbers and room names (not architectural room numbers from the drawings).
1) Electrical
2) Controls
3) Communications
g. Original manufacturer's parts list, illustrations, assembly drawings and diagrams required for maintenance.
1) Predicted life of part subject to wear
2) Items recommended to be stocked as spare parts
h. Schedule of fuses

i. Complete equipment field accessible internal wiring diagrams
j. Schedule of lamps
k. Schedule of ballasts
l. Each Contractor's coordination drawings 1) as installed color coded piping diagrams.
m. List of original manufacturer's spare parts and recommended quantities to be maintained in storage
n. Other data as required under pertinent sections of the specifications

END OF SECTION 26 01 00

**DIVISION 26 ELECTRICAL**

**SECTION 26 05 13 MEDIUM VOLTAGE CABLES**

**PART 1 – GENERAL**

**1.1 SUMMARY**

A. Existing Primary cables on Campus include PILC, EPRLC and EPR. New cables may be matched to existing when repairs or splicing occurs. New cabling shall be designed with Ethylene Propylene Rubber (EPR) insulation and PVC jacket.

**PART 2 – PRODUCTS**

**2.1 CONDUCTORS**

A. Existing Primary cables on Campus include PILC, EPRLC and EPR. New cables may be matched to existing when repairs or splicing occurs. New cabling shall be designed with Ethylene Propylene Rubber (EPR) insulation and PVC jacket.

B. Jacket shall be imprinted with size of conductor, manufacturer's name, type of insulation material, and date of manufacture.

C. All medium Voltage cabling on ECU'S Distribution systems shall have 133% insulation and circuiting shall be comprised of three phases of single conductor, copper tape shielded power cables plus a 600V insulated ground wire sized per circuit ampacity. The ground wire shall not be less than a No. 2 copper wire.

D. Any cable not in conduit shall be fireproofed, individually by phase, with a tape for the purpose, equivalent to Scotch Brand #7700. Fire proofing tape shall be overlapped with a half turn and shall be installed into the conduit 1 inch or more.

**2.2 CONNECTORS AND SPLICES**

A. Connectors and splices in exterior in-ground handholes shall be limited.

**PART 3 – EXECUTION**

**3.1 INSTALLATION OF CONDUCTORS**

A. "High pot" all new cable and splice installations without high potting entire system. Provide copy of test to ECU at the time of Substantial Completion.

B. Splicing shall only be performed by certified cable splicers. "Y" splices are not allowed on the 12kv systems.

C. Cables shall be identified at their point of termination and where they enter and exit a manhole, switch vault, etc. with a tag. Minimum size shall be 1" x 2" with ¾" letters, identifying the circuit number and source (source information provided by ECU). Tags shall be attached with non-metallic, fungus-resistant, heat stabilized, self-extinguishing cable ties made of nylon.

D. Voltage phasing and 1st operation shall be maintained and guaranteed by the Constructor (or Electrical Subcontractor) on all feeders spliced or terminated prior to energizing electrical service to the building. Phasing and 1st operation shall be witnessed by ECU Facilities Services. Contact ECU a minimum of 24 hours in advance to arrange for ECU witnessing.

E. All splices shall be individually grounded to the manhole grounding system. Wiring in in-ground handholes: Loop all phase conductors, neutral conductors, and equipment grounds 360 degrees in handhole before terminating or before pulling to the next handhole.

END OF SECTION 26 05 13

**DIVISION 26 ELECTRICAL**

**SECTION 26 05 19 LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS**

**PART 1 – GENERAL**

**1.1 SUMMARY**

A. This Section includes the following:

1. Building wires and cables rated 600 Volt and less.
2. Connectors, splices, and terminations rated 600 Volt and less.

**PART 2 – PRODUCTS**

**2.1 CONDUCTORS**

A. Conductors shall be Copper: Aluminum conductors are not approved.

B. Conductor Insulation: Color coding shall be employed throughout entire length of conductor for all conductor sizes. Phase taping is not allowed.

C. Use of MC Cable is not approved. Exceptions shall be submitted for ECU Engineering and Architectural Services and ECU Facilities Services approval.

**2.2 CONNECTORS AND SPLICES**

A. Connectors and splices in exterior in-ground handholes shall be limited.

**PART 3 – EXECUTION**

**3.1 CONDUCTOR MATERIAL APPLICATIONS**

A. Feeders: Solid for No. 10 AWG and smaller; class B stranded for No. 8 AWG and larger.

B. Branch Circuits: Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger. Minimum conductor size No. 12 AWG.

C. Conductor sizes over 500 KCM shall not be permitted. Exceptions shall be approved by SCO.

D. Insulation color coding shall be:

| **Phase** | **208/120V** | **480/277V** |
|---|---|---|
| A | Black | Brown |
| B | Red | Orange |
| C | Blue | Yellow |
| Neutral | White | Natural Gray |
| Ground | Green | Green |

**3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS**

A. Service Entrance: Type THHN-THWN, single conductors in raceway.

B. Feeders: Type THHN-THWN, single conductors in raceway.

C. Branch Circuits: Type THHN-THWN, single conductors in raceway.

D. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless-steel, wire-mesh strain relief device at terminations to suit application.

**3.3 INSTALLATION OF CONDUCTORS**

A. Wiring in in-ground handholes: Loop all phase conductors, neutral conductors, and equipment grounds 360 degrees in handhole before terminating or before pulling to the next handhole.

B. Wiring in light poles handholes: Provide at least 18” of slack at handhole.

END OF SECTION 26 05 19

**DIVISION 26 ELECTRICAL**

**SECTION 26 05 26 GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS**

**PART 1 – GENERAL**

**1.1 SUMMARY**

A. Section Includes: Grounding systems and equipment.

B. The A/E shall ensure that provisions are made for the accessibility to equipment and connections for the periodic inspection and testing of the building Grounding system pursuant ANSI NETA MTS section 7.13 Inspection and test Procedures, Grounding Systems. To include: performing resistance measurements through bolted connections with a low-resistance ohmmeter; perform fall-of-potential or alternative test in accordance with IEEE 81 on the main grounding electrode or system; and perform point-to-point test to determine the resistance between the main grounding system and all major electrical equipment frames, system neutral, and/or derived neutral points.

C. The resistance between the main grounding electrode and ground should be no greater than five (5) ohms for large commercial or industrial systems unless otherwise specified by ECU (Reference IEEE142). Point-to-point resistance values which exceed 0.5 ohm shall be investigated

**1.2 ACTION SUBMITTALS**

A. Product data for ground bus bars, electrodes, mechanical and compression connectors, and exothermic connectors.

**1.3 QUALITY ASSURANCE**

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70.

**PART 2 – PRODUCTS**

**2.1 CONNECTORS**

A. Bolted connectors below grade or in ground handholes are not permitted

B. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions. Exothermic CADWELD shall be used for building grounding system connection to driven ground rods, connection to lightning protection driven ground rods, and connection to sports lighting driven ground rods.

**PART 3 – EXECUTION**

**3.1 EQUIPMENT GROUNDING**

A. Provide insulated equipment grounding conductors in all raceways.

B. Aluminum Poles Supporting Outdoor Lighting Fixtures: Provide ground lug with stainless steel screw in pole handhole, adjacent to handhole cover. Bond pole to 3/4 inch diameter by 10 feet long driven grounding rod located in in-ground handhole within 3’ of pole with 8 AWG solid bare copper wire.

**3.2 INSTALLATION**

A. Grounding Conductors: Route along shortest and straightest paths possible, following major building/structure lines, unless otherwise indicated or required by code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.

B. Ground Rods: Drive rods until tops are 6” inches above bottom of inspection well or in-ground handhole gravel base. Connection to ground rod shall be above gravel base.

C. Inspection Wells: Provide inspection/testing wells for all building grounding system driven rods and lightning protection driven grounding rods.

D. Concrete encased electrode in building footer shall be a bare conductor, same size as the building systems grounding conductor, routed minimum 20’ and tie wired to the reinforcing bars.

**3.3 LABELING**

A. Comply with requirements in Division 26 Section "Identification for Electrical Systems" Article for instruction signs. The label or its text shall be green.

**3.4 FIELD QUALITY CONTROL**

A. Perform the following tests and inspections and prepare test reports:

1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
2. Test completed grounding system at each service enclosure grounding terminal, and at driven ground rods inspection wells.
3. Test shall be fall-of-potential method using megohmeter.

B. Report measured ground resistances that exceed 5 ohms.

C. Excessive Ground Resistance: If resistance to ground exceeds 5 ohms, provide additional driven grounding rods until the measured ground resistance does not exceed 5 ohms.

END OF SECTION 26 05 26

**DIVISION 26 ELECTRICAL**

**SECTION 26 05 33 RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS**

**PART 1 – GENERAL**

**1.1 SUMMARY**

A. Section Includes:

1. Metal conduits, tubing, and fittings.
2. Nonmetal conduits, tubing, and fittings.
3. Metal wireways and auxiliary gutters.
4. Nonmetal wireways and auxiliary gutters.
5. Surface raceways.
6. Boxes, enclosures, and cabinets.
7. Handholes and boxes for exterior underground cabling.

**1.2 ACTION SUBMITTALS**

A. Product Data: For raceways, fittings, outlet boxes, junction and pull boxes, floor boxes, hinged-cover enclosures, and cabinets.

B. Shop Drawings: For custom enclosures and cabinets. Include plans, elevations, sections, and attachment details.

**PART 2 – PRODUCTS**

**2.1 NONMETALLIC CONDUITS, TUBING, AND FITTINGS**

A. Where not subject to extreme temperature changes or physical damage, schedule 80 nonmetallic conduit may be utilized as approved by ECU.

**2.2 HANDHOLES AND BOXES FOR EXTERIOR UNDERGROUND WIRING**

A. General Requirements for Handholes and Boxes:

1. Boxes and handholes used in underground systems shall be installed such that water cannot enter any conduits and flow to a downstream box, handhole, or structure.
2. Boxes and handholes used in underground systems shall not be located in areas where storm water could potential cover the lid or cover.
3. Raceways shall only enter boxes in the sides or bottom in wet/damp locations.

B. Polymer-Concrete Handholes and Boxes with Polymer-Concrete Cover (traffic rated): Molded of sand and aggregate, bound together with polymer resin, and reinforced with steel, fiberglass, or a combination of the two.

1. Configuration: Designed for flush burial with open bottom unless otherwise indicated.
2. Cover: Weatherproof, secured by stainless steel bolt devices and having structural load rating consistent with enclosure and handhole location.
3. Cover Legend: Molded lettering, "ELECTRIC”.
4. Color: Gray.
5. Installation: Per manufacturer instructions with gravel base similar to Stone 57. Re-cycled concrete, crushed concrete or pea gravel is not acceptable. Open bottom base shall sit on top of minimum 6” gravel base. Provide additional gravel inside (4 to 6 inches) bottom base to allow proper drainage. Conduits stubbed inside handhole shall extend minimum 6” above gravel.
6. If located in landscaped area, covers must be above anticipated mulch levels.

C. Plastic HDPE Handholes and Boxes: High-density polyethylene; thermoplastic, with frame and covers of polymer concrete.

1. Configuration: Designed for flush burial with open bottom unless otherwise indicated.
2. T-Cover: Weatherproof, secured by stainless steel bolt and having structural load rating consistent with enclosure and handhole location.
3. Cover Legend: Molded lettering, "ELECTRIC".
4. Installation: Per manufacturer instructions with gravel base similar to Stone 57. Re-cycled, crushed concrete or pea gravel is not acceptable. Open bottom base shall sit on top of minimum 6” gravel base. Provide additional gravel inside (4 to 6 inches) bottom base to allow proper drainage. Conduits stubbed inside handhole shall extend minimum 6” above gravel.

## PART 3 – EXECUTION

### 3.1 RACEWAY APPLICATION

A. Outdoors: Specify raceway products as specified below unless otherwise indicated:

1. Exposed Conduit: GRC.
2. Concealed Conduit, Aboveground: GRC, IMC, EMT, or Type schedule 80-PVC for the approved application. Coordinate with ECU Project Manager.
3. Underground Conduit: Type EPC-40-PVC. Minimum size shall be 1”.
4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC or LFMC approved for the application and subject to ECU Project Manager and ECU Facilities Services approval.
5. Boxes and Enclosures, Aboveground: NEMA 250, Type 3R. Provide stainless steel enclosures where required by code, in lift stations areas, chiller plants, tower yards, boiler plants, and wells.
6. Underground Raceways Warning Tapes – 6” wide by 0.004” thick polyethylene film with aluminum coil detectable tape with appropriate label:
   a. Tape color red with label “Caution – Electrical Line Below”
   b. Tape color yellow with label “Caution – Communications Line Below”

B. Indoors: Specify raceway products as specified below unless otherwise indicated.

1. Exposed, Not Subject to Physical Damage: EMT and schedule 80 PVC. Coordinate with ECU Project Manager.
2. Exposed and Subject to Physical Damage: GRC. Raceway locations include the following:
   a. Loading docks.
   b. Corridors used for traffic of mechanized carts, forklifts, and pallet-handling units.
   c. Mechanical rooms.
   d. Main and panels feeder raceways in main electrical rooms.
   e. Lift station, chiller plants, tower yards, and boilers areas.
   f. Fire pump rooms.
3. Concealed in Ceilings and Interior Walls and Partitions: EMT.
4. Connection to Vibrating Equipment, including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment: FMC, except use LFMC in damp or wet locations.
5. Wet Locations: GRC. Schedule 80 PVC may be utilized as approved by owner. Coordinate with ECU Project Manager.
6. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4 stainless steel in kitchens areas, chiller areas, boiler areas, lift stations areas, wells areas.

C. Minimum Raceway Size: 3/4-inch trade size. Minimum EPC-40 size is 1 inch.

D. Raceway Fittings: Compatible with raceways and suitable for use and location.

1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings unless otherwise indicated. Comply with NEMA FB 2.10.
2. EMT: Use compression fittings. Fittings in damp locations shall be die cast compression type. Comply with NEMA FB 2.10.
3. Flexible Conduit: Use only fittings listed for use with flexible conduit. Comply with NEMA FB 2.20.

E. Aluminum conduits, boxes, or fittings shall be used if in direct contact with concrete or earth.

F. Do not install nonmetallic conduit where ambient temperature exceeds 120 deg F.

**3.2 INSTALLATION**

A. Arrange stub-ups so curved portions of bends are not visible above finished slab.

D. Raceways Embedded in Slabs (requires pre-approval from ECU Project Manager):

1. Arrange raceways to cross building expansion joints at right angles with expansion fittings.
2. Do not embed threadless fittings in concrete.
3. Transition from PVC to GRC before rising above floor.

E. Stub-ups to Above Recessed Ceilings:

1. Use EMT, IMC, or RMC for raceways.
2. Use a conduit bushing or insulated fitting to terminate stub-ups.

F. Terminate threaded conduits into threaded hubs or with locknuts on inside and outside of boxes or cabinets. Install bushings on conduits 3/4 to 1-1/4-inch trade size and insulated throat metal bushings on 1-1/2-inch trade size and larger conduits terminated with locknuts.

G. Install bell ends on all PVC conduits entering medium voltage transformers and gear.

H. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb tensile strength. Leave at least 24 inches of slack at each end of pull wire. Cap underground raceways designated as spare above grade alongside raceways in use. Label all spare conduits with origin.

I. Install devices to seal raceway interiors at accessible locations. Locate seals so no fittings or boxes are between the seal and the following changes of environments. Use sealant that can be removed. Seal the interior of all raceways at the following points:

1. Where conduits pass from warm to cold locations, such as boundaries, refrigerated spaces, or data closets
2. Where an underground service raceway enters a building or structure.

J. Expansion-Joint Fittings:

1. Install in each run of aboveground RNC that is located where environmental temperature change may exceed 30 deg F and that has straight-run length that exceeds 25 feet.
2. Install type and quantity of fittings that accommodate temperature change listed for each of the following locations:
   a. Outdoor Locations Not Exposed to Direct Sunlight: 125 deg F temperature change.
   b. Outdoor Locations Exposed to Direct Sunlight: 155 deg F temperature change.
   c. Indoor Spaces Connected with Outdoors without Physical Separation: 125 deg F temperature change.
   d. Attics: 135 deg F temperature change.
3. Install fitting(s) that provide expansion and contraction for at least 0.00041 inch per foot of length of straight run per degree F of temperature change for PVC conduits.
4. Install expansion fittings at all locations where conduits cross building or structure expansion joints.

K. Flexible Conduit Connections: Use a maximum of 72 inches of flexible conduit for recessed and semi-recessed luminaires. Use a maximum of 36 inches of flexible conduit for equipment subject to vibration, noise transmission, or movement; and for transformers and motors.

1. Use LFMC in damp or wet locations subject to severe physical damage.
2. Use LFMC in damp or wet locations not subject to severe physical damage. LFNC can be utilized with approval of the owner.

L. Locate boxes so that cover or plate will not span different building finishes.

M. Support boxes of three gangs or more from more than one side.

N. Fasten junction and pull boxes to or support from building structure. Do not support boxes by conduits.

1. Set metal floor boxes level and flush with finished floor surface.
2. Nonmetallic floor boxes are not permitted
3. Junction boxes, pull boxes, or other boxes (electrical and control) located in chiller plants, boiler plants, lift stations, and irrigation wells shall be stainless steel.

**3.3 INSTALLATION OF UNDERGROUND CONDUIT**

A. Direct-Buried Conduit:

1. Provide GRC conduit elbows at turn up to equipment and at building entrances through floor.
2. Underground Warning Tape: Provide underground warning tape 24” above raceway, or 12” below grade if conduit is buried 24” below grade.

**3.4 INSTALLATION OF UNDERGROUND HANDHOLES AND BOXES**

A. All conduits entering handholes shall be sealed to prevent any water infiltration into the raceway. Additionally, the elevation of the handholes will be evaluated to ensure actions are taken to mitigate any water infiltration to the raceway system and prevent drainage back to any structures served if they are at a lower elevation than the handhold.

C. Elevation: In paved areas, set so cover surface will be flush with finished grade. Set covers of other enclosures 1 inch above finished grade.

D. In-ground handholes and boxes in finish grade:

1. In landscaped areas – Set top 1” above finish ground cover.
2. In sodded areas – Set top 2” above grade before sod is laid. Once sod is laid, the top shall be no more than 1” above the sod.
3. Handholes shall be set to follow slope of grade.

**3.5 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS**

A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies meeting required UL fire ratings.

**3.6 PROTECTION**

A. Protect coatings, finishes, and cabinets from damage and deterioration.

1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
2. Repair damage to paint finishes with matching touchup coating recommended by manufacturer.

**3.7 RENOVATIONS AND DEMOLITION**

A. Remove abandoned outlets and raceways, including conductors, back to last device to remain in service or

back to source panel. Where removed back to source panel, label circuit breaker(s) not re-used as spare and provide an updated typewritten panel directory.

B. Seal all penetrations

END OF SECTION 26 05 33

**DIVISION 26 ELECTRICAL**

**SECTION 26 05 53 IDENTIFICATION FOR ELECTRICAL SYSTEMS**

**PART 1 – GENERAL**

**1.1 SUMMARY**

A. Section Includes:

1. Identification for raceways.
2. Identification for conductors.
3. Underground-line warning tape.
4. Warning labels and signs.
5. Instruction signs.
6. Equipment identification labels.
7. Miscellaneous identification products.

**1.2 ACTION SUBMITTALS**

A. Product Data: For each electrical identification product indicated.

B. Provide sample of each label for approval prior to ordering materials upon ECU Project Manager request.

**PART 2 -- PRODUCTS**

**2.1 CONDUCTOR IDENTIFICATION MATERIALS**

A. Color-Coding for conductors shall be consistent throughout entire length. Phase tape color coding is not acceptable. Applies to feeders' conductors and branch circuit conductors. Color coding shall be:

**Voltage Phase A - Phase B - Phase C - Neutral**

1. 12,470/4,160: Red, White, Blue
2. 277/480: Brown, Orange, Yellow, Gray
3. 120/208: Black, Red, Blue, White
4. 120/240: Black, Orange (*), Blue, White

(*) shall indicate high leg on three phase 240 Volt delta system.

**2.2 FLOOR MARKING**

A. 2-inch- wide, black and white, stripes shall be painted on floors to indicate working clearances in front of equipment.

**2.3 UNDERGROUND-LINE WARNING TAPE**

A. Provide warning tape to identify and locate underground electrical and communications utility lines.

1. Printing on tape shall be permanent and shall not be damaged by burial operations.
2. Tape material and ink shall be chemically inert, and not subject to degrading when exposed to acids, alkalis, and other destructive substances commonly found in soils.

**2.4 WARNING LABELS AND SIGNS**

A. Comply with ECU standard format for Arc Flash warning labels

B. Self-Adhesive Warning Labels: Factory-printed, multicolor, pressure-sensitive adhesive labels, configured for display on front cover, door, or other access to equipment unless otherwise indicated.

C. Baked-Enamel Warning Signs:

1. Preprinted aluminum signs punched or drilled for fasteners, with colors, legend, and size required for application.
2. Danger signage shall be installed at all exterior locations containing MV equipment. Signage shall be bilingual (English and Spanish), engineering grade reflective aluminum. Signage will be placed at: every entrance, each face of the perimeter fence, and every 65ft of the perimeter fence.

**2.5 INSTRUCTION SIGNS**

A. Engraved, laminated acrylic or melamine plastic, minimum 1/16 inch thick for signs up to 20 sq. inches and 1/8 inch thick for larger sizes.

1. Engraved legend with white letters on black face.
2. Punched or drilled for mechanical fasteners.
3. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

B. Adhesive Film Label: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch.

C. Adhesive Film Label with Clear Protective Overlay: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch. Overlay shall provide a weatherproof and UV-resistant seal for label.

**2.6 EQUIPMENT IDENTIFICATION LABELS**

A. Interiors - Self-Adhesive, Engraved, Laminated Acrylic or Melamine Label: Adhesive backed and pop rivet to enclosure, with white letters on a dark-gray background. Minimum letter height shall be ½ inch.

B. Outdoors - Stenciled Legend: In nonfading, waterproof. Adhesive backed and pop rivet to enclosure, seal penetrations with silicone. Minimum letter height shall be ½ inch.

C. Identifications:

1. 277/480 Volt – Black background with white letters.
2. 120/208 (120/240) Volt – Blue background with white letters.
3. Fire Alarm Systems – Bright red surface with white core
4. Security Systems – Dark red (burgundy) surface with white core
5. Emergency Systems – Green surface with white core
6. Telephone Systems – Orange surface with white core
7. Data Systems – Brown surface with white core
8. Paging Systems – White surface with black core
9. TV Systems – Purple surface with white core
10. Designer shall confirm with ECU identification on other systems, such as Legally Required and Optional Standby systems
11. Letters shall be 1/2” high.
12. Each panel shall be labeled with the panel designation, voltage and phase, and all sources feeding the panel including circuit numbers and room location.
13. Each transformer shall be labeled with the transformer designation and primary source and secondary fed equipment designation. Coordinate with ECU Project Manager for labels descriptions.
14. Each safety switch, enclosed circuit breaker enclosure, VFD, etc. shall be labeled with the equipment designation, voltage and phase, and all sources feeding the equipment including circuit numbers and room numbers.

**PART 3 – EXECUTION**

**3.1 INSTALLATION**

A. Underground-Line Warning Tape: Use multiple tapes where width of multiple lines installed in a common trench exceeds 16 inches overall.

B. Label outlet boxes/junction boxes indicating circuits contained therein and source panel. Labels shall be machine type onto permanent tape (No hand labeling).

C. Provide labels on outlets cover plates indicating source panel and circuit number. Labels shall be machine type onto permanent tape (No hand labeling).

D. Paint fire alarm systems outlet boxes/junction boxes red. Fire alarm conduit shall be RED the entire length.

E. Conductors to Be Extended in the Future: Attach write-on tags to conductors and list source.

F. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, and signal connections using same methods as required for other electrical systems noted above.

1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.
2. Use system of marker tape designations that is uniform and consistent with system used by manufacturer for factory-installed connections.
3. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, Power Systems Studies, and the Operation and Maintenance Manual.

G. Workspace Indication: Paint floors to show working clearances in the direction of access to live parts. Workspace shall be as required by NFPA 70 and 29 CFR 1926.403 unless otherwise indicated. Do not install at flush-mounted panelboards and similar equipment in finished spaces.

H. Operating Instruction Signs: Install instruction signs to facilitate proper operation and maintenance of electrical systems and items to which they connect. Install instruction signs with approved legend where instructions are needed for system or equipment operation.

I. Emergency Operating Instruction Signs: Install instruction signs with white legend on a red background with minimum 1/2 inch high letters for emergency instructions at equipment used for power transfer.

J. Each branch circuit conductor shall be labeled with the panel circuit designated 1” from termination to the circuit breaker with self-adhesive vinyl labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.

END OF SECTION 26 05 53

**DIVISION 26 ELECTRICAL**

**SECTION 26 05 73 POWER SYSTEM STUDIES**

**PART 1 – GENERAL**

**1.1 SUMMARY**

A. Section Includes:

1 Short-Circuit Studies
2 Protective Device Coordination Studies
3 Arc-Flash Studies

**1.2 OBJECTIVE**

A. The short-circuit study is to calculate the maximum short-circuit currents produced by balanced three-phase and unbalanced faults at each bus shown on the one line diagrams. Modeling for the worst case fault currents.
B. The protective device coordination study determines overcurrent protective relay and circuit breaker settings in order to provide optimal compromise between protection and selectivity
C. The Arc-Flash Study is utilized to assist qualified personnel in identifying the hazards associated with electrical equipment. ECU requires Arc-Flash Studies for equipment likely to require service or inspection while energized. This guideline is for existing systems, the expansion and modification to existing systems, and new construction.

**1.3 SCOPE OF SECTION:**

A. The A/E or Power Systems Consultant (PSC) shall furnish a power systems study to include short-circuit, protective device coordination and arc-flash hazard studies.
B. The A/E or PSC shall furnish an Arc Flash Hazard Analysis Study per the requirements set forth in NFPA 70E - Standard for Electrical Safety in the Workplace. The arc flash hazard analysis shall be performed according to the IEEE 1584-2018 equations.
C. The scope of the studies shall include all new distribution equipment supplied under the contract as well as all directly affected existing distribution equipment on the campus.
D. Scope shall include at a minimum:
    1. Field verify accuracy of electrical system information
    2. Collect additional electrical system information as needed
    3. Produce a detailed report of findings/recommendations
        a. Draft pre-mitigation report
        b. Finial pre-mitigation report
        c. As built post-mitigation report
    4. Complete a detailed short-circuit analysis
    5. Complete a detailed coordination analysis
    6. Complete a detailed arc-flash risk assessment
    7. Produce up-to-date single-line diagrams (SLDSs)
    8. Produce/apply arc-flash hazard labels
    9. Provide electronic copy of all deliverables

**1.4 INFORMATION/RESOURCES SUPPLIED BY ECU:**

A. SKM Files
B. Single-line diagrams (as available)
C. Floor plans (as available)
D. Assistance during field verification/personnel knowledgeable of electrical system
E. Direction on mitigations to be included in final (pre-mitigation) and as-built (post-mitigation) reports
F. Direction as to how/where labels are to be applied

G. ECU SKM label format
H. Deenergizing of equipment for inspection as requested

**1.5 CODES AND STANDARDS:**

A. Institute of Electrical and Electronics Engineers, Inc. (IEEE):

1. IEEE 141 – Recommended Practice for Electric Power Distribution and Coordination of Industrial and Commercial Power Systems
2. IEEE 242 – Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems
3. IEEE 399 – Recommended Practice for Industrial and Commercial Power System Analysis
4. IEEE 241 – Recommended Practice for Electric Power Systems in Commercial Buildings
5. IEEE 1015 – Recommended Practice for Applying Low-Voltage Circuit Breakers Used in Industrial and Commercial Power Systems.
6. IEEE 1584 - Guide for Performing Arc-Flash Hazard Calculations

B. American National Standards Institute (ANSI):
1. ANSI C57.12.00 – Standard General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers
2. ANSI C37.13 – Standard for Low Voltage AC Power Circuit Breakers Used in Enclosures
3. ANSI C37.010 – Standard Application Guide for AC High Voltage Circuit Breakers Rated on a Symmetrical Current Basis
4. ANSI C 37.41 – Standard Design Tests for High Voltage Fuses, Distribution Enclosed Single-Pole Air Switches, Fuse Disconnecting Switches and Accessories.

C. The National Fire Protection Association (NFPA)

1. NFPA 70 - National Electrical Code, latest edition
2. NFPA 70E – Standard for Electrical Safety in the Workplace, latest edition

**1.6 ACTION SUBMITTALS**

A. The short-circuit and protective device coordination studies shall be submitted to the A/E prior to receiving final approval of the distribution equipment shop drawings and/or prior to release of equipment drawings for manufacturing. If formal completion of the studies may cause delay in equipment manufacturing, approval from the A/E may be obtained for preliminary submittal of sufficient study data to ensure that the selection of device and characteristics will be satisfactory.

**1.7 NEW CONSTRUCTION OR RENOVATION PROJECTS**

A. Selective coordination between two instantaneous trip units for fault levels above the instantaneous pickup of the upstream device shall be avoided unless there is sufficient impedance between the two devices that allows the downstream device to trip first.

B. Utilization of “series rated” overcurrent devices is not allowed.

C. Options for reducing arc exposure time can include upgrading trip units, installing “maintenance switches”, and using relays with multiple settings groups. Each specific location needs to be analyzed to determine which reduction method is best employed. In no case shall the hazard to which ECU staff are exposed, exceed HRC Category 2 or 8 cal/cm2.

D. If a PSC is utilized, they shall make recommendations during the design phase of the project to the A/E in regard to the specification of overcurrent protective devices and fuse ratings that provide for the lowest incident energy levels and the greatest degree of coordination. The A/E shall include this information as “basis of design” on the contract documents. The PSC shall review and make recommendations during the construction phase of the project to the A/E in regard to the submitted overcurrent protective devices

and fuse rating to ensure the submitted equipment complies with the incident energy levels established during the design phase.

**1.8 QUALIFICATIONS A/E or PSC**

A. The short-circuit, protective device coordination and arc flash hazard analysis studies shall be conducted under the supervision and approval of a Registered Professional Electrical Engineer skilled in performing and interpreting the power system studies.

B. The Registered Professional Electrical Engineer shall be a full-time employee of an approved engineering firm or the equipment manufacturer.

C. The Registered Professional Electrical Engineer shall have a minimum of five (5) years of experience in performing power system studies similar to the project.

D. The approved engineering firm shall demonstrate experience with Arc Flash Hazard Analysis by submitting names of at least ten actual arc flash hazard analysis it has performed in the past year.

E. The engineering firm shall provide proof (written documentation) that its employees and or subcontractors working on ECU's campus are electrically qualified to conduct energized work and have been properly trained in the use and application of Arc Flash personal protective equipment (PPE) and the hazards of working on or near energized equipment.

**1.8 COMPUTER ANALYSIS SOFTWARE**

A. The studies shall be performed using the latest revision of the SKM Systems Analysis Power*Tools for Windows (PTW) software program.
B. The A/E or PSC will be responsible for determining if an upgrade to the university's license will be needed to accommodate the new/modified bus count. If an upgrade to the universities license must be made, this should be integrated into the project scope.
C. ECU will provide a backup copy of the existing database files to the A/E or PSC conducting the studies for them to build the new or modified buses.
D. Digital copies of all files related to the studies will be provided to the owner on a media and in a format compatible with importing into ECU's SKM database. Files shall include at a minimum:
   1. One-Line Diagrams
   2. Reports
   3. Libraries
   4. Time Current Curves
   5. Project Files

**PART 2 -- PRODUCTS**

**2.1 DATA COLLECTION**

A. The A/E or PSC performing the short-circuit; protective device coordination and arc flash hazard analysis studies shall furnish a listing of required data immediately after award of the contract.
B. For studies that involve no construction/renovation activities, the A/E or PSC performing the short-circuit; protective device coordination and arc flash hazard analysis studies, shall collect all data required for the power system study.
C. Source combination may include present and future motors and generators.
D. Load data utilized may include existing and proposed loads obtained from Contract Documents provided by Owner, Contractor or A/E.
E. During the course of field investigations, un-named equipment to be included with the study shall be given a logical identifying name for creation of the single-line diagram. The equipment shall be legibly marked with its identifying name during field investigations for later reference prior to final labeling. See Figure A: ECU SKM nomenclature guideline.

## 2.2 SHORT-CIRCUIT AND PROTECTIVE DEVICE EVALUATION STUDY

A. Use actual conductor impedances if known. If unknown, use typical conductor impedances based on IEEE Standard 141.
B. Transformer design impedances shall be used when test impedances are not available.
C. Provide the following:
   1. Calculation methods and assumptions
   2. Selected base per unit quantities
   3. One-line diagram of the system being evaluated
   4. Source impedance data, including electric utility system and motor fault contribution characteristics
   5. Tabulations of calculated quantities
   6. Results, conclusions, and recommendations.
D. Calculate short-circuit momentary and interrupting duties for a three-phase bolted fault at each:
   1. Electric utility's supply termination point
   2. Incoming switchgear
   3. Unit substation primary and secondary terminals
   4. Low voltage switchgear
   5. Motor control centers
   6. Standby generators and automatic transfer switches
   7. Branch circuit panel boards
   8. Other significant locations throughout the system.
E. For grounded systems, provide a bolted line-to-ground fault current study for areas as defined for the three-phase bolted fault short-circuit study.
F. The system shall be modeled in all operating modes [i.e. normal, emergency, and by-pass]. Report shall also indicate the maximum available fault current from all operating modes.
G. Protective Device Evaluation:
   1. Evaluate equipment and protective devices and compare to short circuit ratings
   2. Adequacy of switchgear, motor control centers, and panel board bus bars to withstand short-circuit stresses.
   3. For existing equipment, emphasis shall be placed on equipment exceeding its interrupting rating by more than 110%. For new equipment it shall be rated to withstand the highest level of fault current modeled.
   4. Notify ECU in writing, of existing, circuit protective devices improperly rated for the calculated available fault current.

## 2.3 PROTECTIVE DEVICE COORDINATION STUDY

A. Ideally the settings of any overcurrent device should be high enough to permit the continuous full-load operating capacity of the cables and the equipment they supply, and to ride through system temporary disturbances such as in-rush current. On the other hand, the settings should be low enough to provide overload and short-circuit protection under minimal fault conditions.
B. On new construction and renovations, equipment selections shall be avoided where device limitations impede the ability to properly coordinate devices. Such limitations include fixed operating characteristics of a fuse, the built-in instantaneous or instantaneous over-ride elements of molded case circuit breakers and the limited instantaneous trip range of trip units with an instantaneous trip function.
C. Cases involving redundant protective devices, non-selective breaker operation is acceptable. Protective devices are redundant if, regardless of which device opens, the same system outage occurs.
D. The first building protective device shall coordinate with the closest upstream high voltage protective device.
E. Proposed protective device coordination time-current curves (TCC) shall be displayed on log-log scale graphs.
F. Include on each TCC graph, a complete title and one-line diagram with legend identifying the specific portion of the system covered.
G. Terminate device characteristic curves at a point reflecting maximum symmetrical or asymmetrical fault current to which the device is exposed.
H. Identify the device associated with each curve by manufacturer type, function, and, if applicable, tap, time delay, and instantaneous settings recommended.

I. Plot the following characteristics on the TCC graphs, where applicable:
   1. Electric utility's overcurrent protective device
   2. Medium voltage equipment overcurrent relays
   3. Medium and low voltage fuses including manufacturer's minimum melt, total clearing, tolerance, and damage bands
   4. Low voltage equipment circuit breaker trip devices, including manufacturer's tolerance bands
   5. Transformer full-load current, magnetizing inrush current, and ANSI through-fault protection curves
   6. Conductor damage curves
   7. Ground fault protective devices, as applicable
   8. Pertinent motor starting characteristics and motor damage points, where applicable
   9. Pertinent generator short-circuit decrement curve and generator damage point
   10. The largest feeder circuit breaker in each motor control center and applicable panel board.

J. Provide adequate time margins between device characteristics such that selective operation is provided, while providing proper protection.

## 2.4 ARC FLASH HAZARD ANALYSIS

A. The arc flash hazard analysis shall be performed according to the IEEE 1584-2018 equations that are presented in NFPA 70E.

B. The flash protection boundary and the incident energy shall be calculated at all significant locations in the electrical distribution system (i.e. transformers, switchboards, switchgear, motor-control centers, panel boards, busway, splitters, VFDs, etc.) where staff may need to inspect, troubleshoot or maintain equipment while energized.

C. The Arc-Flash Hazard Analysis shall include all significant locations where work could be performed on energized parts. To include the installation of warning labels for locations where the incident energy is less than 1.2 cal/cm$^2$ or an Arc Flash PPE category of "0", using ECU's standard format.

D. Safe working distances shall be based upon the calculated arc flash boundary considering an incident energy of 1.2 cal/cm2.

E. The clearing times of the phase overcurrent devices will be retrieved from the short-circuit and coordination study model. Ground overcurrent relays should not be taken into consideration when determining the clearing time when performing incident energy calculations.

F. In considering capping clearing times at 2 seconds for the analysis the A/E or PSC shall use sound engineering judgement in considering if there could be circumstances where an employee's egress is inhibited. It is likely that a person exposed to an arc flash will move away quickly if it is possible, and two seconds is a reasonable maximum for calculations. A person who has crawled into equipment will need more time to move away.

G. The short-circuit calculations and the corresponding incident energy calculations for multiple system scenarios must be compared and the greatest incident energy must be uniquely reported for each equipment location. Calculations must be performed to represent the maximum and minimum contributions of fault current magnitude for all normal and emergency operating conditions. The minimum calculation will assume that the utility contribution is at a minimum and will assume a minimum motor contribution (all motors off). Conversely, the maximum calculation will assume a maximum contribution from the utility and will assume the maximum amount of motors to be operating. Calculations shall take into consideration the parallel operation of synchronous generators with the electric utility, where applicable.

H. The incident energy calculations must consider the accumulation of energy over time when performing arc flash calculations on buses with multiple sources. Iterative calculations must take into account the

changing current contributions, as the sources are interrupted or decremented with time. Fault contribution from motors and generators should be decremented as follows:

1. Fault contribution from induction motors should not be considered beyond 3-5 cycles.
2. Fault contribution from synchronous motors and generators should be decayed to match the actual decrement of each as closely as possible (e.g. contributions from permanent magnet generators will typically decay from 10 per unit to 3 per unit after 10 cycles).

I. Analysis shall calculate and assign Arc Flash values based on worst case operational configuration. Examples include: UPS's shall be assumed to be in bypass mode, VFDs shall be in bypass mode, ATSs and MTS's shall be assumed to be on standby power.

J. For each equipment location with a separately enclosed main device (where there is adequate separation between the line side terminals of the main protective device and the work location), calculations for incident energy and flash protection boundary shall include both the line and load side of the main breaker.

K. When performing incident energy calculations on the line side of a main breaker (as required per above), the line side and load side contributions must be included in the fault calculation.

L. Mis-coordination should be checked amongst all devices within the branch containing the immediate protective device upstream of the calculation location and the calculation should utilize the fastest device to compute the incident energy for the corresponding location.

M. Arc Flash calculations shall be based on actual overcurrent protective device clearing time. Maximum clearing time will be capped based on IEEE 1584-2018. Where it is not physically possible to move outside of the flash protection boundary in less than 2 seconds during an arc flash event, a maximum clearing time based on the specific location shall be utilized.

N. **Any point in the system where staff, in the course of inspecting, testing, or maintaining equipment, will be exposed to an incident energy above 8 cal/cm$^2$ or an Arc Flash HRC 2, this condition is not acceptable and will require reevaluation of the overcurrent coordination and available fault currents**.

O. Settings for protective devices cannot be adjusted if the chance of nuisance trips within critical circuits is introduced. Each location, where the incident energy is determined to be unacceptable to ECU, must be individually evaluated to determine the most effective means of reducing the incident energy while maintaining the highest degree of reliability.

P. Medium voltage distribution equipment sized for future loads, that employs fixed fuses as overcurrent protection, fuses shall be sized for the current connected load in order to limit the available fault current that could contribute to an increase arc flash hazard.

## 2.5 REPORT SECTIONS

A. The results of the short-circuit, protective device coordination and arc flash hazard analysis studies shall be summarized in a final report. No more than two (2) bound copies of the complete final report shall be submitted. Additional copies of the short-circuit input and output data shall be provided electronically in PDF format.

B. For all system studies, the A/E or PSC is required to provide the study project files to the Owner in electronic format.

C. The report shall include the following sections:

1. Executive Summary.
2. Descriptions, purpose, basis and scope of the study

3. Tabulations of circuit breaker, fuse and other protective device ratings versus calculated short circuit duties
4. Protective device time versus current coordination curves, tabulations of relay and circuit breaker trip unit settings, fuse selection
5. Fault current calculations including a definition of terms and guide for interpretation of the computer printout
6. Details of the incident energy and flash protection boundary calculations
7. Recommendations for system improvements, where needed
8. One-line diagram

D. Input data shall include, but not be limited to the following:

1. Feeder input data including feeder type (cable or bus), size, length, number per phase, conduit type (magnetic or non-magnetic), and conductor material (copper or aluminum).
2. Transformer input data, including winding connections, secondary neutral-ground connection, primary and secondary voltage ratings, kVA rating, impedance, % taps, and phase shift.
3. Reactor data, including voltage rating, and impedance.
4. Generation contribution data, (synchronous generators and Utility), including short-circuit reactance (X"d), rated MVA, rated voltage, three-phase and single line-ground contribution (for Utility sources) and X/R ratio.
5. Motor contribution data (induction motors and synchronous motors), including short-circuit reactance, rated horsepower or kVA, rated voltage, and X/R ratio.

E. Short-Circuit Output Data shall include, but not be limited to the following reports:

1. Low Voltage Fault Report shall include a section for three-phase and unbalanced fault calculations and shall show the following information for each applicable location:

    a. Voltage
    b. Calculated fault current magnitude and angle
    c. Fault point X/R ratio
    d. Equivalent impedance
2. Momentary Duty Report shall include a section for three-phase and unbalanced fault calculations and shall show the following information for each applicable location:

    a. Voltage
    b. Calculated symmetrical fault current magnitude and angle
    c. Fault point X/R ratio
    d. Calculated asymmetrical fault currents
        1) Based on fault point X/R ratio
        2) Based on calculated symmetrical value multiplied by 1.6
        3) Based on calculated symmetrical value multiplied by 2.7
    e. Equivalent impedance

3. Interrupting Duty Report shall include a section for three-phase and unbalanced fault calculations and shall show the following information for each applicable location:

    a. Voltage
    b. Calculated symmetrical fault current magnitude and angle
    c. Fault point X/R ratio
    d. No AC Decrement (NACD) Ratio
    e. Equivalent impedance
    f. Multiplying factors for 2, 3, 5 and 8 cycle circuit breakers rated on a symmetrical basis
    g. Multiplying factors for 2, 3, 5 and 8 cycle circuit breakers rated on a total basis

C. Recommended Protective Device Settings:

1. Phase and Ground Relays:

    a. Current transformer ratio
    b. Current setting
    c. Time setting
    d. Instantaneous setting
    e. Recommendations on improved relaying systems, if applicable.
2. Circuit Breakers:

    a. Adjustable pickups and time delays (long time, short time, ground)
    b. Adjustable time-current characteristic
    c. Adjustable instantaneous pickup
    d. Recommendations on improved trip systems, if applicable.

D. Incident energy and flash protection boundary calculations

1. Arcing fault magnitude
2. Protective device clearing time
3. Duration of arc
4. Arc flash boundary
5. Working distance
6. Incident energy
7. Hazard Risk Category
8. Recommendations for arc flash energy reduction

E. Floor Plans
1. Produce scaled floorplans in AutoCAD format that indicate the location of all major electrical equipment. Floor plans shall be printed on ledger sized (11 inch X 17 inch) pages with match lines and page numbers to other pages as required. Provide keyed plan to indicate plan location within the associated floor (as needed)
2. Floor plans shall have a title block designating the building number, building name, and drawing number at minimum.
3. For new construction and renovation projects, the A/E is responsible for providing the floor plans to the team conducting the power systems study.
4. Minor updates to floor plans shall be included in this scope to correct any discrepancies observed in the mechanical and electrical rooms.

F. Single Line Diagrams (SLDs)

1. SKM single-line diagrams shall be exported to AutoCAD format and printed on ledger sized (11 inch X 17 inch) pages with references to other pages as required. Provide keyed plan to indicate plan location within the associated floor (as needed)

G. As-built Post-Mitigation - Deliverables

1. Once ECU has provided final comment and direction regarding recommended remediation and all remediation has been completed, the report & model shall be updated, and the following items shall be provided:
    a. Provide two (2 hard copies of report
    b. Provide one (1) CD-ROM or flash drive containing the following:
        1) Electronic copy of the “project>Backup” of the SKM model and all associated files.
        2) Electronic copy of the exported SKM one-line diagram(s) in AutoCAD and PDF formats.
        3) Electronic copy of the scaled floorplan(s) in AutoCAD and PDF formats.
        4) Electronic copy of the report (with all scanned or printed into PDF format).

**PART 3 -- EXECUTION**

### 3.1 FIELD ADJUSTMENT

A. Adjust relay and protective device settings according to the recommended settings table provided by the coordination study. For construction projects the field adjustments are to be completed by the engineering service division of the equipment manufacturer under the Startup and Acceptance Testing contract portion. For Power Systems Study only projects the PSC field technician shall complete the field adjustments
B. Make minor modifications to equipment as required to accomplish conformance with short circuit and protective device coordination studies.
C. Notify Owner in writing of any required major equipment modifications.

### 3.2 ARC FLASH WARNING LABELS

A. The A/E or PSC conducting the Arc Flash Hazard Analysis shall provide a 4 in. x 6 in. thermal transfer type label of high adhesion polyester for each work location analyzed. Brady B-933 Vinyl or equivalent.
B. All labels will be based on recommended overcurrent device settings and will be provided after the results of the analysis have been presented to the owner and after any system changes, upgrades or modifications have been incorporated in the system.
C. Installed warning labels background color will be based upon hazard category, see owner for color matrix. The label must be readable in both indoor and outdoor environments for at least 5 years.
D. The label shall include the following information, at a minimum:
    a. Building name
    b. Room number
    c. Nominal voltage
    d. Arc Flash working distance
    e. Arc Flash boundary
    f. PPE Category
    g. Glove Class
    h. Incident energy
    i. Boundaries (limited, restricted and prohibited)
    j. Engineering report number, revision number, and issue date.
E. When the nominal voltage is 480 VAC, the warning label shall indicate an insulated glove classification of 0 and not 00.
F. Labels shall be machine printed, with no field markings.
G. Obsolete labels previously applied shall be completely removed. Labels that are no longer legible, shall be replaced.
H. Arc flash labels shall be provided in the following manner and all labels shall be based on actual post-mitigation overcurrent device settings.
    a. For each 600, 480 and applicable 208 volt panel board, one arc flash label shall be provided.
    b. For each motor control center, one arc flash label shall be provided for each bucket.
    c. For each VFD, one arc flash labels shall be provided.
    d. For each low voltage switchboard, one arc flash label shall be provided.
    e. For each switchgear, one arc flash label shall be provided for each compartment.
    f. For each medium voltage switch one arc flash label shall be provided
    g. For each medium voltage transformer primary and secondary, one label shall be provided.
    h. For each ATS, one arc flash label shall be provided.
    i. For each piece of utilization equipment 480 volts and above, one arc flash label shall be provided.
    j. For all equipment in 240 volt and 208 volt systems fed from transformers equal to or greater than 45 kVA where work could be performed on energized parts, one arc flash label shall be provided.

k. On any equipment where the hazard level may be different on different components within that piece of equipment, the Designer will work with the owner to determine the best method for labeling.
l. Labels shall be field installed by the engineering firm under the Startup and Acceptance Testing contract portion.
m. If qualified individuals may be required to access front and rear compartments of electrical equipment, then labels shall be installed at both locations indicating the hazard specific to that access point.
n. If the use of maintenance switches has been utilized in order to bring the incident energy under 8cal/$cm^2$, the label shall indicate the use of the switch and its location.

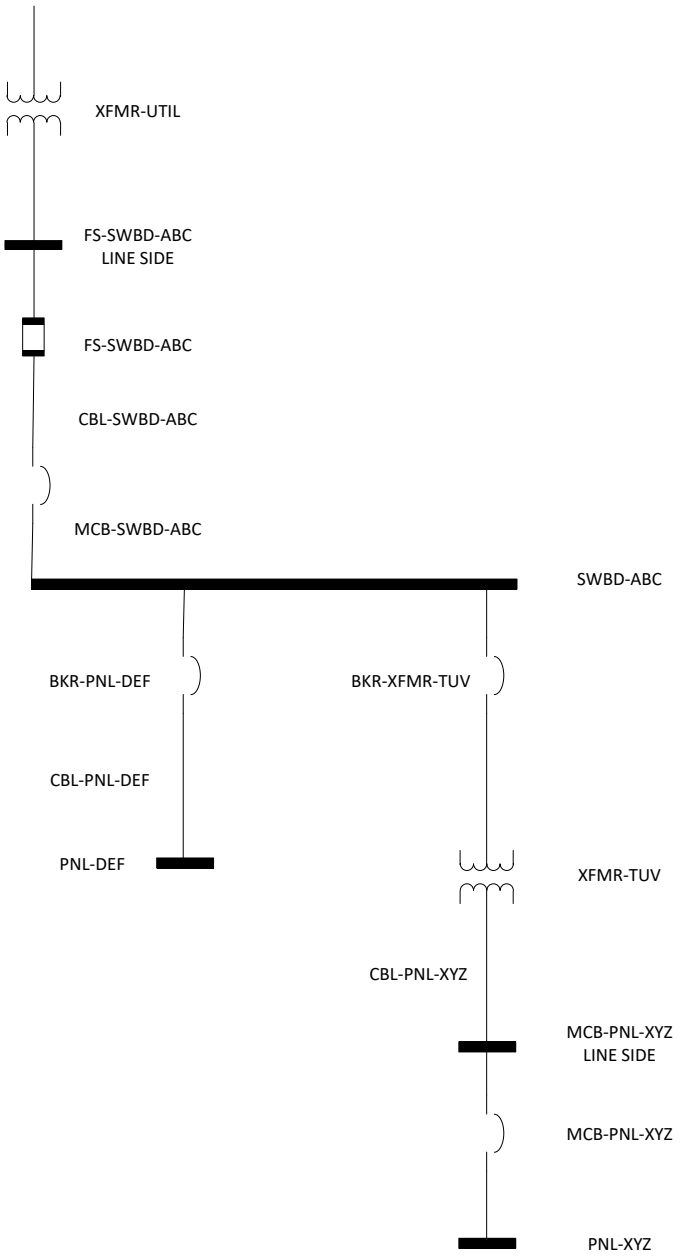
### 3.3 ARC FLASH TRAINING

The engineer/consultant of the Arc Flash Hazard Analysis shall train the owner's qualified electrical personnel on the potential arc flash hazards associated with working on energized equipment (minimum of 4 hours. The training shall include the procedure for the operation of any switching devices that must be used in order to reduce the arc flash hazard to an acceptable level when maintenance must be performed

### 3.4 NOMENCLATURE

## Figure A: ECU SKM nomenclature guideline

Below represents typical nomenclature to be used in all SKM models




LEDGEND:

| | |
|---|---|
| AHU: | Air Handling Unit |
| ATS: | Automatic Transfer Switch |
| BAT: | Battery |
| BKR: | Breaker |
| CBL: | Cable |
| FS: | Fused Switch |
| GEN: | Generator |
| MCB: | Main Circuit Breaker |
| MTR: | Motor |
| NFS: | Non-Fused Switch |
| PMP: | Pump |
| PNL: | Panelboard |
| SWBD: | Switchboard |
| UPS: | Un-Interruptible Power Supply |
| VFD: | Variable Frequency Drive |
| XFMR: | Transformer |

END OF SECTION 26 05 73

**DIVISION 26 ELECTRICAL**

**SECTION 26 08 00 COMMISSIONING OF ELECTRICAL SYSTEMS**

**PART 1 – GENERAL**

**1.1 SUMMARY**

A. This Section includes requirements for commissioning the facility electrical systems, related subsystems and related equipment. This Section supplements the general requirements specified in Section 01 91 00 General Commissioning Requirements.
B. Electrical systems/components to be commissioned include but are not limited to emergency power systems, lighting controls, enterprise metering systems, setting and testing of over current devices, and training
C. Refer to Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS for more details regarding processes and procedures as well as roles and responsibilities for all Commissioning Team members.

**1.2 COMMISSIONED SYSTEMS**

A. Commissioning of a system or systems specified in Division 26 is part of the construction process. Documentation and testing of these systems, as well as training of the ECU Operation and Maintenance personnel in accordance with the requirements of Section 01 91 00 and of Division 26, is required in cooperation with the ECU and the Commissioning Agent.
B. The facility electrical systems commissioning will include the systems listed in Section 01 91 00 General Commissioning Requirements.

**1.3 SUBMITTALS**

A. The commissioning process requires review of selected Submittals that pertain to the systems to be commissioned. The Commissioning Agent (CxA) will provide a list of submittals that will be reviewed by the Commissioning Agent. This list will be reviewed and approved by ECU prior to forwarding to the Contractor.

B. The commissioning process requires submittal review simultaneously with engineering review. Specific submittal requirements related to the commissioning process are specified in Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS.

**PART 2 – PRODUCTS (NOT USED)**

**PART 3 – EXECUTION**

**3.1 CONSTRUCTION INSPECTIONS**

A. Commissioning of Electrical systems will require inspection of individual elements of the electrical systems construction throughout the construction period. The CxA shall coordinate with the Contractor in accordance with Section 01 91 00 and the Commissioning plan to schedule electrical systems inspections as required to support the Commissioning Process.

**3.2 PRE FUNCTION CHECKLIST**

A. The Contractor should be required to complete Pre-Functional Checklists to verify systems, subsystems, and equipment installation is complete and systems are ready for Systems Functional Performance Testing. The CxA will prepare Pre-Functional Checklists to be used to document equipment installation. Completed checklists shall be submitted to the CxA for review. The CxA will at minimum spot check a sample of completed checklists but the CxA should submit a plan to ECU to confirm the level to which each system shall be commissioned. If the CxA determines that the information provided on the checklist is not accurate, the CxA will return the marked-up checklist to the Contractor for correction and resubmission. If the CxA

determines that a significant number of completed checklists for similar equipment are not accurate, the CxA will select a broader sample of checklists for review. If the CxA determines that a significant number of the broader sample of checklists is also inaccurate, all the checklists for the type of equipment will be returned to the Contractor for correction and resubmission. Refer to SECTION 01 91 00 GENERAL COMMISSIONING REQUIREMENTS for submittal requirements for Pre-Functional Checklists, Equipment Startup Reports, and other commissioning documents.

**3.3 CONTRACTORS TEST**

A. The CxA will witness selected Contractor tests at the sole discretion of the CxA. Contractor tests shall be completed prior to scheduling Systems Functional Performance Testing.

**3.4 SYSTEMS FUNCTIONAL PERFORMANCE TEST**

A. The Commissioning Process includes Systems Functional Performance Testing that is intended to test systems functional performance under steady state conditions, to test system reaction to changes in operating conditions, and system performance under emergency conditions. The CxA will prepare detailed Systems Functional Performance Test procedures for review and approval by the ECU Project Manager. The CxA will witness and document testing. See Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS, for additional details.

**3.5 TRAINING OF ECU PERSONNEL**

A. Training of the ECU operation and maintenance personnel is required in cooperation with the ECU Project Manager and CxA. Competent, factory authorized personnel shall be provided to administer instruction to operation and maintenance personnel concerning the location, operation, and troubleshooting of the installed systems. The Contractor shall be required submit training agendas and trainer resumes in accordance with the requirements of Section 01 91 00. The instruction shall be scheduled in coordination with the ECU Project Manager after submission and approval of formal training plans.

**DIVISION 26 ELECTRICAL**

**SECTION 26 09 13 ELECTRICAL POWER AND UTILITY MONITORING**

**PART 1 – GENERAL**

**1.1 SUMMARY**

A. Electrical consumption and usage data for buildings connected to the ECU campus electrical distribution systems, as well as other selected buildings, is monitored by Square D ION, web-based campus enterprise metering system. This system is generally comprised of individual building meters and submeters, which are interconnected via the campus Ethernet to a central computer server and software. The metering system is presently configured to operate on Schneider “ION” software.
B. Nonelectrical meters (e.g. water, natural gas, etc.) shall be provided and installed by the applicable division but the integration into the ION system, shall fall into Division 26
C. This section details the general requirements for metering of building electrical, standby power, and related metering system accessories.
D. This system is separate and distinct from the lighting controls, the building automation systems and the control systems.
E. Proposed meter locations and the specific type of meter shall be reviewed by the Engineering and Architectural Services as well as Facilities Services Staff.
F. New meters and submeters shall match and be fully compatible with the existing campus metering system components and software.
G. Metering is to include provision of all required interconnection wiring, metering accessories (i.e. split-core current transducers, temperature transducers, etc.), 120 VAC power supply connections, data communications wiring, and Ethernet data connections.
H. Metering system shall include all required system configuration, calibration and programming for the software integration of the meters into the campus metering system. Software integration of electric, gas, steam, and water metering data into the campus metering system typically includes the following:
    1. Development of building screens for display of meter data
    2. Setup of historical trend logs for meter interval data and all system status alarm points
    3. Development of “virtual” meter totalizers for combining various loads as may be required
    4. Linking of meter data into various monthly building consumption reporting programs, “reporter” meter data polling programs, building energy use “dashboards, and meter data validation and communications polling programs.
I. For steam, gas, and water meters, all required meter configuration, calibration and programming shall also be included for the integration of the meters into the campus metering system software
J. Metering system interconnection wiring diagrams, and screen shots depicting building meter screen displays, meter data and “virtual” meter configuration shall be submitted for approval by Facilities Services
K. Test system to verify that all metered values recorded into the campus metering system match locally-verified values utilizing portable testing equipment for steam, electric, water and gas meters.

**1.2 ELECTRIC METERING**

A. Required for incoming electrical power for new building construction and for electrical and mechanical systems renovations to existing buildings where metering is not already installed.

B. Exceptions for electrical metering are for spaces that are leased spaces where ECU is a tenant.

C. Sub metering of major building systems (lighting, HVAC, etc.), or of select spaces within the building, may be required for LEED measurement and verification purposes, by specific building program requirements or for sub metering of commercial tenants within the building.

    1. For retrofit applications and for new building loads that are served via small panelboards, utilize prewired metering enclosures, as supplied by Square D, installed adjacent to the metered equipment; enclosure

generally consists of a meter, interconnection wiring fused terminal strips for voltage leads and control power, and shorting blocks for connection to the current transformers.

2. For larger building loads served via a new distribution switchboard(s), install the meters directly within a dedicated, barriered metering compartment designed within the switchboard; metering compartment shall be factory prewired, to terminal strips, with all required three-phase current transducers, voltage inputs and 120 VAC meter power supply.

**1.3 SUBMITTALS**

A. Product Data: Submit product data showing material proposed.

B. Shop Drawings: Submit shop drawings for each product and accessory required. Include information not fully detailed in manufacturer's standard product data.

C. Wiring Diagrams: Submit wiring diagrams detailing power, signal, and control systems, clearly differentiating between manufacturer-installed wiring and field-installed wiring, and between components provided by the manufacturer and those provided by others.

D. Operation and Maintenance Data: Submit operation and maintenance data for electrical power monitoring and control equipment to include in operation and maintenance manuals specified in Division 01 - General Requirements.

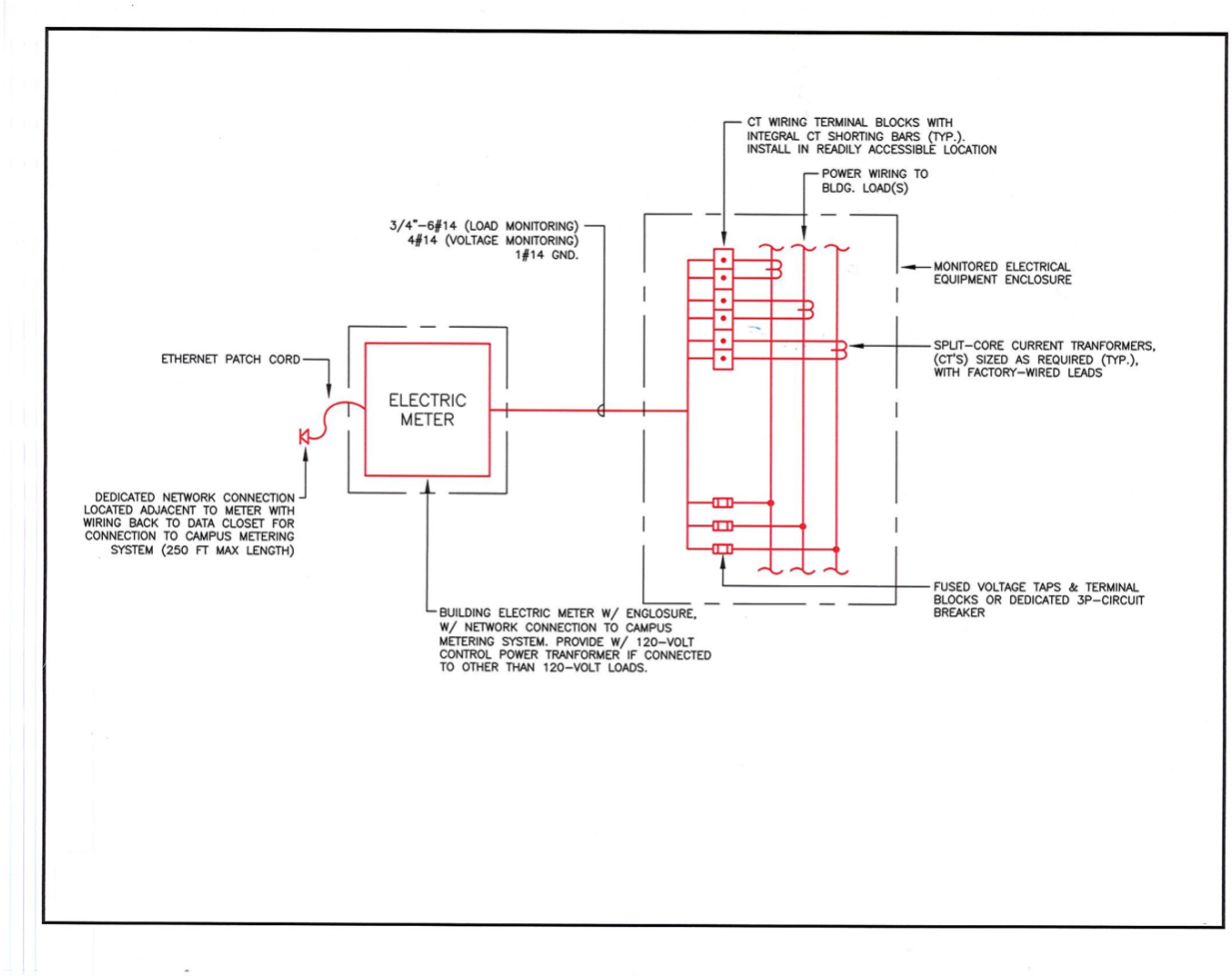
**PART 2 – PRODUCTS**

A. In general, the following electrical meter types are presently utilized as noted:
   1. Medium-voltage distribution feeders: "Power Logic PM8000" manufactured by Schneider Electric or equivalent.
   2. Incoming power meters for research labs, libraries, academic and administrative buildings with research or a large proportion of information technology/computer systems, or other equipment sensitive to power quality issues: "Power Logic PM8000" manufactured by Schneider Electric or equivalent.
   3. Incoming power meters for residential buildings, typical athletic facilities, administration buildings and classroom buildings: "Power Logic PM8000" manufactured by Schneider Electric or equivalent.
   4. Sub metered building loads: "Power Logic PM8000" manufactured by Schneider Electric or equivalent.
   5. Large generator meters: "Power Logic PM8000" manufactured by Schneider Electric or equivalent.
   6. For "Power Logic PM8000" manufactured by Schneider Electric or equivalent, provide with an Ethernet port, (2) Ethernet Modbus connections and minimum of 10 MB of on-board memory to allow for 2-week onboard data storage.
   7. Where required, furnish meter, installed and prewired complete within a common 20" x 20" (nominal) NEMA 4/12 enclosure.
   8. Setup parameters required by the power meter shall be stored in nonvolatile memory and retained in the event of a control power interruption.
   9. The power meter shall be applied across all phases of a four-wire wye, three-wire wye, three-wire delta, direct delta, and single-phase systems.
   10. The PM instrument shall be fully supported by ECU's Enterprise PM software.
   11. The PM instrument shall have no less than three (3) voltage inputs and four (4) current inputs.

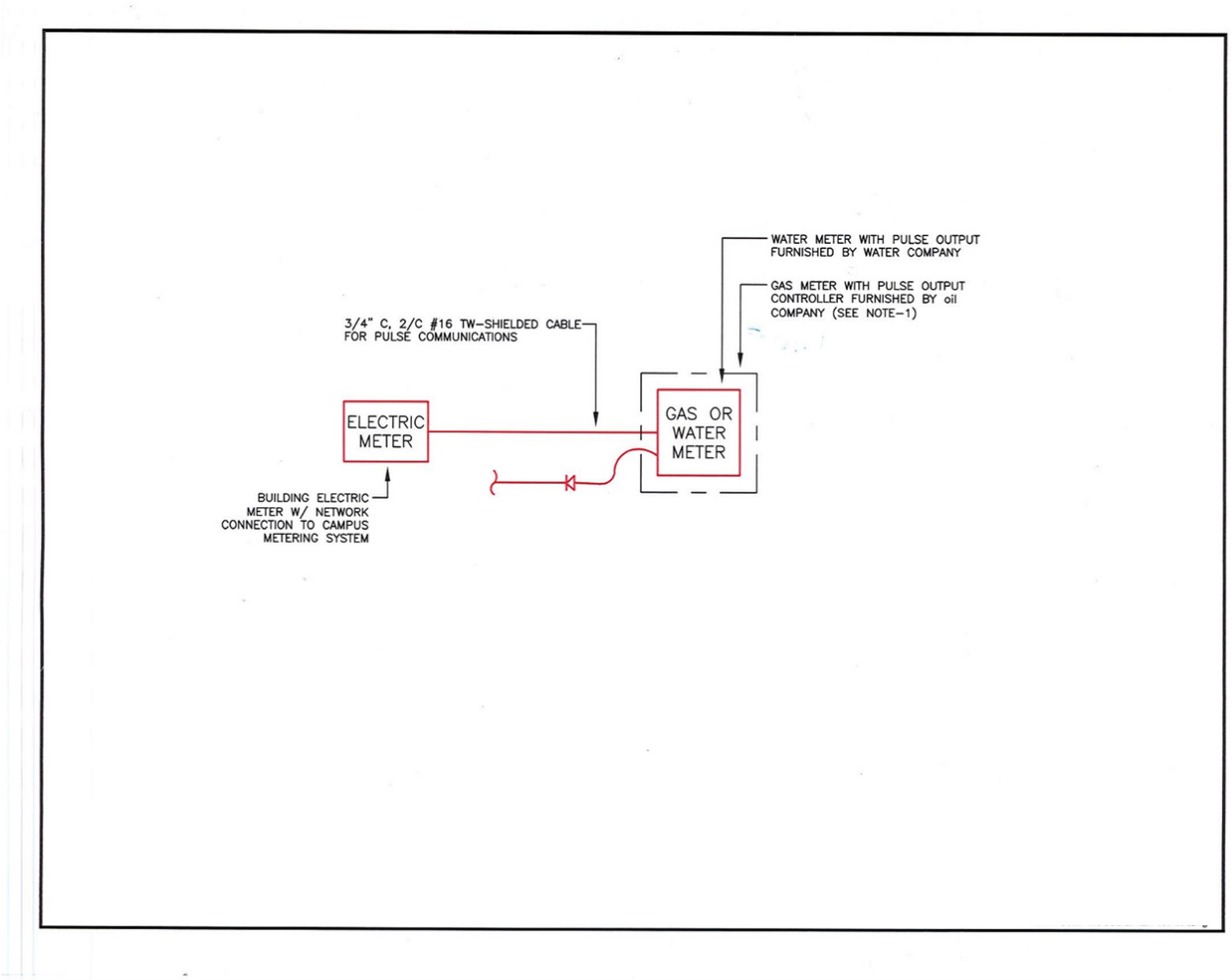
**PART 3 – EXECUTION**

**3.1**

A. Electric Meter Interconnection Detail



B. Water/Gas Meter interconnection Detail



**DIVISION 26 ELECTRICAL**

**SECTION 26 09 23 LIGHTING CONTROL DEVICES**

**PART 1 – GENERAL**

**1.1 SUMMARY**

A. Lighting control shall not be accomplished through audio visual systems (AVS) but shall be a separate system. Lighting control systems shall not interface with the fire alarm system. The lighting control system must be able to be maintained, programmed and modified by Facilities Services staff. Any equipment necessary to be able to program or modify the system, to include computers, software, firmware, and cables, shall be provided as part of the project.

B. Controls that will require periodic updates of software or firmware shall not be used unless the updates shall be provided free of cost to the university in perpetuity.

C. The design of lighting control systems shall be such that the failure of any component in one room shall not impact any other room.

D. Section Includes:

1. Time switches.
2. Photoelectric switches.
3. Indoor occupancy sensors.
4. Building lighting control systems

**1.2 ACTION SUBMITTALS**

A. Product Data: For each type of product.

**1.3 INFORMATIONAL SUBMITTALS**

A. Field quality-control reports.

**1.4 CLOSEOUT SUBMITTALS**

A. Operation and maintenance data.

**PART 2 -- PRODUCTS**

**2.1 TIME SWITCHES**

A. Mechanical time switches shall be the preferred method over electronic

B. Electronic Time Switches: Solid state, programmable, with alphanumeric display.

1. Contact Rating: 20-A ballast load, 120/240-V ac or 277 V ac.
2. Programs: Two on-off set points on a 24-hour schedule, allowing different set points for each day of the week and an annual holiday schedule that overrides the weekly operation on holidays.
3. Circuitry: Allow connection of a photoelectric relay as substitute for on-off function of a program.
4. Astronomic Time: All channels.
5. Automatic daylight savings time changeover.
6. Battery Backup: Not less than seven days reserve, to maintain schedules and time clock.
7. Shall not be interconnected with AVS controls.

C. Electromechanical-Dial Time Switches are not approved.

**2.2 INDOOR CEILING OCCUPANCY SENSORS**

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Leviton Mfg. Company Inc.
2. Lithonia Lighting; Acuity Lighting Group, Inc.
3. Lutron Electronics Co., Inc.

B. General Requirements for Sensors: Ceiling-mounted, dual technology type indoor occupancy sensors.

1. Operation: Unless otherwise indicated, turn lights on when coverage area is occupied, and turn them off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 3 to 30 minutes.
2. Provide manual toggle switch to allow manual means to turn load off. Provide dual switching in classrooms and computer labs, and research labs.
3. Automatic Light-Level Sensor: Adjustable from 10 to 300 fc; turn lights off when selected lighting level is present.
4. LEDs to indicate occupancy detection.
5. Provide five year warranty.

**2.3 SWITCHBOX-MOUNTED OCCUPANCY SENSORS**

A. Manufacturers: Subject to compliance with requirements, provide products by the following:

1. Hubbell Building Automation, Inc.
2. Leviton Mfg. Company Inc.
3. Lutron Electronics Co., Inc.
4. Lithonia Lighting; Acuity Lighting Group, Inc

B. General Requirements for Sensors: Automatic-wall-switch occupancy sensor, suitable for mounting in a single gang switchbox.

1. Standard Range: 180-degree field of view, field adjustable from 180 to 40 degrees; with a minimum coverage area of 900 sq. ft.
4. Sensing Technology: Dual technology - PIR and ultrasonic.
5. Switch Type: Provide with choice of Auto-On or Manual-On.
6. Provide means for manual-Off override via pushbutton.
7. Voltage: Dual voltage, 120 and 277 V; dual-technology type.
8. Ambient-Light Override: Concealed, field-adjustable, light-level sensor from 10 to 300 fc. The switch prevents the lights from turning on when the light level is higher than the set point of the sensor.
9. Concealed, field-adjustable, "off" time-delay selector at up to 30 minutes.

**2.4 BUILDING LIGHTING CONTROL SYSTEMS**

A. Manufacturers: Subject to compliance with requirements, provide products by the following:

1. Intermatic, Inc.
2. Cooper Industries, Inc.
3. Leviton Mfg. Company Inc.
4. Lithonia Lighting; Acuity Lighting Group, Inc

B. Electronic Time Switches: Solid state, programmable, with alphanumeric display.

1. Programs: Two on-off set points on a 24-hour schedule, allowing different set points for each day of the week and an annual holiday schedule that overrides the weekly operation on holidays.
2. Circuitry: Allow connection of a photoelectric relay as substitute for on-off function of a program.
3. Astronomic Time: All channels.

4. Automatic daylight savings time changeover.
5. Battery Backup: Not less than seven days reserve, to maintain schedules and time clock.
6. Shall not be interconnected with AVS controls.
7. Outdoor lighting not permitted to be on electronic lighting controls, only photocells and lighting contactors shall be permitted

**2.6 CONDUCTORS AND CABLES**

A. Power Wiring to Supply Side of Remote-Control Power Sources: Not smaller than No. 12 AWG. Comply with requirements in Division 26 Section "Low-Voltage Electrical Power Conductors and Cables".

**PART 3 -- EXECUTION**

**3.1 INSTALLATION**

A. Locate sensors in locations to achieve not less than 90 percent coverage of areas indicated.

B. Circuit controlled by occupancy sensors shall not be routed through a relay control panel.

D. Exterior lighting shall be controlled via photocell on/off and shall not be routed through a relay control panel or time switch.

E. Interior spaces lighting control shall be via line voltage occupancy sensors with means to manually override the load side off. Refer to **Section 26 09 23, 2.3** Indoor Ceiling Occupancy Sensors and **2.4**, Switchbox-Mounted Occupancy Sensors. Power packs with multiple occupancy sensors shall not be used in large spaces or corridors requiring more than one sensor for adequate coverage.

F. Lighting control systems are permissible in large Auditorium spaces or classroom spaces. Automatic control, vacant and off shall be incorporated into the system. The lighting control system shall be provided with BACnet module for ECU Facilities Services (ECU FS) remote control. Coordinate with ECU Project Manager and ECU FS at design. Dedicated closet space shall be provided for lighting control systems control units and control computer and terminal. This may not be housed in the same room as the AV control system. Wireless systems (communication between sensor and controller) shall be entertained by the university but must be preapproved in advance by ITCS. Wireless systems shall not utilize the university wireless network for communication.

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
    a. Lithonia
    b. Watt Stopper
    c. Allen-Bradley/Rockwell Automation.

2. Description: Lighting Control Systems (as required for the control type):
    a. Shall be interfaced with ECU event management software platform “Events2HVAC”

G. Building lobby lighting and atrium or similar space shall be controlled via the BAS. Coordinate with ECU Project Manager and ECU FS.

H. Provide training for all lighting control devices to ECU FS.

**3.2 FIELD QUALITY CONTROL**

A. Perform the following tests and inspections:

1. Operational Test: After installing time switches and sensors, and after electrical circuitry has been energized, start units to confirm proper unit operation.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Lighting control devices will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

END OF SECTION 26 09 23

**DIVISION 26 ELECTRICAL**

**SECTION 26 10 00 MEDIUM VOLTAGE DISTRIBUTION**

**PART 1 – GENERAL**

**1.1 SUMMARY:**

A. The medium voltage power distribution systems at East Carolina University are composed as follows:

1. Health Sciences Campus: One distinct 12,470V system with multiple primary loop feeds to the campus. The point of delivery by the local utility provider is at the Central Utility Plant. There are three circuits coming from the local utility which feed into the utility's sectionalizing switchgear on site. The utility then feeds into ECU's, two metal-clad switchgear assemblies. Each campus loop terminates into both switchgears. Each of the campus loops contain multiple pad-mounted switchgear that feed the building transformers. The local utility also has two, 1MW, diesel generators sets that tie into ECU's grid and are used for peak shaving by the utility.

B. For reliability, single unit redundancy shall be provided on ECU's Distribution System (EDS).

C. System design shall ensure that the failure of any single component of the EDS shall not prevent the system from carrying the full sectional Campus load. Projects adding load to the system shall include, upgrades or expansion of the system to maintain this redundancy.

D. All new facilities shall be provided with the appropriate redundancy noted above. Over-current protection and switchgear shall be provided to maintain noted redundancy.

E. Underground Transmission and Distribution are the preferred methods for new electrical infrastructure construction on campus. Above ground equipment, such as MV switchgear, sectionalizing switches, and transformers shall be concealed from view where practical. Additions to existing overhead line construction will be allowable in order to extend service or to upgrade existing system's reliability. All poles to be concrete. All cut outs shall be installed outside of the phases.

F. The A/E shall ensure that MV overcurrent protection devices are properly coordinated and that potential arc flash hazards are mitigated. All Power Systems Studies are specified in 26 05 73.

G The A/E shall ensure that at any location where equipment may require inspection, testing or maintenance, that provisions are made for the application of personal protective grounds (PPG). Provisions shall include the ability of personal to apply PPG utilizing live-line tools.

H. The A/E shall ensure that at any location where equipment may require Inspection, testing , or maintenance, that provisions are made to require test points on load break elbows such that contact type voltage meters can be used to confirm a energized status.

I. To ensure that ECU meets the requirements set forth in OSHA 1910.269 Appendix C – Protection From Hazardous Differences in Electrical Potential, the A/E shall conduct an engineering analysis of the power system under fault conditions to determine whether hazardous step and touch voltages will develop. The analysis should determine the voltage on all conductive objects in the work area and the amount of time the voltage will be present. Based on this analysis, ECU can select appropriate measures and protection equipment, including measures and protection equipment outlined in Section III of Appendix C, to protect each employee from hazardous differences in electrical potential.

END OF SECTION 26 10 00

**DIVISION 26 ELECTRICAL**

**SECTION 26 12 00 MEDIUM VOLTAGE TRANSFORMERS**

**PART 1 – GENERAL**

**1.1 SUMMARY**

A. This Section includes:

This section includes design requirements for medium-voltage distribution transformers, typically utilized for building service entrance use, connected to the campus 12.47 KV and 4.16 KV distribution systems

**1.2 ACTION SUBMITTALS**

A. Product Data: For each product indicated.

B. Shop Drawings: Indicate dimensions and weights.

1. Wiring Diagrams: Power, signal, and control wiring.

**1.3 INFORMATIONAL SUBMITTALS**

A. Field quality-control test reports.

**1.4 CLOSEOUT SUBMITTALS**

A. Operation and maintenance data.

**PART 2 -- PRODUCTS**

**2.1 GENERAL MEDIUM VOLTAGE TRANSFORMER REQUIREMENTS**

A. Transformers to be Underwriters' Laboratories (UL) listed; indoor-mounted transformers to be FM listed

B. Transformers shall conform to latest NEMA TP-1 requirements for energy efficiency

C. Transformers shall be capable of operating at 100% of nameplate rating continuously while in an ambient temperature of 40°C (104° F). Maximum temperature rise shall be 80°C

D. Three phase transformers shall be wound in a Delta-Wye configuration unless otherwise required for the application

E. Coolant and insulating fluid: non-toxic, fire resistant, natural ester oil, Envirotemp FR3, as manufactured by Cooper Power Systems, or approved equal

F. Use copper for transformer windings and terminations

G. Electric panels shall not be mounted inside transformer enclosures

H. All transformers are to be new. Rebuilt transformers are allowed only under emergency conditions and must be authorized in by ECU. Field repairs for any transformers that are installed and found to be faulty after installation shall not be accepted and shall be replaced with new at no cost to the university

I. Transformers shall be Radially fed only, with an upstream SF-6 switch to de-energize. This design shall only be utilized for simplifying the wiring congestion within the High Voltage compartment. All unused connections shall be plugged “safe”. The required design is to use a loop fed transformer with the surge lighting arrester inserted into the second set of loop bushings. When the transformer is internally wired as a Radial feed transformer, the surge arrester may be plugged into the back of the separable connector, or into special feed through inserts.

J The A/E shall ensure that at any location where equipment may require inspection, testing or maintenance, that provisions are made for the application of personal protective grounds (PPG). Provisions shall include

the ability of personal to apply PPG utilizing live-line tools.

**2.2 MEDIUM VOLTAGE TRANSFORMERS OIL TYPE PAD MOUNT**

A. Specify the following features: replaceable MOV Elbow surge arresters, internally wired Loop feed transformers types may have source on/off switching only for energizing surge arrester, oil sampler; spare fuses (one set minimum); lifting hooks.

B. New transformers shall be of the Load Break Elbow (separable connector) design. Side bushings shall be configured with NEMA two hole spade type bushings for three phase transformers. On/Off switching on the primary side may be included as a feature to ease the operation of the local transformer.

C. Oil sampling. Configure secondary conduit placement in a manner consistent with the Manufacturer's shop drawing information on the drain oil sampling valve location and configure wiring to assure the sampling operation can occur without having to disconnect secondary cabling.

D. Transformer shall be located to be visually unobtrusive. Provide a reinforced, cast in place (or pre-cast) transformer pad (minimum 6-inches in height) to protect the cabling and bottom of the transformer.

E. Transformers shall be turned over to ECU with a positive pressure of a 2-psi of Nitrogen Gas Blanket above the transformer oil. ECU may require retesting of and various transformer loadings.

F. Taps: externally-operated no-load tap changer, with padlocking provisions, with two taps at 2.5% above and two taps at 2.5 % below nominal voltage.

G. High-voltage terminations: Dead-front type, with 600-amp rated integral dual (loop-feed) primary bushings for load-break elbows and elbow-style surge arrestor

H. Low-voltage terminations: Molded epoxy bushings with blade-type spade terminals, arranged for vertical takeoff; neutral grounded to tank via removable strap

I. Fuses: Bayonet type, oil-immersed type, current-limiting fuses, with external hook-stick access

J. Enclosure:
   1. High and low voltage, full-height compartments located side by side, separated by a grounded metal barrier; low voltage on the right side when facing the front of transformer
   2. High voltage door fastenings not accessible unless low voltage door is opened
   3. 3-point latches for both enclosures
   4. Low voltage door provided with vault type handle with padlock provisions and penta-head access bolt
   5. Stainless steel hinges and door stays
   6. Removable doors, sills and barriers to facilitate cable installation

K. Accessories:
   1. Dial-type thermometer, with resettable max reading indicator
   2. Liquid level gage
   3. Pressure vacuum gage
   4. Automatic Pressure relief device
   5. 1" upper filter press and filling plug
   6. 1" lower drain valve and sampling port, provide with threaded type sealing plug
   7. All load break elbows shall have test caps for voltage testing

**2.3 ACCEPTABLE MANUFACTURES**

A. Acceptable Manufactures: ABB, Cutler Hammer, GE, Square D, Cooper or approved equal from an Original Equipment Manufacturer.

**2.4 IDENTIFICATION DEVICES**

A. Nameplates: Engraved, laminated-plastic. Nameplates are specified in Division 26 Section "Identification for Electrical Systems".

**PART 3 -- EXECUTION 3.1 INSTALLATION**

A. Check primary and secondary voltages and make appropriate tap adjustments after transformer energization to provide optimum voltage conditions to the utilization equipment; provide final report to indicate as left voltages

B. Provide concrete housekeeping pad for floor-mounted transformers

C. All conduits shall enter & exit transformer from beneath the pad or vault

**3.1 FIELD QUALITY CONTROL**

A. Perform tests and inspections.

B. Tests and Inspections:

1. All transformers 300kVA and above shall be tested for winding resistance, Transformer Turns Ratio (TTR) and oil dielectric per the latest ANSI C57 and ASTM D877 industry standards. The test results shall be given to ECU Facilities Electrical Departments prior to energization.

END OF SECTION 26 12 00

**DIVISION 26 ELECTRICAL**

**SECTION 26 13 19 MEDIUM VOLTAGE VACUUM INTERRUPTER SWITCHGEAR**

**PART 1 – GENERAL**

**1.1 SUMMARY**

A. ECU only uses three phase 4-way and 4-way with a tie switch configuration. Any other switch configuration requires written justification and approval of the ECU Facilities Services Department.

**1.2 ACTION SUBMITTALS**

A. Product Data: For each product indicated.

B. Shop Drawings: Indicate dimensions and weights.

1. Wiring Diagrams: Power, signal, and control wiring.

**1.3 INFORMATIONAL SUBMITTALS**

A. Field quality-control test reports.

**1.4 CLOSEOUT SUBMITTALS**

A. Operation and maintenance data.

**PART 2 -- PRODUCTS**

**2.1 GENERAL MEDIUM VOLTAGE SWITCHGEAR REQUIREMENTS**

A. The switchgear shall consist of a gas-tight tank containing SF6 gas and load-interrupter switches with visible open gaps and integral visible grounds. Load-interrupter switch terminals shall be equipped with bushings rated 600 amperes continuous to provide for elbow connection. 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.

B. All new Medium Voltage switchgear shall come System Control and Data Acquisition (SCADA) ready, with the following features:

1. Auxiliary Switches: Indication of Fault Interrupter position and Load Interrupter position and Load Interrupter position. Dry contacts to be terminated in a low-voltage enclosure with terminal blocks.
2. Remote Low Pressure Alarm: Provisions only (plugged pressure gage dog) for a future low pressure warning device.
3. Motor Operator Package: Provisions only to allow retrofit of motor operator to achieve remote control without replacement of the switch or the switch enclosure.
4. External Trip: Provisions to allow an external signal to open a fault interrupter.

D. All hardware, software, and accessories required to communicate with the gear's controllers and/or adjust settings shall be provided to ECU with the closeout documents.

E The A/E shall ensure that at any location where equipment may require inspection, testing or maintenance, that provisions are made for the application of personal protective grounds (PPG). Provisions shall include the ability of personal to apply PPG utilizing live-line tools.

**2.2 MEDIUM VOLTAGE SWITCHGEAR**

A. Switches must be furnished factory filled with an electrical grade of non-toxic, non-flammable SF6 gas, conforming to ASTM D-2471-71.

B. A pressure indicator, which provides visual status of both the insulating and interrupting dielectric, must be included. 100% production testing shall include a mass spectrometer leak test, contact resistance test, AC one minute withstand and corona extinction tests.

C. A gas-fill valve shall be provided.

D. A temperature-compensated pressure gauge shall be provided that is color coded to show the operating range. The gauge shall be mounted inside the gas-tight tank (visible through a large viewing window) to provide consistent pressure readings regardless of the temperature or altitude at the installation site.

E. Each load-interrupter switch shall be provided with a large viewing window at least 6 inches by 12 inches to allow visual verification of the switch-blade position (open, closed, and grounded) while shining a flashlight on the blades.

F. One ground-connection pad shall be provided on the gas-tight tank of the switchgear. The ground-connection pad shall be constructed of stainless steel and welded to the gastight tank and shall have a short-circuit rating equal to that of the switchgear.

G. Basic components:

1. Load-Interrupter Switches. The three-phase, gang-operated load-interrupter switches shall have a three-time and ten-time duty-cycle fault-closing rating. This rating defines the ability to close the switch the designated number of times against a three-phase fault with asymmetrical (peak) current in at least one phase equal to the rated value, with the switch remaining operable and able to carry and interrupt rated current. Certified test abstracts establishing such ratings shall be furnished upon request.
2. The switch shall be provided with an integral ground position that is readily visible through the viewing window to eliminate the need for cable handling and exposure to high voltage to ground the equipment.
3. The ground position shall have a three-time and ten-time duty-cycle fault-closing rating.
4. The switch shall be provided with an open position that is readily visible through the viewing window to eliminate the need for cable handling and exposure to high voltage to establish a visible gap.
5. The open gaps of the switch shall be sized to allow cable testing through a feed thru bushing or the back of the elbow.

H. Operating Mechanisms:

1. Load-interrupter switches and fault interrupters shall be operated by means of a quick-make, quick-break mechanism.
2. The manual handle shall charge the operating mechanism for opening, closing, and grounding of the switches and fault interrupters.
3. A single, integrated operating mechanism shall fully operate each fault interrupter or load interrupter switch in a continuous movement, so that additional operations are not required to establish open or ground positions.
4. Operating mechanisms shall be equipped with an operation selector to prevent inadvertent operation from the closed position directly to the grounded position, or from the grounded position directly to the closed position. The operation selector shall require physical movement to the proper position to permit the next operation.
5. Operating shafts shall be pad-lockable in any position to prevent operation.
6. The operation selector shall be pad-lockable to prevent operation to the grounded position.
7. The operating mechanism shall indicate switch position which shall be clearly visible from the normal operating position.

I. Components:

1. Main Bus: Copper: full length of switchgear.
2. Ground Bus: Copper
3. On each phase of all utilized circuits of a new switch, a fault indicator shall be required. The fault indicator shall be rated at 1200 amps with inrush restraint, current reset and snap action clamp for cable with O.D. of 1.6". The fault indicator shall be installed and positioned to be read easily at a safe distance.

**2.4 ACCEPTABLE MANUFACTURES**

A. G&W or S&C or approved equal

**2.5 IDENTIFICATION DEVICES**

A. Nameplates: Engraved, laminated-plastic. Nameplates are specified in Division 26 Section "Identification for Electrical Systems".

**PART 3 -- EXECUTION 3.1 INSTALLATION**

A. Switches shall be mounted on precast, open, vaults

END OF SECTION 26 13 19

**DIVISION 26 ELECTRICAL**

**SECTION 26 13 26 MEDIUM VOLTAGE OUTDOOR METAL CLAD SWITCHGEAR**

**PART 1 - GENERAL**

Section Includes: Design, detailing, fabrication, factory assembly, testing, and inspection of a 15 kV Class outdoor metal enclosed switching station assembly, including the enclosure, facilities, equipment and auxiliary devices. The assembly shall consist of a complete unit, generally consisting of the following:

1. Incoming breaker sections, power circuit breakers.
2. Feeder sections, power circuit breakers.
3. Tie breaker section, power circuit breaker.
4. Potential and control power transformer section.
5. Miscellaneous items and features as described herein.
6. ION Enterprise SCADA system interface equipment.

**1.2 ACTION SUBMITTALS**

A. Product Data: For each product indicated.

B. Shop Drawings: Indicate dimensions and weights.

1. Wiring Diagrams: Power, signal, and control wiring.

**1.3 INFORMATIONAL SUBMITTALS**

A. Field quality-control test reports.

**1.4 CLOSEOUT SUBMITTALS**

A. Operation and maintenance data.

**1.5 EXTRA MATERIALS**

A. Accessory equipment shall include at least the following:

1. One test cabinet, suitable for wall mounting for operating, testing and inspecting the circuit breaker when it is removed from the stationary structure. Electrical schematics and test instructions shall be included.

2. One removable closing lever for manually closing the circuit breaker.

3. One removable hand crank for moving circuit breaker to the operating position.

4. One set of test plugs/blocks for relays.

5. One set of test jumpers for connecting breaker unit to test cabinet.

6. One lift truck (i.e., breaker jack for hoisting breaker to rails) for breaker handling during installation and removal.

7. One grounding and testing device that can be inserted in place of a circuit breaker.

8. One spare box (five minimum) of each type of indicator lamp in marked container.

9. One spare set (three) of each size potential transformer fuses in marked container.

10. One spare set (two) of each size control power transformer fuses in marked container.

**1.6 WARRANTY**

Warranty period of one (1) year minimum shall start at the date the equipment is energized after acceptance by the University.

## PART 2 - PRODUCTS

**2.1 NAMEPLATES**

A. Provide for each section, unit, instrument, current transformer ratio (shown with associated relay) light, meter, switch, control, terminal strip, rear panel mounted component (including fuses), fuse blocks, timers, relays, auxiliary relays, etc., in accordance with a nameplate schedule, which shall be generated by the Vendor. Color coding will be used for equipment and functional identification.

1. Nameplates shall be laminated two-ply plastic black face to white core) with legend engraved to white core.

2. Characters shall be uniform block style not smaller than 1/4" for switchgear sections, switching devices, panelboards not smaller than 1/8" for instrument transformers, relays, alarms, instruments, and control devices.

3. Nameplates shall be secured using zinc-chromate plated machine screws.

**2.2 POWER CIRCUIT BREAKERS**

A. The power circuit breakers shall be vacuum type, three-pole, electrically charged, mechanically and electrically trip-free, stored-energy operating mechanisms. The stored energy mechanism shall be vertically mounted and located behind the front panel of the circuit breaker, to allow access while the circuit breaker is within its compartment. Provision shall be included for manual charging of the mechanism. Breakers shall be removable and shall roll out from horizontal guide rails. They shall have self-coupling primary and secondary contacts. Safety shutters shall be actuated to cover the stationary primary disconnects when the breaker is moved from the connected position. The breaker shall have integral wheels to permit the breaker to be rolled on the floor when removed from the breaker compartment.

B. The breaker compartment shall be furnished with a mechanism which will move the breaker between operate, test, and disconnect positions. The mechanism shall be designed so that the breaker will be self-aligning and will be rigidly held in the operating position without the necessity of locking bars or bolts. In the disconnect position, the breaker shall be easily removable from the compartment.

C. Operating, test and withdrawn positions shall be provided for the breaker unit. The primary contacts shall be disconnected in the test position, but auxiliary contacts and control circuit contacts shall be maintained in this position or shall have means of being connected for breaker and control circuit testing operations. Connections shall be disconnected in the withdrawn position. The entrance to the stationary primary disconnecting contacts shall be automatically covered by shutter when the breaker is in the disconnected or test withdrawn positions. An indicator shall be furnished to show whether the breaker is in operate, test, or disconnect position. Provisions for padlocking the circuit breaker in the test or disconnected position, and cubicle doors with locks shall be provided.

D. Provisions shall be made for operating breakers manually, and a mechanical "Close-Trip" indicator shall be provided on the breaker.

E. Normally open and normally closed electrically separate sets of mechanism-operated breaker mounted auxiliary contacts shall be provided in addition to those required for the circuit breaker operating mechanism. These contacts shall operate in the test and connect positions. The number of contacts provided shall be in accordance with the Rating and Performance Requirements specified herein under Part 2.3.

F. The breaker compartment shall be equipped with electrically separate and convertible breaker auxiliary switch contacts operated by the breaker when in operating position, and provisions shall be made for operation of these contacts when breaker is in the test position. The switchgear manufacturer shall provide two (2) – six-stage auxiliary switch sections with six (6) "a" contacts and six (6) "b" contacts per six-stage switch.

G. A stationary removable-element position-indicator switch with convertible contacts shall be furnished. The contacts shall operate when the breaker is moved to the connected position.

H. All unused auxiliary contacts shall be wired to the terminal blocks.

I. A mechanical interlock shall be provided to prevent the removable element from being inserted into or withdrawn from its operating position while the circuit breaker is closed.

J. A mechanism shall be provided to prevent over-travel of the removable element when moving into operate, test and disconnect positions, and to latch the element in each position.

K. The switchgear shall be provided with mechanical interlocks to:

1. Prevent moving the breaker to or from the "connected" position when the breaker contacts are in the "closed" position.

2. Prevent closing the breaker unless the primary disconnects are fully engaged or the breaker is in the test/disconnect position.

3. Automatically discharge the closing springs when the breaker is moved between the "connected" and test" positions or when it is inserted into or withdrawn from the compartment.

O. The control power transformer and potential transformer primary fuses, whether located on the CPT or on separate rollout trays, shall not be accessible unless the transformer primary and secondary circuits are open. Rollout trays shall automatically be grounded, throughout its travel, when withdrawn from the compartment.

P. Breakers shall be removable from the equipment by means of a portable lifting device. This device shall be furnished by switchgear manufacturer.

**2.3 CABLE ENTRANCE**

A. Switchgear shall be designed for bottom entry of incoming and feeder cables and for control or other wiring.

B. Each breaker compartment shall have a separate cable entry compartment.

**2.4 INDICATING LAMPS**

A. Green, white and red circuit breaker position indicating lights, with resistors, shall be provided immediately above each circuit breaker switch to indicate when the breaker is in the Open, Ready or Closed position. Lamps and lenses shall be replaceable from the front of the panel.

B. An indicating lamp shall be provided on each incoming breaker cubicle to provide indication of availability of utility power.

C. Blue and yellow Local-Remote indicating lights shall be provided for the SCADA control.

D. Connections to the terminal blocks shall be provided for remote indication.

**2.5 PROTECTIVE RELAYS**

A. Relays shall be utility grade solid state type.

B. Auxiliary relays shall have dust covers and be surface mounted in the cubicle. Other relays to be furnished shall be installed on the front of the instrument compartment and shall be semi-flush, draw out design with integral testing devices as applicable. The rear of the instrument door shall be constructed to provide a dead-front when opened and accessible to operators.

C. Relays shall be capable of communicating using Modbus TCP and Ethernet to the SCADA system (Square D ION, web-based campus enterprise metering system).

D. Relays shall provide functionality to remotely close and open each main, tie, and feeder breakers.

**2.6 METERING**

A. See 26 09 13 for additional requirements on metering.

B. All meters shall be installed so that they are accessible for maintenance, testing, or calibration while the gear is energized. Provide test switch on all meters.

**2.7 AUXILIARY COMPARTMENTS**

A. Compartments shall supply control power and potential instrument voltage for each bus section and other remote devices, as required. Sufficient compartments shall be provided, as necessary, to house equipment and each compartment shall be provided with hinged doors. Interface wiring and conduit needed to connect the switchgear lineup or other devices requiring control power or potential instrument voltage shall be provided and indicated on the shop drawings. Equipment items shall include the following:

**2.8 CONTROL AND AUXILIARY POWER**

A. Switchgear AC control power shall be furnished from an integral control power transformer system. Switchgear DC control power shall be provided from a 125-volt station battery system. Switchgear instrument power shall be provided from instrument transformers.

B. Control (Station) Power Transformer System: Two control power transformers shall be provided, each capable of furnishing the complete switching station power requirements. Each transformer shall be fed from a separate main bus and switched by an automatic selective control to supply the panelboard protecting individual low-voltage circuits.

1. Control Power transformers: Control power transformers shall be ventilated dry type and provide 208Y/120 volt, three-phase, four-wire power to meet the switching station's low-voltage AC power requirements plus 25 percent spare capacity. The transformer sizes shall not be less than indicated on the drawings. Transformer primary current-limiting fuses shall be interlocked with a secondary molded case circuit breaker provided as part of the control power system. Access to primary fuses shall not be possible unless the secondary breaker is in the open position. The primary fuses shall be of the draw out type. Mechanical interlocks shall prevent removal of primary fuses unless the assembly is in the draw out position. Transformer compartment shall have hinged doors.

2. Automatic Selective Control: Automatic selective control (ANSI Device 83) shall switch control power from the "firm" power bus to the "interruptible" power bus when no power is available on the "firm" bus. Auxiliary relay contacts shall be provided to allow status monitoring by the SCADA System.

**2.9 BUS AND BUS TAPS**

A. Bus bars shall be of copper of sufficient size to carry the rated current continuously without exceeding the temperature rise specified in ANSI C37.20 and adequate to withstand mechanical and thermal stresses due to short circuit currents at least equal to those specified for the circuit breaker.

B. All joints shall be silver-plated and shall be made with at least two 3/8 inches (9 mm) zinc-plated, irridite dipped steel bolts per joint. Provide porcelain inserts in bus-support barriers, porcelain standoff insulators for main bus supports and porcelain sleeves for stationary primary disconnect.

C. Bolted connections shall be silver plated.

D. Busses and bus connections shall be completely insulated with anti-hydroscopic track-resistant material possessing flame/retarding self/extinguishing properties.

**2.10 NON-SEGREGATED BUS DUCT (IF REQUIRED)**

A. Outdoor type bus duct shall be used to tie common aisle type switchgear line-ups together.

B. Bus duct shall be non-segregated phase bus enclosed in a rectangular sheet metal enclosure.

C. The bus duct shall be capable of carrying the rated current continuously without exceeding a conductor temperature rise of 65°C above an ambient temperature of 40°C as required by ANSI C37.20.

D. The bus conductors shall be adequately separated and insulated from each other and ground by glass polyester bus supports. Each bus shall be insulated with flame retardant epoxy impregnated, high dielectric strength insulation.

E. All bus duct runs shall be designed to mechanically withstand the forces generated by short-circuit currents up to 60,000 amperes, and 80,000 amperes momentarily.

**2.11 GROUNDING BUS**

A. A copper grounding line bus capable of carrying the rated short-circuit current of the circuit breaker for two seconds shall extend the full length of the switchgear sections. The stationary unit shall be connected directly to the ground bus. The frame of the circuit breaker unit shall be grounded through heavy multiple-finger contacts at all times except when the contacts of the breaker primary disconnecting devices are separated for a safe distance. The end of each bus shall be provided with compression-type terminals suitable for a #4/0 AWG grounding cable.

**2.12 INSTRUMENT TRANSFORMERS**

A. Current Transformers: Current transformers shall be located and have single ratios as indicated on the drawings. Burden and continuous current rating shall be suitable for the installation, as defined by ANSI C37.13. Accuracy ratings shall meet ANSI C37.20 and be increased as necessary to meet burden requirements. CT secondaries shall be connected to shorting type terminal blocks.

B. Potential Transformers: Potential transformers shall be of the draw out type, with current-limiting fuses in both primary and secondary and have a burden and accuracy class rating suitable for the installation, but not less than ANSI accuracy class of 0.3Z. Mechanical interlocks shall prevent removal of the fuses unless the associated potential transformer is in the draw out position. PT compartments shall have hinged doors.

C. Test Blocks and Accessories: Instruments and protective relays, requiring periodic testing or calibration and that are not equipped with integral testing features, shall be provided with test blocks. Test blocks shall have suitable covers, be mounted beneath the devices to be tested and be provided with engraved nameplates.

**2.13 SUPERVISORY CONTROL AND DATA ACQUISITION SYSTEM (SCADA) REMOTE TERMINAL COMPARTMENT**

All SCADA System wiring shall be taken to one compartment containing separate terminal blocks for each set of circuit breaker terminals provided and installed in a logical sequence. Provide 20 percent spare terminals. No other devices shall be installed in this compartment except the master transfer switch (ANSI Device 43B) and its blue indicating light.

**2.14 SWITCHGEAR EXTENSION SECTION**

A. The switchgear shall extend a minimum of at least 8 feet (2.4 m) and more if required to house the equipment specified in Division 26 Section "Batteries and Battery Chargers". Space shall also be provided for a future SCADA remote terminal unit (RTU) which will be supplied by others and mounted in the switchgear extension section. If adequate room is available, the low-voltage AC panelboard and automatic selective control may also be installed in this Section.

**2.15 PANELBOARD, AISLE LIGHTING, AISLE CONVENIENCE OUTLETS AND RECEPTACLES**

A. Panelboard: Provide dead-front safety type lighting and appliance panelboard with anti-burn solderless pressure type lug connectors approved for copper conductors; construct unit for connecting feeders at top or bottom of panel as indicated; equip with copper bus bars, full-sized neutral bar, with bolt-in type heavy-duty, quick-make, quick-break, single-pole circuit breaker with interrupting capacities suitable for the primary source short circuit availability at the switchgear bus. Provide suitable lugs on neutral bus for each outgoing feeder required; provide bare uninsulated grounding bars suitable for bolting to enclosures. Select enclosures fabricated by same manufacturer as panelboards, and which mate properly with panelboards. Provide with ground and neutral buses.

B. Panelboard Enclosure: Provide galvanized sheet steel cabinet type enclosure, in sizes and NEMA 1 type for indoor use, code-gage, minimum 16-gage (1.61 mm) thickness. Construct with multiple knockouts and wiring gutters. Provide fronts with adjustable indicating trim clamps, and doors with flush locks and keys, panelboard enclosures keyed alike with concealed piano door hinges and door swings as indicated. Equip with interior circuit-directory frame, and 8.5 by 11 inches (200 by 280 mm) panel directory with clear plastic covering. Provide baked gray enamel finish over a rust inhibitor coating. Design enclosures for surface mounting. Provide enclosures fabricated by same manufacturer as panelboards, and which mate properly with panelboards to be enclosed.

C. Panelboard Accessories: Provide panelboard accessories and devices including, but not necessarily limited to locking circuit breakers and etc., as recommended by panelboard manufacturer for ratings and applications indicated.

D. Aisle Lighting: LED luminaries shall be an energy efficient fixture and shall be installed in the switchgear aisle to provide a maintained lighting intensity level of 50 foot-candles in the aisle and on faces of units and compartments. Luminaries shall be wired to three-way switches located at each end of the switchgear aisle. Luminaries shall be on Standby Power.

E. Aisle Convenience Outlets: Receptacles shall be installed at each end of the switchgear aisle and not more than 6 feet on centers along the switchgear aisle. Receptacles shall be ground-fault-protected, duplex, 15 ampere, 125-volt, two-pole, three-wire, grounded type with polarized parallel slots, NEMA WD1 configuration 5-15R. Aisle outlet wiring shall be installed in EMT conduit. Receptacles shall be on standby power.

F. Receptacles: One 120 volt AC duplex receptacle shall be provided in each cubicle.

**2.16 SPACE HEATER AND VENTILATION**

A. Thermostatically-controlled space heaters shall be provided for equipment so that the temperature inside each cubicle shall be automatically maintained above the dew point temperature over an ambient temperature

range of minus 20 to 104 deg F (6.7 to 40 deg C). An ammeter shall be provided in the heater circuit with full circuit ampacity clearly marked on the ammeter scale. The space heaters shall be rated 240 VAC but operated by 120 V power source.

B. Aisle ventilation fans shall be provided and shall be adequately sized to provide at least ten air changes per hour. Fans shall be wired to three-way switches located at each end of the switchgear aisle and adjacent to aisle lighting switches. In addition, fans shall be thermostatically controlled to turn fans on when interior temperatures exceed 110 deg F (43,3 deg C).

**2.17 SAFETY DESIGN SHALL INCLUDE AS A MINIMUM**

A. The rating interference plate which allows only a breaker of the correct type and rating to be inserted into any specific breaker compartment.

B. Grounded, metal safety shutters which automatically close to cover the stationary primary disconnects when the breaker is moved from the "connected" position. Safety shutters shall have "LINE" and "LOAD" sides labeled.

C. Dead front construction of exterior and interior surfaces normally accessible to operators while the equipment is energized.

D The A/E shall ensure that at any location where equipment may require inspection, testing or maintenance, that provisions are made for the application of personal protective grounds (PPG). Provisions shall include the ability of personal to apply PPG utilizing live-line tools.

**2.18 BREAKER CONTROL INTERLOCKS**

A. The two incoming line breakers and the tie breaker shall be coordinated and interlocked to permit the following operational control:

1. During normal operation, incoming line breakers will be closed, and tie breaker will be open.

2. A "hot transfer switch" shall be provided on the front panel of the tie breaker to permit transferring of loads from Bus 1 to Bus 2 (1 to 2) or from Bus 2 to Bus 1 (2 to 1). A time delay bypass switch shall relocated, and labeled, adjacent to the time delay relay.

3. Actuation of the "hot transfer switch" (1 to 2) will close the tie breaker and within an adjustable time delay of 0 second to 60 seconds, open the Bus 1 incoming line breaker .

4. Actuation of the "hot transfer switch" (2 to 1) will close the tie breaker and within an adjustable time delay of 0 second to 60 seconds, open the Bus 2 incoming line breaker.

5. Reset of the Switchgear A1, "hot transfer switch," will close the three breakers and within an adjustable time delay of 0 second to 60 seconds, open the tie breaker.

B. "Hot transfer switches" shall be key operated for administration control.

C. All interlock control wiring shall be hard wired without relying on SCADA system.

**2.19 FABRICATION**

A. Construction: The switchgear shall be designed, built and tested in accordance with applicable ANSI, IEEE and NEMA standards for Metal Clad Switchgear. Switchgear shall be of outdoor type construction. The complete switchgear assembly shall be UL certified.

B. Enclosures:

1. Primary compartments of each circuit breaker shall be isolated by grounded metal barriers which shall have no intentional openings. (The primary compartments consist of breaker, main bus, power termination, and auxiliary compartments.) Each breaker and rollout tray shall be furnished with a 1/8 inch (3 mm) thick front plate which isolates the control from the primary compartment.

2. Cable termination compartments shall be located at the rear of the equipment and shall be accessible through locked doors.

3. Ventilation shall be provided by inlet openings through slots in the bottom flange of each front door and louvers in the rear doors. Exhaust will be through basket weave openings in the top covers (not used for power or control cable entry). Intake openings shall be screened and filtered. Top exhaust vents shall be equipped with screens and dust guards.

4. All standard hardware shall be high-tensile strength steel which is zinc-plated and irridite-dipped to resist corrosion.

5. Minimum 6 feet (1.8 m) of working space shall be provided in front of switchgear lineup.

6. Access Doors: Provide padlockable hinged access doors behind switchgear to permit servicing.

7. Ports for infrared monitoring: Provide lockable viewports to allow for thermal imaging. As manufactured by IRISS Inc. or approved equal.

PART 3 - EXECUTION

**3.1 TRAINING**

The Vendor shall provide a training session for up to eight (8) University representatives. The training session shall be conducted by a manufacturer's qualified representative. The training program shall include instructions on the assembly including primary equipment, transformer, and secondary equipment. All circuit breakers, protective devices and other major components shall be included.

END OF SECTION 26 13 26

**DIVISION 26 ELECTRICAL**

**SECTION 26 16 00 MEDIUM VOLTAGE METERING**

**PART 1 – GENERAL**

**1.1 SUMMARY:**

See Division 26, Section 26 09 Electrical Power Monitoring for requirements related to ECU's Electrical Distribution System.

END OF SECTION 26 16 00

**DIVISION 26 ELECTRICAL**

**SECTION 26 22 00 LOW-VOLTAGE TRANSFORMERS**

**PART 1 – GENERAL**

**1.1 SUMMARY**

A. This Section includes the following types of dry-type transformers rated 600 V and less, with capacities up to 1000 kVA:

1. Distribution transformers.
2. Buck-boost transformers.

**1.2 ACTION SUBMITTALS**

A. Product Data: For each product indicated.

B. Shop Drawings: Indicate dimensions and weights.

1. Wiring Diagrams: Power, signal, and control wiring.

**1.3 INFORMATIONAL SUBMITTALS**

A. Field quality-control test reports.

**1.4 CLOSEOUT SUBMITTALS**

A. Operation and maintenance data.

**PART 2 -- PRODUCTS**

**2.1 GENERAL TRANSFORMER REQUIREMENTS**

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

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

C. Coils: Continuous windings without splices except for taps.

1. Internal Coil Connections: Brazed or pressure type.
2. Coil Material: Copper.

**2.2 DISTRIBUTION TRANSFORMERS**

A. Cores: One leg per phase.

C. Indoor enclosure: Ventilated, NEMA 250, Type 2.

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

D. Outdoor enclosure: Ventilated with weather shield, Type 3R.

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

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

F. Taps for Transformers 7.5 to 24 kVA: One 5 percent tap above, and one 5 percent tap below normal full capacity.

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

H. Insulation Class: 220 deg C, UL-component-recognized insulation system with a maximum of 150 deg C rise

above 40 deg C ambient temperature.

I. Energy Efficiency for Transformers Rated 15 kVA and Larger:

1. Complying with NEMA TP 1, Class 1 efficiency levels.
2. Tested according to NEMA TP 2.

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

**2.4 BUCK-BOOST TRANSFORMERS**

A. Description: Self-cooled, two-winding dry type, rated for continuous duty and with wiring terminals suitable for connection as autotransformer. Transformers shall comply with NEMA ST 1 and shall be listed and labeled as complying with UL 506 or UL 1561.

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

1. Finish Color: Gray.

**2.5 IDENTIFICATION DEVICES**

A. Nameplates: Engraved, laminated-plastic. Nameplates are specified in Division 26 Section "Identification for Electrical Systems".

**PART 3 -- EXECUTION 3.1 INSTALLATION**

A. Wall mounted transformers: Top of any wall mounted transformer may not be more than five feet above the finished floor.

B. Floor mounted transformers - Construct 4" housekeeping concrete base and anchor floor-mounting transformers according to manufacturer's written instructions.

C. Dry-type transformers installed indoors and rated 112 ½ KVA or less shall have a separation of at least 12 inches from combustible material, inclusive of drywall, unless separated from the combustible material by a fire resistant, heat-insulated barrier.

D. Transformers must have adequate clearance on all sides to enable the safe removal of all covers and observation for thermographic testing outside the Arc Flash boundary.

**3.2 FIELD QUALITY CONTROL**

A. Perform tests and inspections.

B. Tests and Inspections:

1. Test secondary phase, neutral, and ground to ensure the transformer is connected properly (no floating neutral).

**3.3 ADJUSTING**

A. Adjust transformer taps to provide optimum voltage conditions at secondary terminals. Optimum is defined as not exceeding nameplate voltage plus 10 percent and not being lower than nameplate voltage minus 3 percent at maximum load conditions. Submit recording and tap settings as test results.

B. Connect buck-boost transformers to provide nameplate voltage of equipment being served, plus or minus 5 percent, at secondary terminals.

C. Output Settings Report: Prepare written report recording output voltages and tap settings.

END OF SECTION 26 22 00

**DIVISION 26 ELECTRICAL**

**SECTION 26 24 13 SWITCHBOARDS**

**PART 1 --GENERAL**

**1.1 SUMMARY**

A. Breakers with LSI settings are required for all service entrance breakers above 150A.

B. Section Includes:

1. Service and distribution switchboards rated 600 V and less.
2. Disconnecting and overcurrent protective devices.
3. Instrumentation.
4. Control power.
5. Accessory components and features.
6. Identification.

**1.2 ACTION SUBMITTALS**

A. Product Data: For each type of product indicated.

B. Shop Drawings: For each switchboard and related equipment.

1. Include dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings.
2. Include time-current coordination curves for each type and rating of overcurrent protective device included in switchboards.
3. Include schematic and wiring diagrams for power, signal, and control wiring.

**1.3 INFORMATIONAL SUBMITTALS**

A. Field quality-control reports.

**1.4 CLOSEOUT SUBMITTALS**

A. Operation and maintenance data.

**PART 2 --PRODUCTS**

**2.1 MANUFACTURED UNITS**

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
2. Siemens Energy & Automation, Inc.
3. Square D; a brand of Schneider Electric.

B. Enclosure: Steel, NEMA 250, Type 1.

1. Enclosure Finish: Factory-applied finish in manufacturer's standard gray finish over a rust-inhibiting primer on treated metal surface.
2. Enclosure: Flat roof; bolt-on rear covers for each section, with provisions for padlocking.
3. Switchboards installed as part of a renovation project where steam or water lines pass through the space shall be NEMA 250, Type 2

C. Provide metering compartment in accordance with ECU Facilities Services metering requirements for service

entrance switchboards. If a separate vertical section is required for metering, match and align with basic switchboard. Provide service entrance label and necessary applicable service entrance features. Shorting blocks and control voltage fuses shall be contained within the same compartment. Metering compartment shall be designed such that the incident energy that staff are exposed to while working in the metering compartment is zero (0).

D. Provide necessary equipment/controls as required to reduce Arc Flash Hazards below 8cal/cm2 pursuant SECTION 26 05 73 POWER SYSTEM STUDIES

E. Bus Transition and Incoming Pull Sections: Matched and aligned with basic switchboard.

F. Hinged Front Panels: Allow access to circuit breaker, metering, accessory, and blank compartments.

G. Pull Box on Top of Switchboard:

1. Adequate ventilation to maintain temperature in pull box within same limits as switchboard.
2. Removable covers shall form top, front, and sides. Top covers at rear shall be easily removable for drilling and cutting.
3. Bottom shall be insulating, fire-resistive material with separate holes for cable drops into switchboard.
4. Cable supports shall be arranged to facilitate cabling and adequate to support cables indicated, including those for future installation.

H. Phase and Neutral Buses and Connections: Three phase, four wire unless otherwise indicated. Tin-plated, high-strength, electrical-grade aluminum alloy with tin-plated aluminum circuit-breaker line connections.

1. Main Phase Buses and Equipment Ground Buses: Uniform capacity for entire length of switchboard's main and distribution sections. Provide for future extensions from both ends.
2. Neutral Buses: 100 percent of the ampacity of phase buses, equipped with pressure connectors for outgoing circuit neutral cables.

I. Future Devices: Equip compartments with mounting brackets, supports, bus connections, and appurtenances at full rating of circuit-breaker compartment.

J. Switchboards shall be provided with “Mimic Bus” on the front of the enclosure to depict the actual bus arrangement inside cubicles.

**2.2 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES**

A. Maintenance Switches are required in any instance where staff will be exposed to incident energy levels above 8 cal/cm$^2$ when working on energized equipment or conductors. If remote operation switches are employed as an administrative control, staff are to be trained on their operation and warning labels will note the requirement of their use.

B. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, 100 rated to meet available fault currents.

1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 150 A and larger.

2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.

3. Electronic trip circuit breakers with rms sensing; field-replaceable rating plug or field replaceable electronic trip; and the following field-adjustable settings:
   a. Instantaneous trip.
   b. Long- and short-time pickup levels.
   c. Long- and short-time time adjustments.

d. Ground-fault pickup level, time delay, and $i^2t$ response.

4. Current-Limiting Circuit Breakers: Frame sizes 40 A and smaller; let-through ratings less than NEMA FU 1, RK-5.

5. Molded-Case Circuit-Breaker (MCCB) Features and Accessories:

a. Standard frame sizes, trip ratings, and number of poles.
b. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor material.
c. Ground-Fault Protection when required by NEC: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
d. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.
e. Communication Capability: Communication module with functions and features compatible with ECU's enterprise power monitoring system (Schneider Electric ION System).
f. Under voltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
g. Auxiliary Contacts: Two SPDT switches with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.

C. Insulated-Case Circuit Breaker (ICCB): 100 percent rated, sealed, insulated-case power circuit breaker with interrupting capacity rating to meet available fault current.

1. Fixed circuit-breaker mounting.
2. Two-step, stored-energy closing.
3. Full-function, microprocessor-based trip units with interchangeable rating plug, trip indicators, and the following field-adjustable settings:
   a. Instantaneous trip.
   b. Long- and short-time time adjustments.
   c. Ground-fault pickup level, time delay, and $I^2t$ response.
4. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.
5. Remote trip indication and control.
6. Communication Capability: Integral communication module with functions and features compatible with ECU's power monitoring system (Schneider Electric ION System).

D. Disconnecting and overcurrent protection devices shall have a UL Label, factory applied, indicating the device is listed for the service voltage.

E. All switch boards are required to have a Main breaker.

**2.3 INSTRUMENTATION**

A. Instrument Transformers:

1. Current Transformers: secondary and secondary shorting device. Burden and accuracy shall be consistent with connected metering and relay devices.
2. Control-Power Transformers: Dry type, mounted in separate compartments.
3. Current Transformers for Neutral and Ground-Fault Current Sensing: Connect secondary wiring to ground overcurrent relays, via shorting terminals, to provide selective tripping of main and tie circuit breaker. Coordinate with feeder circuit-breaker, ground-fault protection.

B. Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for three-wire or four-wire systems and with the following features:

1. Provide a Schneider Electric PM8000 meter
2. Mounting: Display and control unit flush or semi flush mounted in instrument compartment door.
3. Meter shall report to Schneider ION Power Monitoring System. Refer to **Section 26 2713** Electricity Metering.

**2.4 CONTROL POWER**

A. Control Circuits: 120-V ac, supplied through secondary disconnecting devices from control-power transformer.

B. Control-Power Fuses: Primary and secondary fuses for current-limiting and overload protection of transformer and fuses for protection of control circuits.

C. Control Wiring: Factory installed, with bundling, lacing, and protection included. Provide flexible conductors for No. 8 AWG and smaller, for conductors across hinges, and for conductors for interconnections between shipping units.

**2.6 IDENTIFICATION**

A. Service Equipment Label: NRTL labeled for use as service equipment for switchboards with one or more service disconnecting and overcurrent protective devices.

**PART 3 --EXECUTION**

**3.1 INSTALLATION**

A. Equipment Mounting: Install switchboards on concrete housekeeping pad base, 4-inch nominal thickness.
1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of concrete base.
2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
4. Install anchor bolts to elevations required for proper attachment to switchboards.

B. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from switchboard units and components after installed.

C. Comply with requirements for terminating feeder bus specified in Division 26 Section "Enclosed Bus Assemblies". Drawings indicate general arrangement of bus, fittings, and specialties.

D. Comply with requirements for terminating cable trays specified in Division 26 Section "Cable Trays for Electrical Systems". Drawings indicate general arrangement of cable trays, fittings, and specialties.

**3.2 IDENTIFICATION**

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with requirements for identification specified in **Section 26 05 53** Identification for Electrical Systems.

B. Switchboard Nameplates: Label each switchboard compartment with a nameplate complying with requirements for identification specified in **Section 26 05 53** Identification for Electrical Systems. Label each switchboard compartment with a factory applied nameplate indicating switchboard manufacturer's name, drawing number, manufacturer location, section number, amperage, voltage, phase, number of wires, short-circuit rating, ampacity interrupting capacity rating, and Arc Flash Warning label in accordance with NEC and ECU standards. Nameplate and factory applied nameplate voltage shall be listed as the service voltage.

C. One-line diagrams shall be placed on the front doors/panels of all switchgear. Additionally, a laminated one-line diagram shall be framed and mounted in the MDP room.

**3.3 FIELD QUALITY CONTROL**

A. Acceptance Testing Preparation:

1. Test insulation resistance for each switchboard bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

B. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
3. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

C. Switchboard will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports, including a certified report that identifies switchboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

END OF SECTION 26 24 13

**DIVISION 26 ELECTRICAL**

**SECTION 26 24 16 PANELBOARDS**

**PART 1 -- GENERAL**

**1.1 SUMMARY**

A. Section includes distribution panelboards and lighting and appliance branch-circuit panelboards.

**1.2 ACTION SUBMITTALS**

A. Product Data: For each type of product indicated.

B. Shop Drawings: For each panel board and related equipment.

1. Include dimensioned plans, elevations, sections, and details. Show tabulations of installed devices, equipment features, and ratings.
2. Detail enclosure types and details.
3. Detail bus configuration, current, and voltage ratings.
4. Short-circuit current rating of panelboards and overcurrent protective devices.
5. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
6. Include wiring diagrams for power, signal, and control wiring.
7. Include time-current coordination curves for each type and rating of overcurrent protective device included in panelboards.

C. Drawings submissions – provide panel schedules including load summary on the design documents. Panel schedules inserted into the specifications or book format are not acceptable.

**1.3 INFORMATIONAL SUBMITTALS**

A. Field quality-control reports.

B. Panelboard schedules for installation in panelboards.

**1.4 CLOSEOUT SUBMITTALS**

A. Operation and maintenance data.

**PART 2 -- PRODUCTS 2.1 GENERAL REQUIREMENTS FOR PANELBOARDS**

A. Enclosures: - Rated for environmental conditions at installed location.

1. Indoor Dry and Clean Locations: NEMA 250, Type 1.
2. Outdoor Locations: NEMA 250, Type 3R.
3. Wash-Down Areas: NEMA 250, Type 4X, stainless steel.
4. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.

B. Front: Secured to box with concealed trim clamps. For surface-mounted fronts, match box dimensions; for flush-mounted fronts, overlap box.

C. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover.

D. Directory Card: Provide typewritten directory indicating areas, rooms, and loads being served by each circuit position inside panel board door, mounted in transparent card holder. Update with new typewritten directory card for all renovations. Handwritten modifications are not acceptable.

E. Phase, Neutral, and Ground Buses: Cooper.

F. Conductor Connectors: Suitable for use with conductor material and sizes.

1. Material: Copper.
2. Main and Neutral Lugs: Mechanical type.
3. Ground Lugs and Bus Configured Terminators: Mechanical type.
4. Feed-Through Lugs: Mechanical type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.
5. Subfeed (Double) Lugs: Mechanical type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.

G. Service Equipment Label: NRTL labeled for use as service equipment for panelboards with one or more main service disconnecting and overcurrent protective devices.

h. Future Devices: Mounting brackets, bus connections, filler plates, and necessary appurtenances required for 20% additional future installation of devices.

I. Panelboard Short-Circuit Current Rating: Fully rated.

J. Exterior Located Panelboards: Provide door handles that are lockable with ECU standard maintenance padlock. Coordinate with ECU Project Manager and ECU Facilities Services.

**2.2 DISTRIBUTION PANELBOARDS**

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
2. Siemens Energy & Automation, Inc.
3. Square D; a brand of Schneider Electric.

B. Panelboards: NEMA PB 1, power and feeder distribution type.

C. Doors: Secured with vault-type latch with tumbler lock; keyed alike.

D. Mains shall be circuit breaker construction.

E. Branch Overcurrent Protective Devices: Circuit-Breakers shall be bolt-on type.

**2.3 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS**

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
2. Siemens Energy & Automation, Inc.
3. Square D; a brand of Schneider Electric.

B. Panelboards: NEMA PB 1, lighting and appliance branch-circuit type.

C. Mains shall be circuit breaker construction.

D. Branch Overcurrent Protective Devices: Bolt-on type.

E. Doors: Concealed hinges; secured with flush latch with tumbler lock; keyed alike.

**2.4 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES**

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
2. Siemens Energy & Automation, Inc.
3. Square D; a brand of Schneider Electric.

B. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, fully rated to meet available fault currents.

C. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 150 A and larger.

D. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.

E. Electronic trip circuit breakers with rms sensing (required for service entrance OCD 150A and above); field-replaceable rating plug or field replicable electronic trip; and the following field-adjustable settings:

1. Instantaneous trip.
2. Long and short-time pickup levels.
3. Long and short-time time adjustments.
4. Ground fault pickup level, time delay, and $i^2t$ response.

F. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.

G. GFCI Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).

H. Ground-Fault Equipment Protection (GFEP) Circuit Breakers: Class B ground-fault protection (30-mA trip).

I. Arc-Fault Circuit Interrupter (AFCI) Circuit Breakers: Comply with UL 1699; 120/240-V, single-pole configuration.

J. Molded-Case Circuit-Breaker (MCCB) Features and Accessories:

1. Standard frame sizes, trip ratings, and number of poles.
2. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor materials.
3. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
4. Communication Capability: Universal-mounted communication module with functions and features compatible with ECU power monitoring system specified in Division 26 Section "Electrical Power Monitoring and Control".
5. Handle Padlocking Device: Fixed attachment for locking circuit-breaker handle in on or off position.
6. Handle Clamp: Loose attachment for holding circuit-breaker handle in on position.

C. Disconnecting and overcurrent protection devices shall have a UL Label, factory applied, indicating the device is listed for the service voltage.

D. Fused Switch: NEMA KS 1, Type HD; clips to accommodate specified fuses; lockable handle.

1. Fuses and Spare-Fuse Cabinet: Comply with requirements specified in Division 26 Section "Fuses."

## 2.5 ACCESSORY COMPONENTS AND FEATURES

A. Provide Portable Test Set: For testing functions of solid-state trip devices without removing from panel board. Include relay and meter test plugs suitable for testing panel board meters and switchboard class relays.

## PART 3 – EXECUTION

## 3.1 INSTALLATION

A. Top of trim 90 inches above finished floor unless otherwise indicated.

B. Stub four, 1-inch, empty conduits from panel board into accessible ceiling space or space designated to be ceiling space in the future. Stub four, 1-inch, empty conduits into raised floor space or below slab not on grade.

C. Conductors in gutters to be arranged into groups and bundle and wrap with wire ties.

**3.2 IDENTIFICATION**

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with **Section 26 05 53** Identification for Electrical Systems.

B. Create a directory to indicate installed circuit loads and incorporating ECU's final room designations. Obtain approval before installing. Use a computer or typewriter to create directory; handwritten directories are not acceptable.

C. Panelboard Nameplates: Label each panel board with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems".

D. Device Nameplates: Label each branch circuit device in distribution panelboards with a nameplate complying with requirements for identification specified in **Section 26 05 53** Identification for Electrical Systems.

E. Panelboard Nameplates: Label each panel board with a factory applied nameplate indicating manufacturer's name, drawing number, manufacturer location, section number, amperage, voltage, phase, number of wires, short-circuit rating, ampacity interrupting capacity rating, and Arc Flash Warning label in accordance with NEC and ECU's standard. Factory applied nameplate voltage shall be listed as the service voltage.

**3.3 FIELD QUALITY CONTROL**

A. Acceptance Testing:

1. Test insulation resistance for each panel board bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

B. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

D. Panelboards will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports including a certified report that identifies panelboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

END OF SECTION 26 24 16

**DIVISION 26 ELECTRICAL**

**SECTION 26 25 00 ENCLOSED BUS ASSEMBLIES**

**PART 1 – GENERAL**

**1.1 OWNER APPROVAL**

A. Enclosed bus assemblies shall not be used unless pre-approved by ECU Project Manager and ECU Facilities Services.

**1.2 SUMMARY**

A. This Section includes the following:

1. Feeder-bus assemblies.
2. Plug-in bus assemblies.
3. Bus plug-in devices.

**1.3 ACTION SUBMITTALS**

A. Shop Drawings: For each type of bus assembly and plug-in device.

1. Show fabrication and installation details for enclosed bus assemblies.
2. Show fittings, materials, fabrication, and installation methods for listed fire-stop barriers and weather barriers.
3. Wiring Diagrams: Power, signal, and control wiring.

**1.4 CLOSEOUT SUBMITTALS**

A. Operation and maintenance data.

**1.5 QUALITY ASSURANCE**

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

**1.6 PROJECT CONDITIONS**

A. De-rate enclosed bus assemblies for continuous operation at indicated ampere ratings for ambient temperature not exceeding 140 deg F.

**PART 2 -- PRODUCTS**

**2.1 MANUFACTURERS**

A. Available Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Eaton Electrical Inc.; Cutler-Hammer Products.
2. Siemens Energy & Automation, Inc.
3. Square D; Schneider Electric.

## 2.2 ENCLOSED BUS ASSEMBLIES

A. Feeder-Bus Assemblies: NEMA BU 1, low-impedance bus assemblies in non-ventilated housing; single-bolt joints; ratings as indicated.

1. Provide 100 percent neutral capacity.
2. Temperature Rise: 55 deg C above 40 deg C ambient maximum for continuous rated current.
3. Bus Materials: Current-carrying copper, fully insulated with Class 130C insulation except at joints; plated surface at joints.
4. Ground:
   a. 50 percent capacity integral with housing.
   b. 50 percent capacity internal bus bars of material matching bus material.
   c. 50 percent capacity isolated, internal bus bar of material matching bus material.
5. Enclosure: Steel or aluminum with manufacturer's standard finish. Aluminum weatherproof with manufacturer's standard finish, sealed seams, drains, and removable closures where installed in damp or exterior locations.
6. Fittings and Accessories: Manufacturer's standard.
7. Mounting: Arranged flat, edgewise, or vertically without derating.

B. Plug-in Bus Assemblies: NEMA BU 1, low-impedance bus assemblies in non-ventilated housing; single-bolt joints; ratings as indicated.

1. Provide 100 percent neutral capacity.
2. Temperature Rise: 55 deg C above 40 deg C ambient maximum for continuous rated current.
3. Bus Materials: Current-carrying copper, fully insulated with Class 130C insulation except at stabs and joints; plated surface at stabs and joints.
4. Ground:
   a. 50 percent capacity integral with housing.
   b. 50 percent capacity internal bus bar of material matching bus material.
   c. 50 percent capacity isolated, internal bus bar of material matching bus material.
5. Enclosure: Steel or aluminum, with manufacturer's standard finish, plug-in openings 24 inches on center, and hinged covers over unused openings.
6. Fittings and Accessories: Manufacturer's standard.
7. Mounting: Arranged flat, edgewise, or vertically without derating.

## 2.3 PLUG-IN DEVICES

A. Molded-Case Circuit Breakers: NEMA AB 1; hook-stick-operated handle, lockable with two padlocks, and interlocked with cover in closed position.

B. Accessories: Hook-stick operator, adjustable to maximum extension of 10 feet. Breakers must be operable from finished floor level.

## PART 3 – EXECUTION

### 3.1 INSTALLATION

A. Support bus assemblies independent of supports for other elements such as equipment enclosures at connections to panelboards and switchboards, pipes, conduits, ceilings, and ducts.

B. Install expansion fittings at locations where bus assemblies cross building expansion joints. Install at other locations so distance between expansion fittings does not exceed manufacturer's recommended distance between fittings.

C. Install weather seal fittings and flanges where bus assemblies penetrate exterior elements such as walls or roofs. Seal around openings to make weather tight.

D. Install a concrete curb at least 4 inches high around bus-assembly floor penetrations.

E. Coordinate bus-assembly terminations to equipment enclosures to ensure proper phasing, connection, and closure.

F. Tighten bus-assembly joints with torque wrench or similar tool recommended by bus-assembly manufacturer. Tighten joints again after bus assemblies have been energized for 30 days.

G. Install bus-assembly, plug-in units. Support connecting conduit independent of plug-in unit.

H. Set field-adjustable, circuit-breaker trip ranges and overload relay trip settings as indicated.

### 3.2 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
2. Infrared Scanning: Two months after Substantial Completion, contractor shall perform an infrared scan of bus assembly including joints and plug-in units.
    a. Use an infrared-scanning device designed to measure temperature or detects significant deviations from normal values. Provide documentation of device calibration.
    b. Perform 2 follow-up infrared scans of bus assembly, one at 4 months and the other at 11 months after Substantial Completion.
    c. Prepare a certified report identifying bus assembly checked and describing results of scanning. Include notation of deficiencies detected, remedial action taken, and scanning observations after remedial action.

END OF SECTION 26 25 00

**DIVISION 26 ELECTRICAL**

**SECTION 26 27 13 ELECTRICITY METERING**

**PART 1 – GENERAL**

**1.1 SUMMARY**

A. Section includes equipment for electricity metering by utility company (Greenville Utilities Commission) and electricity metering by ECU Facilities Services.

**1.2 ACTION SUBMITTALS**

A. Product Data: For each type of product indicated.

B. Shop Drawings: Dimensioned plans and sections or elevation layouts and wiring diagrams.

**1.3 QUALITY ASSURANCE**

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by UL, and marked for intended location and application.

**PART 2 -- PRODUCTS**

**2.1 EQUIPMENT FOR ELECTRICITY METERING BY UTILITY COMPANY, GREENVILLE UTILITIES COMMISSION (GUC)**

A. Coordinate with ECU Engineering and Architectural Services for areas that are fed from the utility company (GUC) prior to project design.

B. Provide meter bases and connections in accordance with GUC standards

**2.2 EQUIPMENT FOR ELECTRICITY METERING OF ECU PROVIDED PRIMARY.**

A. Coordinate with ECU Engineering and Architectural Services for areas that are fed from the ECU provided primary prior to project design.

B. Projects requiring self-contained meters or CT meters. Provide Schneider PM8000 meter, or other ECU Facilities Services approved, across the line or CT meter for appropriate application output (Modbus). CT meters shall be provided with split core CT's and (3) inline fuses. All phases shall be metered. Meters shall be submitted to ECU Project Manager for ECU Engineering and Architectural Services and ECU Facilities Services review and approval prior to design and construction. Obtain meter number to apply to the generic label from ECU Project Manager and/or ECU Facilities Services Electrical Department. The Meters and CT cabinet mounting location shall be coordinated and approved by ECU Project Manager and ECU Facilities Services. The meters shall interface directly with the ECU Power Monitoring System without any third party integration. Meter options to include the following:

1. Across the line socket mounted meters shall be self-contained Class 320 – Form 16S.
2. Frequency shall be 60 Hz.
3. Measurements options shall be Level 1 – W, V, Wh, Power Factor.
4. Demand metering: W, var, A, VA.
5. Cover option shall be demand reset standard.
6. Input/Output option 1 – KYZ outputs, low current / high current (KY) outputs, 0 pulse or state inputs.
7. Power supply shall be standard single-phase power supply (120-480V).
8. CT socket mounted meters shall be transformer rated Class 20 – Form 9S.
9. Enclosure: NEMA 250, Type 1 or Type 3R (suitable for application), with hasp for padlocking with ECU standard maintenance padlock.
10. Identification: Comply with requirements in **Section 26 05 53** Identification for Electrical Systems.
11. Current-Transformer Cabinet: Listed or recommended by metering equipment manufacturer for use with sensors indicated.

12. Current-Transformer Cabinet: Provide isolating means via circuit breaker or non-fused disconnect switch between CTs and monitoring module and between monitoring module and meter.
13. Across the line meters shall have a disconnect switch on the line side to isolate the meter from the supply for maintenance.

C. Projects with main switchboards shall be provided with integral meter capable of communicating with the ECU Utility Enterprise Monitoring System. Metering options shall include the following:

1. Display: LCD with characters not less than 0.25 inches high.
2. Monitoring: A, V, VA, kW, kvar, kWh, kvarh, kVAh, PF, Hz.
3. Demand metering: W, var, A, VA
4. Modbus communications.
5. Three COM ports (two rear RS485 ports and one front RS232 port).
6. Harmonic analysis for power quality review and problem correction.
7. KYZ outputs for ECU Facilities Services monitoring.
8. Provide isolating means via circuit breaker accessible near display meter allowing replacing the display meter without de-energizing the switchboard service.

**PART 3 – EXECUTION**

**3.1 INSTALLATION**

A. Comply with equipment installation requirements.

B. Provide 1” conduit with Cat 6 wire from EEM module to IDF room switch. Coordinate with ECU Project Manager and ECU IT.

C. Wiring from meters to EEM module shall be Belden 88760 002 (Red) or equivalent, shielded plenum communications cable (18 AWG) in 3/4” conduit. Coordinate with Division 22 Plumbing and Division 23 Heating, Ventilation and Air Conditioning for other meter requirements.

D. Comply with requirements for identification specified in Division 26 Section "Identification for Electrical Systems”.

E. New services shall be inspected and approved by ECU Engineering and Architectural Services and ECU Facilities Services prior energizing the service.

F. All meter outputs shall be properly configured at the enterprise level, graphics updated, and alarms established as part of any project that installs metering.

END OF SECTION 26 27 13

**DIVISION 26 ELECTRICAL**

**SECTION 26 27 26 WIRING DEVICES**

**PART 1 – GENERAL**

**1.1 SUMMARY**

A. Section Includes:

1. Receptacles, receptacles with integral GFCI, and associated device plates.
2. Weather-resistant receptacles.
3. Snap switches and wall-box dimmers.
4. Solid-state fan speed controls.
5. Wall-switch and exterior occupancy sensors.
6. Communications outlets.

**1.2 ADMINISTRATIVE REQUIREMENTS**

A. Coordination:
1. Receptacles for ECU furnished equipment - match plug configurations.

**1.3 ACTION SUBMITTALS**

A. Product Data: For each type of product.

B. Shop Drawings: List of legends and description of materials and process used for marking wall plates.

**1.4 INFORMATIONAL SUBMITTALS**

A. Field quality-control reports.

**1.5 CLOSEOUT SUBMITTALS**

A. Operation and maintenance data.

**PART 2 – PRODUCTS**

**2.1 MANUFACTURERS**

A. Source Limitations: Obtain each type of wiring device and associated wall plate from single source from single manufacturer

**2.2 GENERAL WIRING-DEVICE REQUIREMENTS**

A. Wiring Devices, Components, and Accessories: Listed and labeled as defined in NFPA 70, by UL, and marked for intended location and application, 20 amp, commercial grade.

**2.6 WALL-BOX DIMMERS**

A. Dimmer Switches: Modular, full-wave, solid-state units with integral, quiet on-off switches, with audible frequency and EMI/RFI suppression filters.

B. Control: Continuously adjustable slider toggle switch; with single-pole or three-way switching.

C. Fluorescent Lamp Dimmer Switches: Modular; compatible with dimmer ballasts; trim potentiometer to adjust low-end dimming; dimmer-ballast combination capable of consistent dimming with low end not greater than 20 percent of full brightness.

D. LED Dimmer Switches: Compatible with dimmer LED drivers, capable of consistent dimming with low end not greater than 10 percent of full brightness. In new construction, utilize LED dimmable fixtures with compatible LED dimmer.

**2.7 WALL PLATES**

A. Single and combination types shall match corresponding wiring devices.

1. Plate-Securing Screws: Metal with head color to match plate finish.
2. Material for Finished Spaces: Smooth, high-impact thermoplastic, 0.035-inch-thick, satin-finished.
3. Material for Unfinished Spaces: Galvanized steel.
4. Material for Damp Locations: Cast aluminum while in use cover listed and labeled for use in wet and damp locations.
5. Material for kitchens or food processing areas – stainless steel.

B. Wet-Location, Weatherproof Cover Plates: NEMA 250, complying with Type 3R, weather-resistant**,** die-cast aluminum while in use cover.

**2.8 FINISHES**

A. Device Color:

1. Wiring Devices Connected to Normal Power System: Color shall be coordinated with ECU Project Manager. In renovated areas, the color shall match building standard and be approved by ECU Project Manager prior to ordering.
2. Wiring Devices Connected to Emergency Power System: Red.
3. TVSS Devices: Blue.

B. Wall Plate: Stainless steel.

**PART 3 – EXECUTION**

**3.1 INSTALLATION**

A. Comply with NECA 1, including mounting heights listed in that standard, unless otherwise indicated.

B. Device Installation:

1. Replace devices if damaged during construction and that were installed before building finishing operations were complete.
2. Use a torque screwdriver when a torque is recommended or required by manufacturer.
3. When conductors larger than No. 12 AWG are installed on 20-A circuits, splice No. 12 AWG pigtails for device connections.
4. When mounting into metal boxes, remove the fiber or plastic washers used to hold device-mounting screws in yokes, allowing metal-to-metal contact.
5. Do not install GFCI type devices where readily inaccessible such as behind water fountain housings or where food prep equipment blocks access. In these instances, provide a GFCI type circuit breaker

protecting a standard device.

C. Receptacle Orientation:

1. Install ground pin of vertically mounted receptacles down, and on horizontally mounted receptacles to the left.

D. Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.

E. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical and with grounding terminal of receptacles on bottom. Group adjacent switches under single, multi-gang wall plates.

F. Adjust locations of service poles to suit arrangement of partitions and furnishings.

**3.2 FIELD QUALITY CONTROL**

A. Perform the following tests and inspections:

1. Test Instrument for Convenience Receptacles: Digital wiring analyzer with digital readout or illuminated digital-display indicators of measurement.

B. Tests for Convenience Receptacles:

1. Ground Impedance: Values of up to 2 ohms are acceptable.
2. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.
3. Using the test plug, verify that the device and its outlet box are securely mounted.
4. Tests shall be diagnostic, indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault current path, defective devices, or similar problems. Correct circuit conditions, remove malfunctioning units and replace with new ones, and retest as specified above.

C. Wiring device will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

END OF SECTION 26 27 26

**DIVISION 26 ELECTRICAL**

**SECTION 26 28 13 FUSES**

**PART 1 – GENERAL**

**1.1 SUMMARY**

A. Section Includes: Cartridge fuses rated 600-V ac and less for use in control circuits, enclosed switches, fusible panelboards, switchboards, enclosed controllers, and motor-control centers.

**1.2 ACTION SUBMITTALS**

A. Product Data: For each type of product indicated.

**1.3 CLOSEOUT SUBMITTALS**

A. Operation and maintenance data.

**1.4 QUALITY ASSURANCE**

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with NEMA FU 1 for cartridge fuses.

C. Comply with NFPA 70.

**PART 2 -- PRODUCTS**

**2.1 MANUFACTURERS**

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following manufacturers:

1. Cooper Bussmann, Inc.
2. Ferraz Shawmut, Inc.
3. Littelfuse, Inc.

**2.2 CARTRIDGE FUSES**

A. Characteristics: NEMA FU 1, nonrenewable cartridge fuses with voltage ratings consistent with circuit voltages.

**PART 3 -- EXECUTION**

**3.1 FUSE APPLICATIONS**

A. Service Entrance & Feeder Circuits over 600A: Class L, current limiting with 200K Amp interrupting rating.

B. Service Entrance & Feeder Circuits 600A and less: Class RK1 or J, current limiting with 200K Amp interrupting rating

C. Motor, motor controller and transformer Circuits: Class RK5, current limiting time delay, with 200K Amp interrupting rating.

D. Other Equipment where fault current does not exceed 50 KA: Class K5, with 50 KA interrupting rating.

E. Control Circuits: Class CC, time delay.

**3.2 INSTALLATION**

A. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.

**3.3 IDENTIFICATION**

A. Install labels complying with requirements for identification specified in **Section 26 05 53** Identification for Electrical Systems and indicating fuse replacement information on inside door of each fused switch and adjacent to each fuse block and holder.

END OF SECTION 26 28 13

**DIVISION 26 ELECTRICAL**

**SECTION 26 28 16 ENCLOSED SWITCHES AND CIRCUIT BREAKERS**

**PART 1 -- GENERAL**

**1.1 SUMMARY**

A. Section Includes:

1. Fusible switches.
2. Non-fusible switches.
3. Shunt trip switches.
4. Molded-case circuit breakers.
5. Enclosures.

**1.2 DEFINITIONS**

A. NC: Normally closed.

B. NO: Normally open.

C. SPDT: Single pole, double throw.

**1.3 ACTION SUBMITTALS**

A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated.

B. Shop Drawings: For enclosed switches and circuit breakers. Include plans, elevations, sections, details, and attachments to other work.

1. Wiring Diagrams: For power, signal, and control wiring.

**1.4 INFORMATIONAL SUBMITTALS**

A. Field quality-control reports.

**1.5 CLOSEOUT SUBMITTALS**

A. Operation and maintenance data.

**1.6 QUALITY ASSURANCE**

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with NFPA 70.

**PART 2 -- PRODUCTS**

**2.1 FUSIBLE SWITCHES**

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
2. Siemens Energy & Automation, Inc.
3. Square D; a brand of Schneider Electric.

B. Type HD, Heavy Duty, Single Throw, 600-V ac, 1200 A thru 400 A: UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate specified fuses, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

C. Type HD, Heavy Duty, Single Throw, 600-V ac, 200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated,

with clips or bolt pads to accommodate specified fuses, lockable handle with capability to accept one padlock, and interlocked with cover in closed position.

D. Accessories:

1. Equipment Ground Kit: Internally mounted and labeled for copper ground conductors.
2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper neutral conductors.
3. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
4. Service-Rated Switches: Labeled for use as service equipment.
5. Ferrule and blade fuse reducers are not permitted
6. Cover viewing window positioned over blades to allow visual verification of the ON-OFF status.

**2.2 NON-FUSIBLE SWITCHES**

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
2. Siemens Energy & Automation, Inc.
3. Square D; a brand of Schneider Electric.

B. Type HD, Heavy Duty, Single Throw, 600-V ac, 1200 A thru 400 A: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

C. Type HD, Heavy Duty, Single Throw, 600-V ac, 200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept one padlock, and interlocked with cover in closed position.

D. Accessories:

1. Equipment Ground Kit: Internally mounted and labeled for copper ground conductors.
2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper neutral conductors.
3. Cover viewing window positioned over blades to allow visual verification of the ON-OFF status.

**2.3 SHUNT TRIP SWITCHES**

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
2. Siemens Energy & Automation, Inc.
3. Square D; a brand of Schneider Electric.

B. General Requirements: Comply with ASME A17.1, UL 50, and UL 98, with 200-kA interrupting and short-circuit current rating when fitted with Class J fuses.

C. Switches: Three-pole, horsepower rated, with integral shunt trip mechanism and Class J fuse block; lockable handle with capability to accept three padlocks; interlocked with cover in closed position.

**2.4 MOLDED-CASE CIRCUIT BREAKERS**

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
2. Siemens Energy & Automation, Inc.
3. Square D; a brand of Schneider Electric.

B. General Requirements: Comply with UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents.

C. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 150 A and larger.

D. Electronic Trip Circuit Breakers: Field-replaceable rating plug, rms sensing, with the following field-adjustable settings:

1. Instantaneous trip.
2. Long- and short-time pickup levels.
3. Long- and short-time time adjustments.
4. Ground-fault pickup level, time delay, and $i^2t$ response.

E. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller, and let-through ratings less than NEMA FU 1, RK-5.

F. Features and Accessories:

1. Standard frame sizes, trip ratings, and number of poles.
2. Ground-Fault Protection: Comply with UL 1053; integrally mounted type with mechanical ground-fault indicator; relay with adjustable pickup and time-delay settings, push-to-test feature, internal memory, and shunt trip unit; and three-phase, zero-sequence current transformer/sensor.
3. Shunt Trip: Trip coil energized from separate circuit, with coil-clearing contact.
4. Auxiliary Contacts: Two SPDT switches with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
5. Alarm Switch: One NC contact that operates only when circuit breaker has tripped.

**2.5 ENCLOSURES**

A. Enclosed Switches and Circuit Breakers: NEMA AB 1, NEMA KS 1, NEMA 250, and UL 50, to comply with environmental conditions at installed location.

1. Indoor, Dry and Clean Locations: NEMA 250, Type 1.
2. Outdoor Locations: NEMA 250, Type 3R.
3. Wash-Down Areas: NEMA 250, Type 4X, stainless steel.
4. Other Wet or Damp, Indoor Locations: NEMA 250, Type 4.
5. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 12.

**PART 3 -- EXECUTION**

**3.1 INSTALLATION**

A. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.

B. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

C. Install fuses in fusible devices.

D. Comply with NECA 1.

E. Exterior located switches and circuit breaker enclosures shall be pad lockable with ECU standard facilities pad lock.

**3.2 IDENTIFICATION**

A. Comply with requirements in Division 26 Section "Identification for Electrical Systems".

1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
2. Label each enclosure with engraved metal or laminated-plastic nameplate.
3. Indicate manufacturer's name, amperage, voltage, phase, number of wires, short-circuit rating, ampacity interrupting capacity rating, and Arc Flash Warning label in accordance with NEC and ECU standards.

**3.3 FIELD QUALITY CONTROL**

A. Perform tests and inspections.

B. Acceptance Testing Preparation:

1. Test insulation resistance for each enclosed switch and circuit breaker, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

C. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

D. Enclosed switches and circuit breakers will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports, including a certified report that identifies enclosed switches and circuit breakers and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

END OF SECTION 26 28 16

**DIVISION 26 ELECTRICAL**

**SECTION 26 32 13 ENGINE GENERATORS**

**PART 1 – GENERAL**

**1.1 SUMMARY**

A. This Section includes packaged engine-generator sets for emergency and standby power supply with the following features:

1. Natural gas or diesel engine. The fuel source shall be coordinated with ECU Project Manager and Facilities Services Director prior to design and construction.
2. Unit-mounted cooling system.
3. Unit-mounted control and monitoring.
4. Outdoor enclosure.

B. A single engine generator shall not serve more than one building or set of connected structures (e.g. a single structure with a wing A, B, and C). ECU may entertain a generator serving multiple buildings in certain cases based on programming. Coordinate with ECU Project Manager.

C. See **Section 26 36 00** Transfer Switches for transfer switches including sensors and relays to initiate automatic-starting and -stopping signals for engine-generator sets.

D. The A/E is responsible for developing, documenting, and promoting technical discussion of proposed systems early in the project design phase. Early submittals are to include narrative technical discussion of system types, materials, and controls; including options, advantages, disadvantages, relative costs, Life Cycle Cost Analysis, GHGE, and architect/engineer recommendations.

E. The A/E shall evaluate if having multiple smaller units verses a single larger gen-set provides a needed level of redundancy for critical loads. Coordinate with the ECU Project Manager.

F. The A/E shall ensure that all major decisions regarding system types, materials, and controls are determined and agreed to by owner/user by the end of design development phase; and documented in the design development submittal. Costs are to be included in the A/E's design development estimate of construction cost.

G. The A/E is responsible for reviewing the universities Air Permits and is expected to make any needed modifications to the permits.

H. Landscaping should be located such that the mature drip line of any plantings or trees are no closer than 25 feet.

I. The A/E should confirm if the gen-set will be utilized for load management.

J. The A/E is responsible for ensuring that the gen-set is located away from building air intakes such that exhaust cannot become entrained and pulled into the building.

**1.2 ACTION SUBMITTALS**

A. Product Data: For each type of packaged engine generator and accessory indicated.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

**1.3 INFORMATIONAL SUBMITTALS**

A. Source quality-control test reports.

B. Field quality-control test reports.

C. Warranty: Special warranty specified in this Section.

**1.4 CLOSEOUT SUBMITTALS**

A. Operation and maintenance data.

B. University Spill Prevention Control and Countermeasures plan update

C. University Air Permit modifications

D. Documents certifying any underground fuel storage systems as being compliant with all state and federal regulatory agencies.

**1.5 QUALITY ASSURANCE**

A. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for the project/facility.

B. Manufacturer Qualifications: A qualified manufacturer. Maintains, within 150 miles of ECU, a service center capable of providing training, parts, and emergency maintenance repairs.

C. Electrical Components, Devices, and Accessories: Listed and labeled by UL as defined in NFPA 70, Article 100, and marked for intended use.

D. Comply with ASME B15.1.

E. Comply with NFPA 37.

F. Comply with NFPA 70.

G. Comply with NFPA 99.

H. Comply with NFPA 110 requirements for applicable Level 1 or 2 emergency power supply system.

I. Comply with UL 2200.

J. Engine Exhaust Emissions: Tier 4, comply with applicable state and local government requirements.

K. Noise Emission: Comply with applicable state and local government requirements for maximum noise level due to sound emitted by generator set including engine, engine exhaust, engine cooling-air intake and discharge, and other components of installation. Utilize critical grade exhaust silencer and sound attenuated enclosure so not to exceed 72dBA 20' from generator.

**1.6 PROJECT CONDITIONS**

A. Environmental Conditions: Engine-generator system shall withstand the following environmental conditions without mechanical or electrical damage or degradation of performance capability:

1. Ambient Temperature: 5 to 40 deg C.
2. Relative Humidity: 0 to 95 percent.
3. Altitude: Sea level to 100 feet.
4. Wind Sustained: 150 mph

**1.7 WARRANTY**

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of packaged engine generators and associated auxiliary components that fail in materials or workmanship within specified warranty period.

1. Warranty Period: 5 years from date of Substantial Completion.

**PART 2 -- PRODUCTS**

**2.1 MANUFACTURERS**

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Caterpillar; Engine Div.
2. Cummins
3. Kohler

B. Health Sciences Campus: Preferred Brand Alternate: Caterpillar

**2.2 ENGINE-GENERATOR SET**

A. Factory-assembled and tested, engine-generator set.

B. Mounting Frame: Maintain alignment of mounted components without depending on concrete foundation; and have lifting attachments.

C. Batteries: Gel cell type.

D. Generator-Set Performance:

1. Steady-State Voltage Operational Bandwidth: 3 percent of rated output voltage from no load to full load.
2. Transient Voltage Performance: Not more than 20 percent variation for 50 percent step-load increase or decrease. Voltage shall recover and remain within the steady-state operating band within three seconds.
3. Steady-State Frequency Operational Bandwidth: 0.5 percent of rated frequency from no load to full load.
4. Steady-State Frequency Stability: When system is operating at any constant load within the rated load, there shall be no random speed variations outside the steady-state operational band and no hunting or surging of speed.
5. Transient Frequency Performance: Less than 5 percent variation for 50 percent step-load increase or decrease. Frequency shall recover and remain within the steady-state operating band within five seconds.
6. Output Waveform: At no load, harmonic content measured line to line or line to neutral shall not exceed 5 percent total and 3 percent for single harmonics. Telephone influence factor, determined according to NEMA MG 1, shall not exceed 50 percent.
7. Sustained Short-Circuit Current: For a 3-phase, bolted short circuit at system output terminals, system shall supply a minimum of 250 percent of rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to generator system components.
8. Start Time: Comply with NFPA 110, Type 10, system requirements.

**2.3 ENGINE**

A. Fuel:

1. Natural gas or diesel. The fuel source shall be discussed with ECU Project Manager and Facilities Services Director prior to design and construction. Generators serving critical programming facilities such as research, mission critical IT, and surgical clinics shall have diesel fuel source.

B. Rated Engine Speed: 1800 rpm.

C. Maximum Piston Speed for Four-Cycle Engines: 2250 fpm.

D. Lubrication System: The following items are mounted on engine or skid:

1. Filter and Strainer: Rated to remove 90 percent of particles 5 micrometers and smaller while passing full flow.
2. Thermostatic Control Valve: Control flow in system to maintain optimum oil temperature. Unit shall be capable of full flow and is designed to be fail-safe.
3. Crankcase Drain: Arranged for complete gravity drainage to an easily removable container with no disassembly and without use of pumps, siphons, special tools, or appliances.
4. Auxiliary valves shall be installed so that the oil filters can be changed without draining the system

E. Engine Fuel System:

1. Main Fuel Pump: Mounted on engine. Pump ensures adequate primary fuel flow under starting and load conditions.
2. Relief-Bypass Valve: Automatically regulates pressure in fuel line and returns excess fuel to source.
3. Natural Gas System:
   a. Carburetor.
   b. Secondary Gas Regulators: One for each fuel type.
   c. Fuel-Shutoff Solenoid Valves: One for each fuel source.
   d. Flexible Fuel Connectors: One for each fuel source.

F. Coolant Jacket Heater: Electric-immersion type, factory installed in coolant jacket system. Comply with NFPA 110 requirements for Level 1 equipment for heater capacity. Auxiliary valves shall be installed on coolant jacket.

G. Governor: Adjustable isochronous, with speed sensing. The governor shall maintain acceptable frequency regulation from no load to fully rated load. The steady state operating band shall be within 2%.

H. Cooling System: Closed loop, liquid cooled, with radiator factory mounted on engine generator-set mounting frame and integral engine-driven coolant pump.

1. Coolant: Solution of 50 percent ethylene-glycol-based antifreeze and 50 percent water, with anticorrosion additives as recommended by engine manufacturer.
2. Temperature Control: Self-contained, thermostatic-control valve modulates coolant flow automatically to maintain optimum constant coolant temperature as recommended by engine manufacturer.

I. Muffler/Silencer: Critical type, sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.

1. Sound level measured at a distance of 20 feet from exhaust discharge after installation is complete shall be 72 dBA or less.

J. Air-Intake Filter: Heavy-duty, engine-mounted air cleaner with replaceable dry-filter element and "blocked filter" indicator.

K. Starting System:

1. Components: Sized so they will not be damaged during a full engine-cranking cycle with ambient temperature at maximum specified in **Paragraph 1.6** Project Conditions.
2. Cranking Motor: Heavy-duty unit that automatically engages and releases from engine flywheel without binding.
3. Cranking Cycle**:** As required by NFPA 110 for system level specified.
4. Battery: Adequate capacity within ambient temperature range specified in **Paragraph 1.6** Project Conditions to provide specified cranking cycle at least twice without recharging.
5. Battery-Charging Alternator: Factory mounted on engine with solid-state voltage regulation and 35-A minimum continuous rating.
   a. Battery Charger: Current-limiting, automatic-equalizing and float-charging type. Unit shall comply with UL 1236.

**2.4 FUEL OIL STORAGE**

A. Comply with NFPA 30.

B. If fuel stores are required by the application that would be beyond the typical volume for a base-mounted tank, the preference is that the additional storage tank be above ground.

C. Base-Mounted Fuel Oil Tank: Factory installed and piped, complying with UL 142 fuel oil tank. Features include the following:

1. Tank level indicator.

2. Capacity: Required fuel supply for 72 hours of continuous operation at 100 percent rated power output.
3. Lockable-vandal-resistant fill cap. Coordinate fill cap type with ECU Project Manager and ECU Facilities Services Department.
4. Containment Provisions: Comply with requirements of authorities having jurisdiction.
5. Provide structural supports and neoprene pads or similar means to lift skid base mounted tanks above concrete pad to prevent moisture accumulation around and in contact with tank. Include methods and details in generator shop drawings for ECU Engineering and Architectural Services and Facilities Services Departments review and approval.
6. Spill Prevention, Control and Countermeasure (SPPC) Plan – Provide spill prevention, control and countermeasure (SPCC) plan adhering to the requirements of the United States Environmental Protection Agency (USEPA) regulations contained in 40 C.F.R. part 112 – Oil Pollution Prevention. The SPCC plan shall be generated and signed and sealed by an environmental professional engineer registered in the State of North Carolina and submitted to NCDENR. SPCC plan and EPA permitting shall be implemented and complete prior to generator arriving on site. Coordinate with ECU Project Manager and ECU Facilities Services Department.

**2.5 CONTROL AND MONITORING**

A. Automatic Starting System Sequence of Operation: When mode-selector switch on the control and monitoring panel is in the automatic position, remote-control contacts in one or more separate automatic transfer switches initiate starting and stopping of generator set. When mode-selector switch is switched to the on position, generator set starts. The off position of same switch initiates generator-set shutdown. When generator set is running, specified system or equipment failures or derangements automatically shut down generator set and initiate alarms.

B. Manual Starting System Sequence of Operation: Switching on-off switch on the generator control panel to the on position starts generator set. The off position of same switch initiates generator-set shutdown. When generator set is running, specified system or equipment failures or derangements automatically shut down generator set and initiate alarms.

C. Configuration: Operating and safety indications, protective devices, basic system controls, and engine gages shall be grouped in a common control and monitoring panel mounted on the generator set. Mounting method shall isolate the control panel from generator-set vibration.

D. Indicating and Protective Devices and Controls: As required by NFPA 110 for applicable Level 1 or 2 system, and the following:

1. AC voltmeter.
2. AC ammeter.
3. AC frequency meter.
4. DC voltmeter (alternator battery charging).
5. Engine-coolant temperature gage.
6. Engine lubricating-oil pressure gage.
7. Running-time meter.
8. Ammeter-voltmeter, phase-selector switch.
9. Generator-voltage adjusting rheostat.
10. Fuel tank derangement alarm.
11. Fuel tank high-level shutdown of fuel supply alarm.
12. Fuel level indicator.
13. Generator overload.

E. Supporting Items: Include sensors, transducers, terminals, relays, and other devices and include wiring required to support specified items. Locate sensors and other supporting items on engine or generator, unless otherwise indicated.

F. Common Remote Audible Alarm: Comply with NFPA 110 requirements for Level 1 systems. Include necessary contacts and terminals in control and monitoring panel.

1. Over crank shutdown.
2. Coolant low-temperature alarm.
3. Control switch not in auto position.
4. Battery-charger malfunction alarm.
5. Battery low-voltage alarm.

G. Remote Alarm Annunciator: Comply with NFPA 99. An LED labeled with proper alarm conditions shall identify each alarm event and a common audible signal shall sound for each alarm condition. Silencing switch in face of panel shall silence signal without altering visual indication. Connect so that after an alarm is silenced, clearing of initiating condition will reactivate alarm until silencing switch is reset. Cabinet and faceplate are surface- or flush-mounting type to suit mounting conditions indicated.

H. Generator controllers shall interface with the applicable campus enterprise system for alarm monitoring, data acquisition, and remote operation. Coordinate with the ECU Project Manager prior to design.

**2.6 GENERATOR OVERCURRENT AND FAULT PROTECTION**

A. Generator Circuit Breaker: Molded-case, thermal-magnetic type; 100 percent rated; complying with NEMA AB 1 and UL 489.

1. Tripping Characteristic: Designed specifically for generator protection.
2. Trip Rating: Matched to generator rating.
3. Shunt Trip: Connected to trip breaker when generator set is shut down by other protective devices. Generator EPO button shall simultaneously shut off the generator engine ad and shunt trip the generator circuit breaker(s).
4. Mounting: Adjacent to or integrated with control and monitoring panel.

B. Ground-Fault Indication: Comply with NFPA 70, "Emergency System" signals for ground-fault. Integrate ground-fault alarm indication with other generator-set alarm indications.

**2.7 GENERATOR, EXCITER, AND VOLTAGE REGULATOR**

A. Comply with NEMA MG 1.

B. Drive: Generator shaft shall be directly connected to engine shaft. Exciter shall be rotated integrally with generator rotor.

C. Electrical Insulation: Class H or Class F.

D. Stator-Winding Leads: Brought out to terminal box to permit future reconnection for other voltages if required.

E. Construction shall prevent mechanical, electrical, and thermal damage due to vibration, over speed up to 125 percent of rating, and heat during operation at 110 percent of rated capacity.

F. Enclosure: Drip proof.

G. Instrument Transformers: Mounted within generator enclosure.

H. Voltage Regulator: Solid-state type, separate from exciter, providing performance as specified.

1. Adjusting rheostat on control and monitoring panel shall provide plus or minus 5 percent adjustment of output-voltage operating band.

I. Strip Heater: Thermostatically controlled unit arranged to maintain stator windings above dew point.

J. Windings: Two-thirds pitch stator winding and fully linked amortisseur winding.

K. Sub-transient Reactance: 12 percent, maximum.

### 2.8 OUTDOOR GENERATOR-SET ENCLOSURE

A. Description: Vandal-resistant, weatherproof sound attenuated aluminum housing, wind resistant up to 150 mph unless directed otherwise by ECU Project Manager, verify prior to design. Multiple panels shall be lockable and provide adequate access to components requiring maintenance. Panels shall be removable by one person without tools. Instruments and control shall be mounted within enclosure.

B. Engine Cooling Airflow through Enclosure: Maintain temperature rise of system components within required limits when unit operates at 110 percent of rated load for 8 hours with ambient temperature at top of range specified in system service conditions.

1. Louvers: Fixed-engine, cooling-air inlet and discharge. Storm-proof and drainable louvers prevent entry of rain and snow.
2. Automatic Dampers: At engine cooling-air inlet and discharge. Dampers shall be closed to reduce enclosure heat loss in cold weather when unit is not operating.

C. Interior Lights with Switch: Factory-wired, vapor proof-type fixtures within housing; arranged to illuminate controls and accessible interior. Arrange for external electrical connection.

1. AC lighting system and connection point for operation when remote source is available.
2. DC lighting system for operation when remote source and generator are both unavailable.
3. Provide LED fixtures, 4100K.

D. Convenience Outlets: Factory wired**,** GFCI. Arrange for external electrical connection. Do not wire lights or battery charger downstream from GFCI outlet.

E. All generators shall have a load bank breaker for the connection of a portable load bank for periodic testing.

F. All installations where either the enclosure interior floor height exceeds 24” above grade or the midpoint of equipment access doors exceeds 48” above grade, an exterior access platform with steps and handrails shall be provided. If an exterior platform is required, A/E shall also provide exterior lighting for staff to safely move about platform.

## PART 3 -- EXECUTION

### 3.1 INSTALLATION

A. Comply with packaged engine-generator manufacturers' written installation and alignment instructions and with NFPA 110.

B. Install packaged engine generator to provide access, without removing connections or accessories, for periodic maintenance.

C. Install packaged engine generator with elastomeric isolator pads or restrained spring isolators having a minimum deflection of 1 inch on 4-inch high concrete base. Secure sets to anchor bolts installed in concrete bases.

D. Install Schedule 40, black steel piping with welded joints and connect to engine muffler. Install thimble at wall. Piping shall be same diameter as muffler outlet. Flexible connectors and steel piping materials and installation requirements are specified in Division 23 Section "Hydronic Piping”.

1. Install condensate drain piping to muffler drain outlet full size of drain connection with a shutoff valve, stainless-steel flexible connector, and Schedule 40, black steel pipe with welded joints.

E. Electrical Wiring: Install electrical devices furnished by equipment manufacturers but not specified to be factory mounted.

F. Connect fuel, cooling-system, and exhaust-system piping adjacent to packaged engine generator to allow service and maintenance.

G. Connect engine exhaust pipe to engine with flexible connector.

H. Connect fuel piping to engines with a gate valve and union and flexible connector.

I. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems".

J. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables".

K. Identify system components according to Division 26 Section "Identification for Electrical Systems".

L. Conduits that stub up into the base of a generator enclosure shall not come up into a sump or depression that can collect water and enter the raceways.

**3.2 FIELD QUALITY CONTROL**

A. Perform tests and inspections and prepare test reports.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
2. Provide fuel for testing and fill tank upon completion of test prior to turning project over to ECU.

B. Tests and Inspections:

1. Perform tests recommended by manufacturer and each electrical test and visual and mechanical inspection for "AC Generators and for Emergency Systems" specified in NETA Acceptance Testing Specification. Certify compliance with test parameters.
2. Tests shall include a minimum of 10 starts of generator set, minimum of 10 operations of transfer switches, 4 hour maintained operation under full load via load bank. Ensure manufacturer cool down period between the engine starts.
3. NFPA 110 Acceptance Tests: Perform tests required by NFPA 110 that are additional to those specified here including, but not limited to, single-step full-load pickup test.
4. Battery Tests: Equalize charging of battery cells according to manufacturer's written instructions. Record individual cell voltages.
   a. Measure charging voltage and voltages between available battery terminals for full-charging and float-charging conditions. Check electrolyte level and specific gravity under both conditions.
   b. Test for contact integrity of all connectors. Perform an integrity load test and a capacity load test for the battery.
   c. Verify acceptance of charge for each element of the battery after discharge.
   d. Verify that measurements are within manufacturer's specifications.
5. Battery-Charger Tests: Verify specified rates of charge for both equalizing and float-charging conditions.
6. System Integrity Tests: Methodically verify proper installation, connection, and integrity of each element of engine-generator system before and during system operation. Check for air, exhaust, and fluid leaks.
7. Exhaust-System Back-Pressure Test: Use a manometer with a scale exceeding 40-inch wg (120kPa). Connect to exhaust line close to engine exhaust manifold. Verify that back pressure at full-rated load is within manufacturer's written allowable limits for the engine.
8. Exhaust Emissions Test: Comply with applicable government test criteria.
9. Voltage and Frequency Transient Stability Tests: Use recording oscilloscope to measure voltage and frequency transients for 50 and 100 percent step-load increases and decreases, and verify that performance is as specified.
10. Harmonic-Content Tests: Measure harmonic content of output voltage under 25 percent and at 100 percent of rated linear load. Verify that harmonic content is within specified limits.
11. Noise Level Tests: Measure A-weighted level of noise emanating from generator-set installation, including engine exhaust and cooling-air intake and discharge, at locations 20' from generator enclosure, and compare measured levels with required values.

C. Coordinate tests with tests for transfer switches and run them concurrently.

D. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.

E. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

F. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

G. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation resistances, time delays, and other values and observations. Attach a label or tag to each tested component indicating satisfactory completion of tests.

H. At conclusion of testing, service the generator set including replacing air, oil and fuel filters, changing lubrication oil, checking batteries, adjusting fan belts for manufacturer required tightness, and refilling cooling system.

**3.3 DEMONSTRATION**

A. Engage a factory-authorized service representative to train ECU Facilities Services maintenance personnel to adjust, operate, and maintain packaged engine generators.

END OF SECTION 26 32 13

**DIVISION 26 ELECTRICAL**

**SECTION 26 36 00 TRANSFER SWITCHES**

**PART 1 -- GENERAL**

**1.1 SUMMARY**

A. This Section includes automatic transfer switches rated 600 V and less.

B. The A/E is responsible for discussing the criticality of various loads that will be served with ECU Facilities prior to specifying the equipment.

**1.2 ACTION SUBMITTALS**

A. Product Data: Include rated capacities, weights, operating characteristics, furnished specialties, and accessories.

B. Shop Drawings: Dimensioned plans, elevations, sections, and details showing minimum clearances, conductor entry provisions, gutter space, installed features and devices, and material lists for each switch specified.

**1.3 INFORMATIONAL SUBMITTALS**

A. Field quality-control test reports.

**1.4 CLOSEOUT SUBMITTALS**

A. Operation and maintenance data.

**1.5 QUALITY ASSURANCE**

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. Comply with NEMA ICS 1.

C. Comply with NFPA 70.

D. Comply with NFPA 99.

E. Comply with NFPA 110.

F. Comply with UL 1008 unless requirements of these Specifications are stricter.

**1.6 WARRANTY**

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components that fail in materials or workmanship within specified warranty period.
1. Warranty Period: 5 years from date of Substantial Completion.

**PART 2 -- PRODUCTS**

**2.1 MANUFACTURERS**

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Transfer Switches:

a. Emerson; ASCO Power Technologies, LP.
b. Generac Power Systems, Inc.
c. Kohler Power Systems; Generator Division.
d. Onan/Cummins Power Generation; Industrial Business Group.

e. Russelectric, Inc.

**2.2 GENERAL TRANSFER-SWITCH PRODUCT REQUIREMENTS**

A. Indicated Current Ratings: Apply as defined in UL 1008 for continuous loading and total system transfer.

B. Tested Fault-Current Closing and Withstand Ratings: Adequate for duty imposed by protective devices at installation locations in project/facility under the fault conditions indicated, based on testing according to UL 1008.

1. Where transfer switch includes internal fault-current protection, rating of switch and trip unit combination shall exceed indicated fault-current value at installation location.

C. Solid-State Controls: Repetitive accuracy of all settings shall be plus or minus 2 percent or better over an operating temperature range of minus 20 to plus 70 deg C.

D. Resistance to Damage by Voltage Transients: Components shall meet or exceed voltage-surge withstand capability requirements when tested according to IEEE C62.41. Components shall meet or exceed voltage-impulse withstand test of NEMA ICS 1.

E. Electrical Operation: Accomplish by a non-fused, momentarily energized solenoid or electric-motor-operated mechanism, mechanically and electrically interlocked in both directions.

F. Switch Characteristics: Designed for continuous-duty repetitive transfer of full-rated current between active power sources.

1. Limitation: Switches using molded-case switches or circuit breakers or insulated-case circuit-breaker components are not acceptable.
2. Switch Action: Double throw; mechanically held in both directions.
3. Contacts: Silver composition or silver alloy for load-current switching. Conventional automatic transfer-switch units, rated 225 A and higher, shall have separate arcing contacts.

G. Neutral Switching. Where four-pole switches are indicated, provide neutral pole switched simultaneously with phase poles. Provide four-pole switches on services where NEC requires GFCI.

H. Neutral Terminal: Solid and fully rated, unless otherwise indicated.

I. Enclosures: General-purpose NEMA 250, applicable Type 1, 3R, or 12 complying with NEMA ICS 6 and UL 508, unless otherwise indicated.

**2.3 AUTOMATIC TRANSFER SWITCHES**

A. Comply with Level 1 equipment according to NFPA 110.

B. Switching Arrangement: Double-throw type, incapable of pauses or intermediate position stops during normal functioning, unless otherwise indicated.

C. Signal-Before-Transfer Contacts: A set of normally open/normally closed dry contacts operates in advance of retransfer to normal source. Interval is adjustable from 1 to 30 seconds.

D. Transfer Switches Based on Molded-Case-Switch Components: Comply with NEMA AB 1, UL 489, and UL 869A.

E. Automatic Transfer-Switch Features:

1. Undervoltage Sensing for Each Phase of Normal Source: Sense low phase-to-ground voltage on each phase. Pickup voltage shall be adjustable from 85 to 100 percent of nominal, and dropout voltage is adjustable from 75 to 98 percent of pickup value. Factory set for pickup at 90 percent and dropout at 85 percent.
2. Adjustable Time Delay: For override of normal-source voltage sensing to delay transfer and engine start signals. Adjustable from zero to six seconds, and factory set for one second.
3. Voltage/Frequency Lockout Relay: Prevent premature transfer to generator. Pickup voltage shall be adjustable from 85 to 100 percent of nominal. Factory set for pickup at 90 percent. Pickup frequency

shall be adjustable from 90 to 100 percent of nominal. Factory set for pickup at 95 percent.

4. Time Delay for Retransfer to Normal Source: Adjustable from 0 to 30 minutes, and factory set for 10 minutes to automatically defeat delay on loss of voltage or sustained undervoltage of emergency source, provided normal supply has been restored.
5. Test Switch: Simulate normal-source failure.
6. Switch-Position Pilot Lights: Indicate source to which load is connected.
7. Source-Available Indicating Lights: Supervise sources via transfer-switch normal- and emergency-source sensing circuits.
   a. Normal Power Supervision: Green light with nameplate engraved "Normal Source Available."
   b. Emergency Power Supervision: Red light with nameplate engraved "Emergency Source Available."
8. Unassigned Auxiliary Contacts: Two normally open, single-pole, double-throw contacts for each switch position, rated 10 A at 240-V ac.
9. Transfer Override Switch: Overrides automatic retransfer control so automatic transfer switch will remain connected to emergency power source regardless of condition of normal source. Pilot light indicates override status.
10. Engine Starting Contacts: One isolated and normally closed, and one isolated and normally open; rated 10 A at 32-V dc minimum.
11. Engine Shutdown Contacts: Instantaneous; shall initiate shutdown sequence at remote engine-generator controls after retransfer of load to normal source.
12. Engine Shutdown Contacts: Time delay adjustable from zero to five minutes, and factory set for five minutes. Contacts shall initiate shutdown at remote engine-generator controls after retransfer of load to normal source.
13. Engine-Generator Exerciser: Solid-state, programmable-time switch starts engine generator and transfers load to it from normal source for a preset time, then retransfers and shuts down engine after a preset cool-down period. Initiates exercise cycle at preset intervals adjustable from 7 to 30 days. Running periods are adjustable from 10 to 30 minutes. Factory settings are for 7-day exercise cycle, 20-minute running period, and 5minute cool-down period. ECU Facilities shall be able to make all interval/period adjustments Exerciser features include the following:
    a. Exerciser Transfer Selector Switch: Permits selection of exercise with and without load transfer.
    b. Push-button programming control with digital display of settings.
    c. Integral battery operation of time switch when normal control power is not available.
    d. Program changes to exerciser cannot require any special hardware/software
14. For buildings serving primarily research, vivarium, data centers, or clinical operations; closed transition transfer switches with bypass/isolation, shall be provided for the safe and convenient means for manually bypassing and isolating the automatic transfer switch, regardless of the condition or position of the ATS, with the ability to be used as an emergency backup system in the event the transfer switch should fail.
15. The transfer switch shall be equipped with a Microprocessor Controller with a Power Supply Module, CPU and I/O Modules for all voltage and ampere ratings. The controller shall be capable of both Serial and Ethernet communications.

F. All automatic transfer switches shall report status to the building automation system (BAS) via BACnet protocol.

1. Required monitoring points for reporting status to BAS.
   a. Loss of Normal Power
   b. Loss of Phase
   c. Phase Reversal
   d. Transfer Switch Position
   e. Generator Run Status (running or not running).

f. Generator Fault Status
g. Power Source Status

2. Provide ECU Facilities Services preapproved field controller or equal, in general purpose enclosure adjacent to each automatic transfer switch. Provide connection between automatic transfer switch and field controller for the monitoring points as directed by the automatic transfer switch manufacturer instructions. Verify type of BACnet field controller for each installation with ECU Facilities Services prior to the design.

3. Provide connection to nearest active BAS controller with #18 shielded twisted pair cable in 3/4" conduit.

**2.4 SOURCE QUALITY CONTROL**

A. Factory test and inspect components, assembled switches, and associated equipment. Ensure proper operation. Check transfer time and voltage, frequency, and time-delay settings for compliance with specified requirements. Perform dielectric strength test complying with NEMA ICS 1.

**PART 3 -- EXECUTION**

**3.1 INSTALLATION**

A. Floor-Mounting Switch: Anchor to floor by bolting.

1. Concrete Bases: 4 inches high, reinforced, with chamfered edges. Extend base no more than 4 inches in all directions beyond the maximum dimensions of switch, unless otherwise indicated.

B. Identify components according to **Section 26 05 53** Identification for Electrical Systems.

C. Set field-adjustable intervals and delays, relays, and engine exerciser clock. Coordinate with ECU Project Manager and ECU Facilities Services Department.

**3.2 CONNECTIONS**

A. Ground equipment according to **Section 26 05 26** Grounding and Bonding for Electrical Systems.

B. Connect wiring according to **Section 26 05 19** Low-Voltage Electrical Power Conductors and Cables.

**3.3 FIELD QUALITY CONTROL**

A. Perform tests and inspections and prepare test reports.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.
2. After installing equipment and after electrical circuitry has been energized, test for compliance with requirements.
3. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
4. Measure insulation resistance phase-to-phase and phase-to-ground with insulation-resistance tester. Use test voltages and procedure recommended by manufacturer. Comply with manufacturer's specified minimum resistance.

   a. Check for electrical continuity of circuits and for short circuits.
   b. Inspect for physical damage, proper installation and connection, and integrity of barriers, covers, and safety features.
   c. Verify that manual transfer warnings are properly placed.
   d. Perform manual transfer operation.
5. After energizing circuits, demonstrate interlocking sequence and operational function for each switch at least three times.

   a. Simulate power failures of normal source to automatic transfer switches and of emergency source with

normal source available.
b. Simulate loss of phase-to-ground voltage for each phase of normal source.
c. Verify time-delay settings.
d. Verify pickup and dropout voltages by data readout or inspection of control settings.
e. Perform contact-resistance test across main contacts and correct values exceeding 500 microhms and values for 1 pole deviating by more than 50 percent from other poles.
f. Verify proper sequence and correct timing of automatic engine starting, transfer time delay, retransfer time delay on restoration of normal power, and engine cool-down and shutdown.

6. Ground-Fault Tests: Coordinate with testing of ground-fault protective devices for power delivery from both sources.
a. Verify grounding connections and locations and ratings of sensors.
b. Coordinate tests with tests of generator and run them concurrently.
c. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation and contact resistances and time delays. Attach a label or tag to each tested component indicating satisfactory completion of tests.
d. Remove and replace malfunctioning units and retest as specified above.

**3.4 DEMONSTRATION**

A. Engage a factory-authorized service representative to train ECU Facilities Services maintenance personnel to adjust, operate, and maintain transfer switches and related equipment. To include fully demonstrating all of the manufactures recommended inspection, testing and maintenance procedures.

B. Coordinate transfer switch training with generator set training.

END OF SECTION 26 36 00

**DIVISION 26 ELECTRICAL**

**SECTION 26 41 13 LIGHTNING PROTECTION FOR STRUCTURES**

**PART 1 -- GENERAL**

**1.1 SUMMARY**

A. This section contains the requirements for lightning protection system (LPS) for the protection of University structures from direct lightning strikes.

1. This is an optional system that should be evaluated for inclusion in new construction or renovation projects. Evaluation shall be made in accordance with guidelines set forth in the latest edition of NFPA 780, Standard for the Installation of Lightning Protection systems, Annex L, Lightning Risk Assessment. Submit copies of the evaluation for review and approval by East Carolina University.

**1.2 ACTION SUBMITTALS**

A. Product Data: For each type of product indicated.

B. Shop Drawings: For air terminals and mounting accessories.

1. Layout of the lightning protection system, along with details of the components to be used in the installation.
2. Include indications for use of raceway, data on how concealment requirements will be met, and calculations required by NFPA 780 for bonding of grounded and isolated metal bodies.

**1.3 INFORMATIONAL SUBMITTALS**

A. Field quality-control reports.

**1.4 QUALITY ASSURANCE**

A. Installer Qualifications: Certified by UL as a Master Installer/Designer, trained and approved for installation of units required for this Project.

B. System Certificate:

1. UL Master Label.
2. UL Master Label Recertification for renovations and expansions. If existing structure does not have a UL Master Label, provide “Letter of Compliance”.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 780, "Definitions" Article.

**PART 2 -- PRODUCTS**

**2.1 LIGHTNING PROTECTION SYSTEM COMPONENTS**

GENERAL:

A. The LPS shall be comprised of air terminals, down conductors, ground terminals, counterpoised ground conductor, interconnecting conductors, arresters and other connectors or fittings required to complete the system. The lightning protection ground components shall be connected to the electrical service ground. System design shall be in accordance with the latest edition of the following:

1. NFPA 70, National Electrical Code
2. NFPA 780, Standard for the Installation of Lightning Protection Systems

3. LPI-175, Lightning Protection Institute (LPI), Standard of Practice
4. UL 96A, Underwriters Laboratories, Installation Requirements for Lightning Protection Systems.

B. Comply with UL 96 and NFPA 780.

C. System Conductors and Down Conductors: sized per classification required in NFPA and for Master UL Label.

D. Counterpoise System Ground: Copper, provide when required by NFPA and for Master UL Label.

E. The installer/certifier shall prepare and provide to the university, a complete Inspection Guide and forms for conducting all inspections and testing of the lightning protection system as noted in the Annex to NFPA 780, Inspection and Maintenance of Lightning Protection Systems.

F. The installer/certifier shall instruct university personnel how to properly inspect, test, and maintain the lightning protection system as noted in the Annex to NFPA 780, Inspection and Maintenance of Lightning Protection Systems.

**PART 3 -- EXECUTION**

**3.1 INSTALLATION**

A. Provide lightning protection components and systems according to UL 96A and NFPA 780 on all new facilities, renovated facilities, and where roof replacements require removing or modifying existing lightning protection systems.

B. Conceal the following conductors:

1. System conductors.
2. Down conductors.
3. Interior conductors.
4. Conductors within normal view of exterior locations at grade.

C. Cable Connections: Use crimped or bolted connections for all conductor splices and connections between conductors and other components. Use exothermic-welded connections in underground portions of the system.

D. Air Terminals on Single-Ply Membrane Roofing: Comply with roofing membrane and adhesive manufacturer's written instructions.

E. Bond extremities of vertical metal bodies exceeding 60 feet in length to lightning protection components.

F. Ground Loop: Install ground-level, potential equalization conductor and extend around the perimeter of structure.

1. Bury ground ring not less than 24 inches from building foundation.
2. Bond ground terminals to the ground loop.
3. Bond grounded building systems to the ground loop conductor within 12 feet of grade level.

G. Bond lightning protection components with intermediate-level interconnection loop conductors to grounded metal bodies of building at 60-foot intervals.

H. Ground conductors located outside of building shall have 24” minimum burial depth.

I. Provide inspection-wells as well as test and disconnect points as needed to ensure adequate access for testing and inspection of the lightning protection system as noted in the Inspection and Maintenance of Lighting Protection Systems Annex of NFPA 780.

**3.2 CORROSION PROTECTION**

A. Do not combine materials that can form an electrolytic couple that will accelerate corrosion in the presence of moisture unless moisture is permanently excluded from junction of such materials.

B. Use conductors with protective coatings where conditions cause deterioration or corrosion of conductors.

**3.3 FIELD QUALITY CONTROL**

A. UL Inspection: Meet requirements to obtain a UL Master Label for system. Provide UL Master Label in accordance with UL 96A with project closeout documents.

B. Test resistance to ground at each lightning protection driven ground round, using fall-of-potential method using megohmeter. If the measured resistance to ground is greater than 25 ohms, provide additional driven grounds per 2.1 E until the measured resistance is less than 25 ohms.

END OF SECTION 26 41 13

**DIVISION 26 ELECTRICAL**

**SECTION 26 43 13 TRANSIENT-VOLTAGE SUPPRESSION FOR LOW-VOLTAGE ELECTRICAL POWER CIRCUITS**

**PART 1 -- GENERAL**

**1.1 SUMMARY**

A. Section includes field-mounted TVSS for low-voltage (120 to 600 V) power distribution and control equipment.

**1.2 ACTION SUBMITTALS**

A. Product Data: For each type of product indicated. Include unit dimensions, rated capacities, operating weights, electrical characteristics, furnished specialties, and accessories.

**1.3 INFORMATIONAL SUBMITTALS**

A. Field quality-control reports.

B. Warranty information.

C. Drawings: Provide shop drawings indicating mounting provisions, installation instructions, and wiring diagrams.

**1.4 CLOSEOUT SUBMITTALS**

A. Operation and maintenance data.

**1.5 QUALITY ASSURANCE**

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a testing agency, and marked for intended location and application.

**1.6 WARRANTY**

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of surge suppressors that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

**PART 2 -- PRODUCTS**

**2.1 SERVICE ENTRANCE SUPPRESSORS – Type 1**

A. Surge Protection Devices:
1. Comply with UL 1449.
2. Fabrication using bolted compression lugs for internal wiring.
3. Integral disconnect switch when connected to line side of main service switch.
4. TVSS shall be integral to incoming service entrance board and part of the UL assembly.
5. Redundant suppression circuits.
6. Arrangement with wire connections to phase buses, neutral bus, and ground bus.
7. LED indicator lights for power and protection status.

C. Peak Single-Impulse Surge Current Rating: 160 kA per mode/320 kA per phase.

D. Protection modes and UL 1449 SVR for grounded wye circuits with 480Y/277 V or 208Y/120 V, 3-phase, 4-wire circuits shall be as follows:

1. Line to Neutral: 800 V for 480Y/277 V / 400 V for 208Y/120 V.
2. Line to Ground: 800 V for 480Y/277 V / 400 V for 208Y/120 V.
3. Neutral to Ground: 800 V for 480Y/277 V / 400 V for 208Y/120 V.

E. Protection modes and UL 1449 SVR for 240/120 V, single-phase, 3-wire circuits shall be as follows:

1. Line to Neutral: 400 V.
2. Line to Ground: 400 V.
3. Neutral to Ground: 400 V.

F. Protection modes and UL 1449 SVR for 240/120-V, 3-phase, 4-wire circuits with high leg shall be as follows:

1. Line to Neutral: 400 V, 800 V from high leg.
2. Line to Ground: 400 V.
3. Neutral to Ground: 400 V.

G. Protection modes and UL 1449 SVR for 240 V, 480 V, or 600 V, 3-phase, 3-wire, delta circuits shall be as follows:

1. Line to Line: 2000 V for 480 V / 1000 V for 240 V.
2. Line to Ground: 2000 V for 480 V / 1000 V for 240 V.

H. Units integral with the switchboard are not allowed.

I. All building MDPs will be provided with TVSS.

## PART 3 -- EXECUTION

### 3.1 FIELD QUALITY CONTROL

A. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test stated in NETA ATS, "Surge Arresters, Low-Voltage Surge Protection Devices" Section. Certify compliance with test parameters.
2. After installing TVSS devices but before electrical circuitry has been energized, test for compliance with requirements.
3. Complete startup checks according to manufacturer's written instructions.

C. TVSS device will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

### 3.3 STARTUP SERVICE

A. Do not energize or connect service entrance equipment or panelboards to their sources until TVSS devices are installed and connected.

B. Do not perform insulation resistance tests of the distribution wiring equipment with the TVSS installed. Disconnect before conducting insulation resistance tests, and reconnect immediately after the testing is over.

### 3.4 DEMONSTRATION

A. Engage a factory-authorized service representative to train ECU Facilities Services maintenance personnel to maintain TVSS devices.

END OF SECTION 26 43 13

**DIVISION 26 ELECTRICAL**

**SECTION 26 51 00 INTERIOR LIGHTING**

**PART 1 – GENERAL**

**1.1 SUMMARY**

A. Section Includes:

1. Interior lighting fixtures, lamps, and ballasts.
2. Emergency lighting units.
3. Exit signs.
4. Lighting fixture supports.

B. Related Sections:

1. Division 26 Section "Lighting Control Devices" for automatic control of lighting, including time switches, photoelectric relays, and occupancy sensors.

**1.2 ACTION SUBMITTALS**

A. Product Data: For each type of lighting fixture, arranged in order of fixture designation. Include data on features, accessories, and finishes.

B. Shop Drawings: Show details of nonstandard or custom lighting fixtures. Indicate dimensions, weights, methods of field assembly, components, features, and accessories. Product Certificates: For each type of ballast for bi-level and dimmer-controlled fixtures, from manufacturer.

C. Provide a fixture sample if directed by ECU Project Manager.

D. Submit photometric calculations superimposed onto the floor plan. The photometric levels are to be legible when plotted to scale.

E. Lighting fixture schedule indicating the fixture manufacturer, catalog number, input watts, lamp and color identification, and description shall be included on the electrical documents.

F. Light levels shall meet IESNA recommendations unless directed otherwise by ECU Project Manager.

G. Designers shall insure that the light fixture selection and location shall be serviceable without the erection of scaffolding or the temporary relocation of fixed in place equipment or furnishings.

H. A/E is responsible for ensuring a spare parts list is provided for each type of fixture used.

**1.3 INFORMATIONAL SUBMITTALS**

A. Field quality-control reports.

**1.4 QUALITY ASSURANCE**

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with NFPA 70.

**1.5 WARRANTY**

A. LED Fixtures, Light Emitting Diodes (LEDs), and Drivers: Manufacturer shall provide five year warranty against defects in materials and workmanship for all products. A letter of warranty shall be provided by the manufacture to ECU. Project contractor shall replace defective fixtures and components during the first year of warranty without additional compensation from ECU.

B. Warranty period shall begin on date of substantial completion.

**PART 2 -- PRODUCTS**

**2.1 MANUFACTURERS**

A. Manufacturers: Subject to compliance with requirements, provide the products noted by the one of the following:

1. Interior - General

    1. Cree
    2. Lithonia
    3. Phillips

2. Interior - Exit Lights and Signs

    a. Lithonia
    b. Dual Lite
    c. Emergee Lite

B. All other products are subject to ECU Engineering and Architectural Services review and approval.

1. Provide electronic (PDF format) cut sheets of proposed fixtures with reflected ceiling plan at design development.
2. Provide electronic (PDF format) cut sheets of specified fixtures at 100% Construction Documents.

**2.2 GENERAL REQUIREMENTS FOR LIGHTING FIXTURES AND COMPONENTS**

A. Recessed Fixtures: Comply with NEMA LE 4 for ceiling compatibility for recessed fixtures.

B. Incandescent, MR16, and quartz lamp fixtures shall not be used. LED fixtures shall be utilized in lieu of these sources.

C. Fluorescent fixtures: shall not be used.

D. HID lamp fixtures shall not be used.

E. LED: UL listed per document UL 8750.

F. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

G. Diffusers and Globes:

1. Use of acrylic lens luminaires requires approval from ECU Engineering and Architectural Services and ECU Facilities Services prior to design.
2. Acrylic Lighting Diffusers: 100 percent virgin acrylic plastic. High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
    a. Lens Thickness: At least 0.125 inch minimum unless otherwise indicated.
    b. UV stabilized.
3. Glass: Annealed crystal glass unless otherwise indicated.
4. Polycarbonate lens are not permitted.

H. Air-handling - fluorescent fixtures shall not be used.

I. Spare fixtures shall be provided for all non-standard, architectural fixtures

**2.5 EMERGENCY LED POWER UNIT**

A. Internal Type, only allowed in locations without a life safety generator: Self-contained, modular, battery-inverter unit, factory mounted within lighting fixture body and compatible with LED controller.

1. Emergency Connection: Operate LEDs continuously at an output of 1100 lumens each. Connect unswitched circuit to battery-inverter unit and switched circuit to fixture.
2. Nightlight Connection: Operate one half of LEDs continuously. Utilize switchable unit when located in conference rooms or in rooms where nightlight is not permissible.
3. Test Push Button and Indicator Light: Visible and accessible without opening fixture or entering ceiling space.
   a. Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
   b. Indicator Light: LED indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.
4. Battery: Sealed, maintenance-free, nickel-cadmium type.
5. Charger: Fully automatic, solid-state, constant-current type with sealed power transfer relay.
6. Integral Self-Test: Factory-installed electronic device automatically initiates code-required test of unit emergency operation at required intervals. Test failure is annunciated by an integral audible alarm and a flashing red LED.
7. Interference: Comply with 47 CFR 18, Ch. 1, Subpart C, for limitations on electromagnetic and radio-frequency interference for nonconsumer equipment.
8. Protection: Class P thermal cutout.

B. Wall or ceiling mount dual head emergency lights with battery back-up are not approved. Provide self-contained, modular, battery inverter unit in LED fixtures in accordance with 2.5 A. Everything must be contained within the fixture with no separate relays above ceiling. Fixtures that drop down from ceiling upon activation are not permitted.

**2.6 EXIT SIGNS**

A. General Requirements for Exit Signs: Comply with UL 924; for sign colors, visibility, luminance, and lettering size, comply with authorities having jurisdiction.

B. Internally Lighted Signs:

1. Lamps for AC Operation: LEDs, 50,000 hours minimum rated lamp life.
2. Self-Powered Exit Signs (Battery Type), locations without a life safety generator only: Integral automatic charger in a self-contained power pack.
   a. Battery: Sealed, maintenance-free, nickel-cadmium type.
   b. Charger: Fully automatic, solid-state type with sealed transfer relay.
   c. Operation: Relay automatically energizes lamp from battery when circuit voltage drops to 80 percent of nominal voltage or below. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger.
   d. Test Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
   e. LED Indicator Light: Indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.

**2.7 LAMPS**

A. ECU campus standard LED for interiors: 4000K.

**2.8 LIGHTING FIXTURE SUPPORT COMPONENTS**

A. Comply with **Section 26 05 29** Hangers and Supports for Electrical Systems for channel- and angle-iron supports and nonmetallic channel and angle supports.

B. Single-Stem Hangers: 1/2-inch steel tubing with swivel ball fittings and ceiling canopy. Finish same as fixture.

C. Twin-Stem Hangers: Two, 1/2-inch steel tubes with single canopy designed to mount a single fixture. Finish same as fixture.

D. Wires: ASTM A 641/A 641M, Class 3, soft temper, zinc-coated steel, 12 gage.

E. Wires for Humid Spaces: ASTM A 580/A 580M, Composition 302 or 304, annealed stainless steel, 12 gage.

F. Rod Hangers: 3/16-inch minimum diameter, cadmium-plated, threaded steel rod.

G. Hook Hangers: Integrated assembly matched to fixture and line voltage and equipped with threaded attachment, cord, and locking-type plug.

**Part 3 -- EXECUTION**

**3.1 INSTALLATION**

A. Suspended Lighting Fixture Support:

1. Pendants and Rods: Where longer than 48 inches brace to limit swinging.
2. Stem-Mounted, Single-Unit Fixtures: Suspend with twin-stem hangers.
3. Continuous Rows: Use tubing or stem for wiring at one point and tubing or rod for suspension for each unit length of fixture chassis, including one at each end.
4. Is fully supported independent of any suspended ceiling system.

B. Adjust amiable lighting fixtures to provide required light intensities.

C. Connect wiring according to **Section 26 05 19** Low-Voltage Electrical Power Conductors and Cables.

D. Light fixtures located in equipment rooms shall have wire guards if not protected by a lens.

E. All fixtures lamps, ballasts, generators, and drivers shall be readily accessible from underneath the fixture, through the lens, door, open aperture, etc.

F. Provide emergency lights in all restrooms.

G. Provide emergency lights in all mechanical/electrical rooms.

H. Provide emergency lights in all wet bench research laboratories.

I. Provide emergency lights in all clinical/surgical procedure rooms.

J. Provide emergency lights on all loading docks.

K. Provide emergency lights at all roof top HVAC equipment

L. Provide emergency lights in all animal holding areas and support spaces.

M. Facilities with life safety generator (Level 1): connect all emergency egress lighting and exit signs to the life safety generator.

N. Consult with ECU Engineering and Architectural Services and ECU Facilities Services if any locations within the scope of the project may be considered as locations for emergency operations centers and may require additional lighting on emergency power.

**3.2 FIELD QUALITY CONTROL**

A. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery and retransfer to normal.

B. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.

**DIVISION 26 ELECTRICAL**

**SECTION 26 56 00 EXTERIOR LIGHTING**

**PART 1 --GENERAL**

**1.1 SUMMARY**

A. Section Includes:

1. Exterior luminaires with lamps and LED drivers.
2. Poles and accessories.

**1.2 GENERAL**

A. A/E should thoroughly review Appendix F (PDF) ECU Exterior Lighting Master Plan, to insure conformity with all established standards for exterior lighting.

B. Color Temperature: A color temperature of 4000K shall be the basis of design for exterior lighting.

C. Way finding: Way finding signage or pictographs shall be illuminated at night

D. Wall packs may only be utilized in very specific locations. Use of wall pack must be approved in advance

E. Design Light levels (Provide for ECU Engineering and Architectural Services review and approval in the 50% Construction Document Phase or earlier submission):

1. The required light levels can be found in Appendix F (PDF), Table 1: “Illuminance guidelines after dusk”. Otherwise adhere to IESNA recommendations unless noted otherwise below.

2. Design light levels shall be maintained levels.

3. **For parking lot border/perimeter applications:** it is recommended to use a 30-foot to 35- foot high fixture utilizing a single or dual head luminaire where appropriate. Luminaire locations should be well coordinated with landscape planning, accounting for the mature growth of tree canopies.

4. **Primary and Secondary Pedestrian Paths:** For these Paths continue to use the Campus standard 12’ high LED fixture. Evaluate the stature of pedestrian paths through modification of the Campus standard luminaire (different pole base, red marker light on top of pole cap, accent color, etc.), adding a way finding component, luminaire layout modification (luminaires on both sides of paths, symmetrical or staggered), or light level modification. For all paths that are adjacent to buildings, particularly residence halls, it is recommended to orient the luminaires for light distribution away from the buildings to mitigate light trespass. For Paths that are adjacent to plazas, it is recommended to locate the luminaires opposite the plaza, so the path lighting forms an outside boundary that does not compete with plaza lighting.

5. **Stairs and Ramps:** There are various lighting solutions for stairs and ramps across Campus. For safety and ongoing maintenance standpoints, it is recommended to standardize on use of the Campus standard 12’ high pole fixture, with the option for increased pole height where warranted, e.g. at the bottom of longer stairs for adequate coverage. Recommendation should be made to avoid placement of luminaires on extreme slopes or mid-stair runs so they can be maintained from a level surface. Bollards and step lights are not recommended at stair and ramps due to increased maintenance; and poor quality of illumination for viewing pedestrians and surveillance

6. Plazas: The campus standard for plazas is a low brightness, visually comfortable source such an indirect post top. Define lighting for adjacent building and pedestrian zones to enforce uniformity requirements.

7. Bollards are strongly discouraged for path lighting due to potential for glare, lack of usable vertical light on faces and difficulty of maintenance. Where illuminated bollards must be used as a part of a building design, they shall not be the principal means of path illuminance.

8. Use of in-grade fixtures is discouraged. Any considered must be equivalent of IP67 and aimed at objects in a manner that reduces spill light and glare. In-grade fixtures may only be used in hardscape or lawns where mulch and other planting materials will not impede the operation and maintenance of the fixtures. They shall be no more than (within 1/2") above grade to avoid creating a tripping hazard. They shall not be installed at the low-point of adjacent grades where they may become de facto drains.

9. On-grade landscape lighting may be used in planting beds, but not in or near lawns or pathways where they may cause a tripping hazard and complicated lawn maintenance. For durability , on-grade fixtures shall be machined from a solid billet of copper free aluminum, brass or stainless steel and be IP66 rated or higher and be anchored to remain rigid and watertight when kicked or similarly impacted. Basis of Design: BK Artistar Series.

10. Judicious façade lighting is encouraged. Use ASHRAE 90.1.2004 for guidance on maximum lighting power density. LED sources encouraged where life-cycle costs analysis prove payback over the system life. All fixtures shall be IP66 Rated or better.

11. Non-cutoff wall-packs may NOT be used unless lamp is cutoff by a physical structure in a manner that prevents view from normal angles.

12. Unshielded canopy lights my NOT be used. Lights at buildings shall reduce glare by shielding light source from view from pedestrian paths by baffle or other means of control. All building mounted lighting shall be easily accessible for maintenance.

13. Catenary type pedestrian scale lighting may be used if approved as a part of the building design.

14. BUG (Backlight, Uplight, Glare) Rating as defined by IESNA TM-15-07 Addendum A shall not exceed B2-U2-G2 except when mounted near residence halls or perimeter of campus when B0 is required

**1.2 STRUCTURAL ANALYSIS CRITERIA FOR POLE SELECTION**

A. Wind Load: Pressure of wind on pole and luminaire and banners and banner arms, calculated and applied as stated in the North Carolina Building Code. Poles and fixtures assemblies shall meet 145 mph.

**1.3 ACTION SUBMITTALS**

A. Product Data: For each luminaire, pole, and support component, arranged in order of lighting unit designation. Include data on features, accessories, spare parts, and finishes.

B. Provide a fixture sample if directed by ECU Project Manager.

C. Submit photometric calculations superimposed onto the site plan or floor plan for all exterior lighting. The photometric levels shall be legible when plotted to scale. Provide separate photometric calculations for emergency egress lighting.

D. Lighting fixture schedule indicating the fixture manufacturer, catalog number, voltage, input watts, lamp and color identification, mounting, and description shall be included on the electrical documents in a "Fixture Schedule".

**1.4 QUALITY ASSURANCE**

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with IEEE C2, "National Electrical Safety Code".

C. Comply with NFPA 70.

**1.5 WARRANTY**

A. LED fixtures, lighting emitting diodes, and drivers: Manufacturer shall provide five year warranty against defects in materials and workmanship for all products. Manufactures are to provide a letter of warranty to ECU. Project contractor shall replace defective fixtures and components during the first year of warranty without additional compensation from ECU.

B. Warranty period shall begin on date of substantial completion.

**PART 2 --PRODUCTS**

**2.1 MANUFACTURERS**

A. See ECU Master Lighting Plan, Annex F for acceptable Manufacturers and products.

1. Provide electronic (PDF format) cut sheets of proposed fixtures at design development.
2. Provide electronic (PDF format) cut sheets of specified fixtures at 100% Construction Documents.

B. Coordinate with ECU Project Manager for building mounted fixture color. All building mounted and canopy luminaires shall be LED.

C. Prior approval from ECU Engineering and Architectural Services and ECU Facilities Services is required for use of induction lamp luminaires in special applications.

**2.2 GENERAL REQUIREMENTS FOR LUMINAIRES**

A. Luminaires shall comply with UL 1598 and be listed and labeled for installation in wet locations by an NRTL acceptable to authorities having jurisdiction.

B. All exterior light fixtures including building mounted and canopy luminaires shall be full cutoff type, dark sky friendly, to reduce light pollution.

D. Sheet Metal Components: Corrosion-resistant aluminum unless otherwise indicated. Form and support to prevent warping and sagging.

E. Housings: Rigidly formed, weather- and light-tight aluminum enclosures that will not warp, sag, or deform in use.

F. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position. Doors shall be removable for cleaning or replacing lenses.

G. Exposed Hardware Material: Stainless steel.

H. Plastic Parts: High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.

I. Light Shields: Metal baffles, factory installed and field adjustable, arranged to block light distribution to indicated portion of normally illuminated area or field.

J. Lenses and Refractors Gaskets: Use heat- and aging-resistant resilient gaskets to seal and cushion lenses and refractors in luminaire doors.

K. Provide factory mounted in-line surge projection in all exterior roadway fixtures, parking lot fixtures, and pedestrian/sidewalk fixtures. Provide additional surge protector in each pole handhole equal to PQ Protection Series meeting Department of Transportation standards.

L. Factory-Applied Labels: Comply with UL 1598. Include recommended lamps and ballasts, driver or generator. Labels shall be located where they will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place.

**2.4 GENERAL REQUIREMENTS FOR POLES AND SUPPORT COMPONENTS**

A. Structural Characteristics: Comply with North Carolina Building Code.

1. Wind-Load Strength of Poles: Adequate at indicated heights above grade without failure, permanent deflection, or whipping in steady winds of speed indicated in "Structural Analysis Criteria for Pole Selection" Article.

B. Luminaire Attachment Provisions: Comply with luminaire manufacturers' mounting requirements. Use stainless-steel fasteners and mounting bolts unless otherwise indicated.

C. Mountings, Fasteners, and Appurtenances: Corrosion-resistant items compatible with support components.

1. Materials: Shall not cause galvanic action at contact points.

D. Handhole: Oval-shaped, with minimum clear opening of 2-1/2 by 5 inches, with cover secured by stainless-steel captive screws. Provide ground lug with stainless steel screw inside of pole, adjacent to the handhole opening. Center line of handhole shall be 24” above finish grade for all poles. Handhole cover shall be flush to pole.

E. The tops of concrete bases for light poles shall be a minimum of 12”-18” above the surrounding finished grade in order to protect the pole from damage by lawn maintenance equipment. Also, the concrete base shall have a finished exterior.

**2.5 ALUMINUM POLES**

A. Poles: Seamless, extruded structural tube complying with ASTM B 429/B 429M, Alloy 6063T6 with access handhole in pole wall.

1. Shape: Round, tapered.
2. Direct Burial.

B. Pole-Top Tenons: Fabricated to support luminaire or luminaires and brackets indicated, and securely fastened to pole top.

C. Brackets for Luminaires: Detachable, with pole and adapter fittings of cast aluminum. Adapter fitting welded to pole and bracket, and then bolted together with stainless-steel bolts.

E. Poles Delivered to Site:

1. Unwrap protective covering immediately and store so not to damage finish.
2. Schedule inspection with ECU Project Manager to ensure protective wrapping has been removed and the pole finish is acceptable to ECU.

F. ECU standard poles: Substitution requires pre-approval from ECU Project Manager prior to design.

1. Roadway and Parking Lot Poles: Fixture mounting heights, 30’ above finish grade. Valmont Structures 290845806TEA-45RPTSC, or preapproved equal. Fixture Truss Arm shall be 1TA0832BSBF 8’ arm.
2. Post Top Pedestrian Lights Pole: Fixture mounting heights, top of pole 9’-8” to 10’-0” above finish grade. Valmont Structures 1108 30404TE TENON DNA, or preapproved equal.
3. Burial (embedded) depths shall be as required by manufacturer to meet wind load requirement. Provide protective coating (Bitumastic) from pole bottom to line indicated for the embedded depth. The pole shall not be embedded no lower than the protective coating. If pole is embedded beyond this line, the contractor shall replace pole at no additional compensation from ECU.

**PART 3 --EXECUTION**

**3.1 LUMINAIRE INSTALLATION**

A. Install lamps in each luminaire.

B. Provide final aiming and focusing of luminaires that require field adjustment or aiming under the direction of ECU Project Manager. Aiming and focusing luminaires shall be performed during non-daylight hours.

C. Provide adjustment of photoelectric device to prevent false operation of relay by artificial light sources, favoring a north orientation.

**3.2 POLE INSTALLATION** (Site Lighting - Pedestrian Light Poles, Roadway Light Poles, Parking Lot Light Poles, etc.)

A. Alignment: Align poles for optimum directional alignment of luminaires and their mounting provisions on the pole.

B. Coordinate all pole locations with ECU Project Manager prior to installation. All pole locations shall be staked for ECU review and approval prior to excavating. Failure to verify proposed pole locations prior to excavating, the contractor shall bear all costs to relocate raceways, handholes, and poles as directed by ECU. Maintain the following minimum horizontal distances from surface and underground features:

1. Fire Hydrants – 7'-6".
2. Water, Gas, Electric, Communication, and Sewer Lines: 5'.
3. Trees: 5' feet from anticipated mature tree drip line.
4. All roadway and parking lot light poles shall be located 4' from edge of parking or roadway curb to face of pole.
5. All sidewalk light poles shall be located 3' from edge of sidewalk to face of pole.

C. Embedded Poles with Tamped Earth Backfill: Set poles to depth below finished grade indicated by the manufacturer to meet the wind load requirements.

1. Dig holes large enough to permit use of tampers in the full depth of hole.
2. Backfill in 6-inch layers and thoroughly tamp each layer so compaction of backfill is equal to or greater than that of undisturbed earth.
3. Contractor shall re-tamp grade around pole 30 days after installation. Provide required fill and sod.

D. Raise and set poles using web fabric slings (not chain or cable).

E. Provide an in-ground handhole within 3' of each light pole for branch wiring connection to light pole. Minimum distance from pole shall be 1'-6", but no closer that will affect the wind load rating for the pole assembly installation; consult with pole manufacturer performing the wind load structural analysis. In-ground handhole shall be located behind the pole, opposite of the sidewalk or roadway. The pole handhole shall face the in-ground handhole. "Electrical" label on in-ground handhole cover shall face the sidewalk or roadway. These may not be shown on plan view, but they are implied by the pole location.

F. Branch wiring connection to light pole (between in-ground handhole and pole handhole) shall be 2 #10, 1 #10 equipment ground, and 1 #8 bare ground (bond between driven ground rod and pole ground lug) in 1" non-metallic flexible conduit.

G. Connection to luminaires shall be #10 and #10 equipment ground. Provide slack at luminaire to allow removal from pole or mounting arm without disconnecting conductors and ground.

H. Electrical connections in in-ground handholes shall be weatherproof closures UL listed for the application.

I. Provide identification tag on each light pole as directed by ECU Project Manager and ECU Facilities Services Department. Tag shall read top to bottom and face the roadway, parking lot, or sidewalk as directed by ECU Project Manager and ECU Facilities Services Department. The top of the tag shall be located 10' above finish grade for roadway and parking lot poles and 8'-6" for pedestrian/sidewalk poles. The tags shall be Panduit nominal 3" x 1-3/4" with black background and yellow reflective numbers: Panduit PRL250YB-1 with appropriate letter and number.

**3.3 GROUND MOUNTED LUMINAIRES**

A. All landscape up lighting, building floodlighting, sign lighting, and flag up lighting shall be LED type floodlight mounted on concrete base.

B. Install on concrete base with top of concrete 6" above finish grade. Cast conduit or support into base, and finish by troweling and rubbing smooth.

C. Concrete base diameter shall provide protection for the luminaire from lawn equipment, but in no case be smaller than 18" diameter, or less than 6" from furthest end of luminaire.

D. Must be located inside a plant bed to protect from mowing activities.

**3.4 GROUNDING**

A. Ground metal poles and support structures according to Division 26 Section "Grounding and Bonding for Electrical Systems".

1. Install grounding electrode for each pole in pole handhole.
2. Provide #8 bare copper ground from grounding electrode to ground lug in pole. Bond the equipment grounds and pole ground to the driven grounding electrode via Acorn type connector. Ground pole to driven grounding electrode with #8 bare copper, looped through the Acorn connector at the electrode and connect to #6 and #10 equipment grounds in the in-ground handhole.

**3.5 ECU EMERGENCY PHONES BLUE LIGHTS**

A. The emergency safety light and phone towers (Blue Lights) shall be “Talk-a-phone” Model ETPMT/R OP PCS, equipped with GSM cellular option and power option. Pole tower shall be painted ECU standard color ??? with reflective white lettering. Coordinate with ECU Project Manager and ECU Facilities Services for most current specification.

1. Talk-A-Phone ETP-MT/R OP PCS: Tower mount for wireless and switched power.
2. Talk-A-Phone ETP-400V: Hands Free Help Phone.
3. Talk-A-Phone ETP-CI/GSM: GSM Cellular Phone.
4. Talk-A-Phone PCS-1: Power charging system for switched power.
5. Talk-A-Phone PCS-SD-480: Transformer 480/240 VAC to 120 VAC.
6. Talk-A-Phone PCS-SD-277: Transformer 277 VAC to 24 VAC for PCS-1.
7. Talk-A-Phone Blue Light shall be LED.

B. Provide concrete base per manufacturer installation instructions.

C. Blue Lights located away from buildings shall be connected to the nearest roadway branch circuit. Provide step down transformer in the tower base.

D. Blue Lights located in building parking lots or near buildings shall be connected to a dedicated 120 Volt branch circuit on emergency power from the building. Provide a lock-on handle on the branch circuit breaker.

E. Coordinate Blue Lights locations with ECU Project Manager, ECU Facilities Services Department, and ECU University Police prior to conduit rough-in.

**3.6 EXTERIOR POLE MOUNTED LIGHTING CONTROL**

A. Locate on interior of building as directed by ECU Project Manager and ECU Facilities Services Department.

B. Provide backboard in enclosure for mounting equipment. Backboard shall be manufactured with fire resistant materials.

C. Provide single pole circuit breaker for local means to disconnect power.

D. Locate contactor on inside of a building.

E. Provide on/off/auto selector switch for lighting contactor override control. Selector switch shall be located inside the enclosure, lower left hand corner. Selector switch shall not be integral to the lighting contactor and shall not be able to be controlled by the public while the enclosure is closed. Label the selector switch control positions: ON / OFF / AUTO.

F. Provide photocell for lighting control. Face photocell away from light sources. Locate photocell such that is accessible from a working surface and does not require ladders or aerial lift to inspect or maintain.

G. All branch circuits serving exterior lighting shall have a dedicate neutral, no sharing of neutral conductors.

H. Provide the same exterior lighting control apparatus listed in above 3.6 A thru G for the emergency egress pole mounted lighting. Emergency egress lighting branch circuit breaker can be sized to the load, but no smaller

than 30 amperes. All items on the load side of the contactor shall meet ECU site lighting standards, such as single phase branch circuit, minimum conductor size #6 AWG, and minimum conduit size 1-1/2". The emergency lighting branch circuit, circuit breaker, and contactor can be located in the same enclosure as the normal exterior lighting branch circuit apparatus provided there is a separation barrier and there is NEC code required space in the enclosure. Contractor shall provide layout for ECU approval prior to ordering, include in project submittals.

END OF SECTION 26 56 00

END OF DIVISION 26