PART 1: GENERAL

1.01 SYSTEM DESCRIPTION

A. Most new loads will be served from the underground electric distribution system. This system is a primary selective open loop configuration served by a resistance grounded Delta source operating at 13.2 kV. Primary distribution switchgear and overcurrent devices shall be designed for 750 MVA/25kA of available fault current. It is important to note that bushings, insulators, and arrestors must be rated for a full 15kV to ground, not the 8 kV typical of a grounded Wye system.

1.02 SUBMITTALS

A. Products described in this section shall be submitted for review to Cornell University’s Electrical Utility Engineer before ordering equipment.

PART 2: PRODUCTS

2.01 MEDIUM VOLTAGE CABLE

A. 13.2 kV System:
   1. Single conductor.
   2. Copper conductor, compact stranded, standard sizes: #2/0, 350 kcmil, 500 kcmil, 750 kcmil.
   3. 15 kV EPR insulation, 220-mil (133%), 105 degrees C.
   4. Extruded conductor screen and insulation screen.
   5. Copper tape insulation shield, 5-mil.
   6. PVC jacket, 80-mil minimum, rated for cable tray use.
   7. Acceptable manufacturers: Okonite, General Cable, Southwire, Prysmian.

B. 2.4 kV System:
   1. Single conductor.
   2. Copper conductor, standard sizes: #2, 350 kcmil.
   3. 5 kV EPR insulation, 115-mil minimum (133%), 105 degrees C.
   4. Extruded conductor screen and insulation screen.
   5. Copper tape insulation shield, 5-mil.
   6. PVC jacket, 80-mil minimum, rated for cable tray use.
      NOTE: As existing 2.4kV cable is replaced it shall be replaced with 15kV cable as specified in section 2.01.A.
   7. Acceptable manufacturers: Okonite, General Cable, Southwire, Prysmian.
2.02 Cable Terminations

A. Splicing: 3M, Raychem, or INERTIA-REPL splice kits.

B. Dead break elbows: Elastimold, 15 kV, 600 series elbow with test point and tape shield adapter.

C. Air Terminations:
   • Elastimold, 15 kV, outdoor rated, R2T28 series with tape shield adapter.
   • 3M, 15kV, 7690-S series, 4-skirt, with tape shield adapter.
   • Raychem TFTR with or without sheds for indoor/outdoor.

D. Arc Flash Tape:
   1. 3M Scotch tape 77W is approved for use. Arc flash tape shall be used in the vicinity of adjacent circuits per mfg. recommendations.

2.03 DUCT BANKS

A. No less than two 5" schedule 40 PVC ducts per duct bank.

B. The duct bank shall be encased in reinforced concrete with a minimum 3" cover over any ferrous material and full encapsulation of the PVC duct with a minimum of 4" cover on all sides. Where duct banks pass under heavy traffic areas a structural design review shall be made prior to release for installation. Compacted fill to support the duct bank or clean stone to aid drainage must be evaluated by the Engineer of Record.

C. A minimum of five feet of clearance shall be maintained from steam and condensate lines where parallel runs exist. For 90 degree crossings, thermal breaks must be utilized. Duct bank concrete shall not encapsulate other utilities.

D. The Contractor shall verify duct bank continuity by pulling a mandrel ½" smaller than the conduit internal diameter (ID) through each duct immediately after placing concrete and prior to pulling cable in. The contractor installing cable is responsible for verifying continuity in pre-existing duct banks.

E. Plastic bell ends and plugs shall be used in the manhole and building.

F. Install a 3/16" diameter nylon fish in all ducts.

G. Minimum 48" bending radius required. Bend radius, total degrees of bend and pulling tension shall be calculated by the consultant and provided to the owner representative for review; 90 degree bends shall be avoided where possible.
H. Ductbank entrances to buildings and vaults shall be centered on (and within) the wall and sealed with water stop such as Volclay or equivalent. Provide waterproofing at duct to wall transition as shown in Cornell Standard Detail 4.2.13 – Typical Section at Precast Tunnel to Vault Wall Connection. Control joints, if required, shall be determined by the Engineer of Record.

2.04 MANHOLES

A. Ductbank entrances to manholes shall be centered on (and within) the wall and sealed with water stop such as Volclay or equivalent. Provide waterproofing at duct to wall transition as shown in Cornell Standard Detail 4.2.13.

B. Pulling irons shall be located on the opposite wall and one foot below the horizontal projection of the lowest duct for each duct bank entering the manhole.

C. A manhole ground lug shall be connected to two driven 8' electrodes in corners of the manhole.

D. All manhole penetrations shall be sealed and watertight. Manholes installed in roadways and sidewalks where salt is applied shall have additional external waterproof wrap applied, as approved by the Engineer of Record.

E. The manhole shall have an effective gravity drain with a minimum 3” diameter pipe protected by a trash screen with ½” holes. The screen shall have an effective surface area greater than two times the pipe diameter.

F. Utilize a 36" non-vented round manhole hinged cover and drop ring with elastomer gasket (Pamrex or equal). Other sizes and manufacturers will be evaluated for specific applications. Cover shall be centered in manhole to maximize use of cable racks.

G. Fiberglass cable racking shall be provided within manholes for securing cable. Cable within manholes shall be wrapped with high voltage fire retardant wrapping material.

H. The minimum size is: 8' Long x 6' Wide x 7' High. Larger manholes may be required at the discretion of the Cornell Energy and Sustainability Department.

I. Vaults shall be rated AASHTO H25.

2.05 PRIMARY SWITCHGEAR AND TRANSFORMERS

A. MEDIUM VOLTAGE NETWORK (LOOP) SWITCH

1. Taps into the building 13.2 kV distribution system are accomplished using pad-mounted or vault-mounted medium voltage distribution network switches. In applications where a convenient tap-in point is not available, a medium
A voltage distribution network switch is required. The switch requires two switched-ways for the incoming and outgoing loop feeders, one switched-way for the building load, and at least one spare switched-way. Engineer of Record will be responsible for determining if a fused-way or fault interrupter-way will be required for the application. Distribution network switchgear is not permitted to be located in manholes. Rooms containing distribution network switches shall have emergency lighting and power.

2. Review switch location electrically and geographically within the distribution system for application of advanced features and functionality, such as self-healing and remote operability and monitoring. Consult with Cornell Energy and Sustainability for design direction.

3. Where required by Cornell Energy and Sustainability, the medium voltage network switch shall be provided with Modbus/TCP communications capability and the design shall include providing communications hardware and wiring to the network switch room to interconnect the network switch with the campus SCADA system for remote monitoring and/or operation of the switch.

4. The engineer shall specify Deadbreak Insulated Caps (with test point and stud) for all spare switchways.

5. Interior Vault-Style SF6 Insulated Switch Ratings:
   a. Voltage: 15.5 kV
   b. Continuous Current & Loadbreak: 600 amps
   c. BIL: 95 kV
   d. One Second Symmetrical Withstand: 25,000 amps
   e. Operations at 600 amps: 1,000 minimum
   f. Bushings: 600 amp apparatus
   g. Acceptable manufacturers: G&W RAM style switch or S&C Vista style switch.
   h. Dead front

6. Exterior Pad-mounted SF6 Insulated Switch Ratings:
   a. Voltage: 15.5 kV
   b. Continuous Current & Loadbreak: 600 amps
   c. BIL: 95 kV
   d. One Second Withstand: 25,000 amps minimum
   e. Enclosure: cold rolled steel with gasket and padlock provisions
   f. Acceptable Manufacturers: G&W Ram style or S&C Vista Switch
   g. Dead front

7. Exterior Pad-mounted Air Insulated Switch Ratings:
   a. Voltage: 14.4 kV
   b. Continuous Current & Loadbreak: 600 amps
c. BIL: 95 kV

d. One Second Withstand: 25,000 amps minimum

e. Acceptable Manufacturers: S&C PME with mini-rupter switch

f. Dead front

8. Exterior pad-mounted switches shall be installed on concrete pads. Pads shall be designed with a concrete box under the pad to provide a minimum of 36" of exposed cable under the primary bushing. A grounding grid shall be installed around the perimeter of the pad. The grounding grid shall be comprised of 4/0 AWG bare copper conductor buried one foot deep. The grid shall be bonded to a minimum of two driven 5/8” x 8’ copperweld grounding electrodes evenly spaced a minimum of 6 feet apart along the grid. The pad-mounted switch shall be grounded to the grounding grid using 4/0 AWG copper conductor. Spare conduit entryways shall be plugged to prevent entry of rodents.

B. TRANSFORMERS

1. Dry-type transformers (for interior applications):

   a. Rooms must be accessible from both inside and outside of the building. The outside entrance must be large enough to allow installation and removal of the primary switchgear, transformer, and secondary switchgear. Dry-transformer unit substations (close coupled) are preferred over separate equipment. Transformer rooms shall be ventilated to the outside and shall have emergency lighting and power.

   b. Medium voltage 13.2kV transformers shall carry a minimum primary BIL of 95 kV.

   c. A temperature rise of 80 deg. C is preferred. Temperature rise of 115 deg. C is acceptable only in areas with dedicated outside ventilation ducting. Transformer design sizing based on forced-air ratings is permitted; 150 deg. C rise is not acceptable.

   d. Minimum efficiency shall meet DOE 2016 energy efficiency regulations.

   e. Acceptable Manufacturers: MGM, Federal Pacific, GE, Square D

2. Pad-mounted Transformers (for outdoor applications):

   a. New outdoor locations must be approved by the Campus Planning Office.

   b. Pad-mount transformers shall be FR3 Envirottemp or E200 fluid-filled. Factory Mutual (FM) approved transformers may also be required in
locations near buildings or other outdoor equipment. Contact Cornell Facilities Engineering for Guidance.

c. Concrete pads shall be designed with a concrete box under the pad to provide a minimum of 36” of exposed cable under the primary bushing. A grounding grid shall be installed around the perimeter of the pad. The grounding grid shall be comprised of 4/0 AWG bare copper conductor buried one foot deep. The grid shall be bonded to a minimum of two driven 5/8” x 8’ copperweld grounding electrodes evenly spaced a minimum of 6 feet apart along the grid. The pad-mounted transformer shall be grounded to the grounding grid using 4/0 AWG copper conductor.

d. Transformer primary over-current protection shall consist of drywell, Bay-o-net fuses in series with under-oil current limiting fuses on transformers 500 kVA and smaller. A complete set of spare fuses shall be supplied. Vacuum interrupters shall be used with transformers 750 kVA and larger.

e. Primary load-break switch to be integral with transformer tank.

f. Primary loop configured bushings shall consist of 600 amp dead-break bushings with a minimum 15 kV single phase to ground rating.

g. Primary and secondary compartments shall be separated by a steel bulkhead.

h. Temperature rise shall be 55/65 deg. C.

i. Minimum efficiency shall meet DOE 2016 energy efficiency regulations.

j. Preferred manufacturer: Cooper Power or Owner approved equivalent.

3. All transformers shall be protected with dead-break style surge arresters. Arrester rating shall be 18 kV rated, 15.5 kV MCOV for the 13.2 kV system. Arrestors may be placed on primary bushings where appropriate.

4. All transformers shall be sized in accordance with Paragraph 2.05F. of Cornell Standard 262413 - Service and Main Secondary Distribution.

C. PRIMARY OVERCURRENT PROTECTION

1. The primary switchgear protecting an indoor transformer bank shall consist of a fused, air-insulated, load-break switch. The fuses and fuse holders shall be S&C SM-5S. One set of spare power fuses shall be provided.

2. Engineer of Record to determine if vacuum fault interrupter is required to provide adequate protective coordination and meet acceptable arc flash hazard
category levels as outlined in Cornell Standard 262413 – Service and Main Secondary Distribution.


D. METERING

1. Metering for MV distribution substations shall consist of panelboard style, revenue grade digital power meter/analyzer with the following requirements.
   a. Measurements: True RMS 3-phase voltage, current and power, harmonics, K-factor, symmetrical components, and sag/swell data.
   b. Communications: DNP 3.0 protocols, Ethernet ports, GPS synchronized meter clock, and remote alarm notification; Allen Bradley PM 5000 M5 with Ethernet on feeder breakers and PM 5000 M6 with Ethernet shall be used on main breakers.
   c. Data Logging: Sequence of events and min/max logging, scheduled event-driven logging of up to 32 parameters concurrently on-board data logging features.
   d. Set Points: Set point on any parameter or condition for 1 second.
   e. Outputs: Serial port communications connection.
   f. Security: Multi-user, multilevel security, customizable up to 16 users with multiple levels of access.
   g. Acceptable manufacturers: Allen Bradley PM 5000.

2. Instrument transformers used for metering shall meet ANSI accuracy class 0.6 or better.

E. GROUNDING

1. A continuous grounding system shall be provided for grounding of primary cable shields, switchgear and transformer frames, and transformer secondary neutrals. The grounding system shall meet the requirements of the NEC Article 250.

2. A minimum #2/0 grounding conductor shall be installed in each MV cable conduit with each MV cable circuit.
PART 3: EXECUTION

3.01 INSTALLATION

A. All medium voltage cable pulling, splicing, and terminating for building services shall be done in accordance with the cable manufacturer’s guidelines. Hi Pot tests shall be performed in accordance with IEEE standard 400. Cable pulling plan, pulling tensions and linear feet of pull must be recorded.

B. Cable that is pulled in and not terminated within 24 hours must have adequate end protection and be sealed from the elements with approved MV tape, shrink tube or similar product intended for that use.

C. Construction documents shall reflect the following demarcation between Contractor and Cornell FM Shops/Line Department performed work for electrical work performed on the Ithaca Campus medium voltage system. For Cornell owned/managed locations outside of the Ithaca Campus, contact Cornell Facilities Engineering for guidance:

1. Operation of Switching Equipment:
   a. Contractors shall not operate medium voltage circuit breakers, distribution switches, and other switching equipment except to de-energize a circuit in the event of an emergency. Cornell linemen will perform all live switching operations.

2. Work on New Systems:
   a. Contractors may perform all necessary work on new systems installed by the Contractor, without the necessity for supervision or assistance of Cornell personnel. The Contractor is expected to follow standard de-energizing, locking-out, testing, grounding, and tagging procedures before handling any medium or low voltage equipment. Any connection to existing equipment shall require the contractor and Cornell personnel to adhere to the following procedure. Once a system has been energized and put into service, it shall be considered to be “existing equipment.”

3. Work on Existing Systems:
   a. Any time a Contractor must make a connection to or work on an existing system, the following procedures shall be used to ensure the safety of all personnel involved:

       1) Cornell linemen will operate all switching equipment as required to de-energize a circuit in preparation for work. A representative of the
Contractor shall be present during all switching and both the Contractor’s electrician and a Cornell lineman shall install locks on all switches as required to prevent accidental switch operation. Each switch shall be tagged to inform others of the work being done. **Manhole switches are never operated with personnel in the manhole;** Cornell linemen shall use remote switching devices.

2) Cornell lineman will test a circuit to ensure that it is “dead” before any contact is made with the circuit. After testing, grounds will be installed by Cornell linemen to ensure the circuit remains dead and cannot become energized. The Contractor may also install grounding equipment.

3) A Contractor shall not work on any existing cable without first having a Cornell lineman verify that the correct cable has been selected and the cable is de-energized. **Cornell linemen will make the first cut into any existing cable system prior to Contractor splicing or terminating.** This is to ensure that the Contractor does not select and cut into an energized cable. Cornell linemen will perform the switching, locking, tagging, and testing procedure before cutting into the cable and grounding each phase. The Contractor may then proceed with work.

D. Exceptions to this standard need to be approved by Cornell Facilities Engineering and Cornell Energy & Sustainability.

### 3.02 ELECTRICAL WORKER QUALIFICATIONS

#### A. CONSTRUCTION DOCUMENTS & SUBMITTAL REQUIREMENTS

1. The construction documents shall require the Contractor to provide, as a submittal, a list of all Medium Voltage Electricians, Test Technicians, and Protection Relay Technicians that will be working on the project, including their level of training and related certifications.

2. Only Electrical Workers with the experience, training and certifications described in the following paragraphs of this standard will be permitted to work on Cornell electrical systems over 600 volts.

#### B. PERSONNEL QUALIFICATION REQUIREMENTS:

1. MV Electrical Safety Manager
   a. Must be trained and certified in MV safety management.
   b. Must implement and monitor a structured company site specific Safety Program.
   c. The safety program must be focused on medium voltage construction and
maintenance, including regularly scheduled and documented training for electrical workers.

2. All Electrical Workers
   a. Must be trained and have PPE on-site to meet NFPA70E requirements, for the voltage and skill level for projects to which they are assigned.
   b. Must have successfully completed a minimum of OSHA 10 Hour Occupational Safety and Health Training.

3. MV Electricians
   a. Contractor shall provide a list of MV electricians that will be assigned to the project, including the individual’s training level and certifications. Specific training, experience and/or certifications shall include the following:
      i. Certified training and progression achieved through an in-house or industry recognized medium voltage training and progression program (Formal industry recognized medium voltage line, substation, or underground construction and maintenance certification programs as offered by NALTC, AVO, IBEW/NECA, or equal; or similar Electrical Utility or Linemen’s Local IBEW lineman and/or UC&M Apprentice and Progression Programs.)

4. Test Technicians Requirements
   a. Contractor shall provide a list of Test Technicians that will be assigned to the project, including the individual’s training and certification levels. Specific training, experience and/or certifications shall include the following:
      i. Certified training and progression achieved through an in-house or industry recognized relay test technician training and progression program (Formal industry recognized programs as offered by AVO, IBEW/NECA, or equal; or similar Electrical Utility IBEW Field Test Technicians Training and Progression Program or similar International IBEW recognized Specialty Training Progression Program.)

5. Protection Relay Technicians Requirements
   a. Contractor shall provide a list of Protection Relay Technicians that will be assigned to the project, including the individual’s training and certification level. Specific training, experience and/or certifications shall include the following:
      i. Certified training and progression achieved through an in-house or industry recognized relay test technician training and progression program (Formal industry recognized programs as offered by AVO, IBEW/NECA or equal; or similar Electrical Utility IBEW System...
3.03 TESTING AND COMMISSIONING

A. The Engineer of Record shall specify that the contractor is responsible for adjusting network switch relay settings in compliance with the Engineer of Record’s equipment coordination study. Engineer shall verify settings during punchlist walkthrough.

B. A third party commissioning agent shall verify the actual field electrical settings to be in accordance with the approved settings.

C. Testing deliverables as follows:
   1. Hi-Pot Test (New Installation Acceptance Test): New Medium Voltage Cable
   2. Megger Test (Maintenance Test): Existing Medium Voltage Cable, new service transformers.
   3. Functional Tests (current injection test): Vacuum Interrupter
   4. Metering verification: Verify correct CT ratio.
   5. Testing to be witnessed by a qualified owner’s representative.

3.04 ARC FLASH LABELING

A. The Engineer of Record shall perform an arc flash incident energy exposure hazard analysis. The Engineer of Record shall provide the arc flash incident energy exposure data to Cornell in printed spreadsheet format. The data shall include the switch name, building room number, date arc flash analysis was conducted, upstream protective device, consultant’s (company) name, flash hazard boundary (inches), arc flash incident energy (cal/cm²) at 18”, voltage, glove class, Limited Approach (inches), and Restricted Approach (inches).

B. The Engineer of Record shall provide and apply the arc flash hazard labels to the equipment. The labels shall include all of the information noted in Paragraph 3.04A above. Labels shall have “DANGER” printed along the upper margin if the calculated arc flash incident energy exceeds 40 cal/cm² at 18” and shall have “WARNING” printed along the upper margin if the incident energy is 40 cal/cm² or below at 18”. If the equipment submitted is different than the basis of design equipment specified by the Engineer of Record, the Engineer of Record shall be responsible for updating the study, providing, and applying the arc flash labels to the equipment.