DIVISION 16 - ELECTRICAL

16020 - BASIC ELECTRICAL REQUIREMENTS

1. Intent: Provide electrical design, construction documents and record documents adequate for operations and future modifications.

2. Electrical Drawings

2.1. Demolition and construction drawings shall be depicted separately.

2.2. Show conduit sizes and routings, along with number and sizes of conductors for feeders and home runs and complicated circuitry. State that any modifications to the number, size and type of wires or conduits from those indicated is prohibited.

2.3. Show circuit lighting and power outlets on the drawings and identify the panel terminal point for each circuit. Identify load locations and/or room numbers on panelboard schedules.

2.4. Indicate on the drawings and size special system raceways and wiring, including voice/data, either on the floor plans or on a riser diagram. Describe or schedule cable types.

2.5. Provide a schematic wiring diagram of power and lighting-related control circuits on the construction drawings. Identify electrical and mechanical devices.

2.6. Provide power distribution one line diagram from the service primary switchgear through the distribution panelboards and major loads, including fire pump and metering.

2.7. Provide a riser diagram for each system covered under Division 16. Identify location and/or room numbers for components.

2.8. Show electrical schedules for panelboards, distribution boards, motors, control centers and related items on the drawings (not in the specifications).

2.9. Define responsibility and coordination of work between the contractor and the equipment supplier. State that rough-in locations and requirements be verified with the equipment supplier's shop drawings prior to installation of the wiring system.

2.10. Identify provisions for intended additions or modifications in the future.

3. Electrical Reference Symbols

3.1. Use industry standard symbols for medium-voltage, temperature-control and fire alarm drawings.

3.2. Define symbols in a legend on the drawings.

4. Electrical Test Data

4.1. Specify the operational tests and test methods required for the following equipment and materials:

A. Primary cable and equipment
B. Engine-generators and emergency power system
C. Auditorium sound systems
D. Television antenna and systems
E. Fire alarm systems
F. Lightning protective systems
G. Transformers
H. Ground fault protective systems
I. Secondary service conductors/bus duct
J. Security systems
K. Satellite systems

4.2. The contractor shall furnish all instruments, labor, communication devices and expertise needed for conducting and recording tests.

4.3. The contractor shall furnish a copy of certification and test results to the university.

4.4. The A/E shall review and accept the test results.

4.5. Specify that tests on electrical service equipment and material be completed. The A/E shall review and accept the test results at least one week before the contractor's request for the first electrical outage and/or switching to the university.

5. Demonstration of Electrical Systems

5.1. The contractor shall test and supervise the initial operation of all equipment and special systems. The contractor shall demonstrate the equipment and special systems to university personnel, and instruct university personnel in operation and maintenance.

5.2. Refer to Division 1, Section 01650 - Commissioning and Section 16303 - Electric Utility Commissioning.

6. Identification

6.1. All switching, protective devices, and metering on main distribution switchboards shall be identified with black-white-black laminated 1/8-inch thick plastic plates. Plastic plates shall be attached to the equipment with screws, rivets or appropriate adhesives.

6.2. Identification plates are required for all electrical distribution equipment from the service through branch circuit panelboards and motor control centers. Labels shall identify the equipment designation, operating voltage, and the source supplying the equipment.

6.3. The A/E shall specify numbering and wording of identification plates.

6.4. Motor and associated equipment numbers shall be the same.

7. Electrical Equipment Locations

7.1. PROHIBITED: Installing electrical distribution equipment in stairwells, corridors or other occupied space of a building.

7.2. PROHIBITED: Locating plumbing facilities above the electric vault or switchboard room.

7.3. Locate electrical distribution equipment in dedicated electrical closets, electrical rooms or mechanical equipment rooms.

7.4. Exclude piping, ductwork and other systems that are not compatible with the electrical installation from the entire interior of electrical closets and electrical rooms.

7.5. Equipment and raceways in such rooms shall be mounted or suspended in a manner that will prevent excessive noise and vibrations in adjacent spaces.

7.6. Exclude raceways and electrical equipment from ducts, plenums, areaways and tunnels unless required by their function to be located there.

8. Special Building Requirements: The design for buildings that house sensitive laboratory or data processing equipment shall clearly address the power quality requirements for the equipment.

16050 - BASIC ELECTRICAL MATERIALS AND METHODS

1. PROHIBITED: Direct-buried conductor systems for underground wiring because of protection and space congestion.

2. PROHIBITED: Lead, fiber or wood anchors that support raceways or equipment.

3. PROHIBITED: Power distribution cables in open raceways or cable trays, except medium-voltage cables in electric vaults.

4. Basic Minimum Requirements

4.1. Electrical work in architecturally finished spaces shall be concealed or installed in approved surface raceway systems where concealment is not possible.

4.2. Provide nominal 4-inch-high concrete housekeeping pads for floor-mounted equipment. Pads shall extend 2 inches to 4 inches horizontally beyond equipment.

5. Cleaning

5.1. Require exterior and interior surfaces of electrical equipment enclosures be wiped or cleaned with a vacuum two weeks before scheduled use, and again immediately prior to final completion.

5.2. Accessible elements of disconnecting and protective equipment items shall be cleaned with a vacuum before energizing.

5.3. Scratches on painted surfaces shall be touched up with paint of equivalent quality and matching color.

6. Fire-stopping

6.1. Identify and provide installation practices for fire-stopping materials associated with the construction materials. Include details of fire-stop systems. List specific UL or other approved test assembly numbers.

6.2. Use removable fire-stopping pillows for cable tray penetration fire-stop.

16060 - GROUNDING AND BONDING

1. General

1.1. Grounding systems shall not be specified solely by conformance with the NEC. The systems shall be fully designed, specified and shown on the drawings. Include a one-line diagram of the facility grounding system on the drawings.

1.2. Specify types of attachment or connection such as cable to cable, flat metal, pipes, conduits, and to boxes or enclosures.

1.3. Specify individual system grounding with single point grounding to eliminate ground current flow. The grounding shall be independent from the building

interior electrical system for electron microscopes, instrument laboratories, data and communication rooms, lightning protection and radio frequency shielded rooms, but shall eventually tie into the building electrical grounding system in compliance with codes.

1.4. The design shall ensure adequate grounding of generator neutrals, shielded isolation transformers, and regulation transformers as required for separately derived systems.

1.5. All grounding system components shall be copper. All connections shall be UL listed and exothermic welded or use compression connectors qualified to IEEE Standard 837. Standard mechanical connectors shall not be used.

1.6. Bond the ground grid to the reinforcing steel or building structural steel at maximum 50-foot intervals.

1.7. Provide an exposed ground bus with minimum dimensions of 6 feet long by 4 inches wide by 1/4-inch thick. Mount the bus on standoff insulators 18 inches above the floor of the electrical equipment room with a direct tap connection from the ground grid. This tap provides ground connection for separately derived systems and miscellaneous equipment.

1.8. The commissioning authority shall inspect the completed ground grid system prior to back-filling and testing ground resistance as noted on the specifications. Inspection also should be done prior to connecting the ground grid system to existing ground systems or grounded piping systems.

1.9. Surface raceway systems shall incorporate a separate grounding conductor, integrally connected to all devices, the raceway and building ground system.

2. Medium Voltage Installations

2.1. Contract documents shall include a fully designed, detailed and specified grounding system for electrical services and primary equipment electrical rooms. Specification only by reference to NEC or other code requirements is not acceptable. Include a single-line diagram of the grounding system in the contract documents.

2.2. Provide a buried or embedded ground grid system under all primary voltage electrical equipment rooms. The system shall have bonding connections to the building perimeter ground loop, lightning protection ground system and other building ground systems. The minimum size of ground grid and tap conductors is #4/0 AWG.

2.3. Provide a direct tap connection from the ground grid through the floor and equipment pad to the equipment ground bus for all equipment operating at primary voltage.

2.4. Provide an insulated (600-volt) equipment-grounding conductor in all raceways with medium-voltage conductors. The size of the grounding conductor shall match the size of the phase conductor (except the grounding conductor shall not be required to exceed 250 kcmil). Bond grounding conductor to equipment ground bus at all termination points of circuit.

2.5. Where outdoor primary voltage equipment is installed, include a grounding system designed to limit step and touch potentials per IEEE Standard 80 - Guide for Safety in AC Substation Grounding.

2.6. Refer to Section 16304 - Medium Voltage Distribution for grounding in electrical manholes.

16120 - WIRES AND CABLES

1. PROHIBITED: Aluminum wires.

2. PROHIBITED: Solid conductors for lighting and power circuits.

3. The minimum size of conductors for lighting and power circuits is No.12 AWG.

4. Wires shall not be drawn into conduit until plastering and tile work are complete and conduit has been thoroughly swabbed out.

5. Any conductors installed in flexible conduit at terminal connections of rotating, vibrating or moveable equipment shall be of stranded wire.

6. 600-volt conductor insulation shall be rated 75 degrees C minimum temperature rating.

7. Neutral conductor capacity shall be increased as necessary for harmonics.

8. Conductors for street lighting installed in PVC or rigid conduit underground and outdoors shall have type USE insulation on conductors. Other popular insulation has resulted in shorter service life.

16121 - MEDIUM VOLTAGE POWER CABLES - ELECTRIC UTILITY

1. General

1.1. The contractor shall furnish and install the primary cable between the first medium-voltage load interrupter switchgear and medium voltage transformers.

1.2. The standard cable size that is used by the university for this purpose is #2/0 AWG. The A/E shall select the appropriate cable size based on load current and short circuit current thermal damage criteria.

1.3. The location of all medium-voltage cable terminators and stress cones shall be indicated on the distribution system one-line diagram.

1.4. Pulling tension calculations shall be included in Operations and Maintenance (O and M) manuals for primary conduits and ductbank spans routed within and through buildings. Proper pulling sheaves shall be used to prevent the cable from bending less than vendor specifications.

1.5. Cables shall be wrapped with arc-resistant tape, 3M Scotch 77 or university-approved equal. Cables shall be bound with glass fiber tape, 3M Scotch 69 or university-approved equal in manholes and pullboxes that can contain more than one cable circuit.

1.6. Loop primary cables in manholes to provide slack for splices or extensions in the future.

2. Cable Specification

2.1. Cable construction shall comply with ICEA Standard S-68-516 ethylene propylene rubber or S-66-524 tree-resistant cross-linked polyethylene.

2.2. Primary cable shall be rated 15 kV, *100 percent insulation*, 105 degrees C, UL Type MV-105, and suitable for cable tray use. Primary neutral/ground shall be sized at 250 kcmil.

2.3. Conductors shall be bare, compact-stranded, annealed copper per ASTM B8 with an extruded semi-conducting strand shield layer.

2.4. Insulation shall consist of 175 mils of ethylene propylene rubber or tree-resistant cross-linked polyethylene.

2.5. An extruded, free-stripping, semi-conducting layer shall be applied over the insulation beneath the shield.

2.6. An overall jacket of thermoplastic Unigard RE DFDC 1638 or other university-approved low-smoke, non-halogen, flame-retardant material shall be specified. The jacket shall be classified low-smoke per UL 1581 and UL 1685 requirements.

2.7. Acceptable cable manufacturers are BICC, Cable, Cablic, Kerite, Okonite, Pirelli, Rome and Southwire.

3. Terminations

3.1. Primary cable terminations shall be made with heat-shrink or cold-shrink termination kits as manufactured by Raychem or 3M.

3.2. Primary cable splices shall be 600 amp modular (similar to 3M 5815 series).

3.3. Refer to Section 16302 - Electric Utility Construction for qualifications of personnel making terminations.

4. Field Acceptance Testing: Specifications shall state that the contractor hire a qualified independent testing agency according to IEEE Standard 400 and instructions from the cable manufacturer. The agency shall test the completed cable installation in the field and integrate it into the commissioning process, which the commissioning authority may witness.

5. Submittals: Specifications for primary cable shall include the following submittal requirements:

A. Catalog data and cable and termination specifications from the manufacturer
B. Instructions for handling, installing and field testing from the cable manufacturer
C. Two, 12-inch long cable samples that contain the jacket markings from the manufacturer
D. Qualifications of personnel that perform cable terminations
E. Qualifications of the cable testing firm
F. The A/E's review and approval of the certified factory, full reel test reports per Insulating Cable Engineers Association (ICEA) requirements prior to shipment of cable

16131 - RACEWAYS

1. PROHIBITED: Thinwall indenter, die cast or slip-on metallic fittings. All fittings shall be galvanized steel or malleable iron.

2. Rigid Non-metallic Conduit

2.1. Rigid non-metallic raceways may be used below grade, embedded in concrete, and for special service applications such as corrosive locations. Non-metallic raceways shall not be used inside of buildings unless specifically permitted elsewhere in the standard.

2.2. Specify that steel elbows are to be used with non-metallic conduits. PVC-covered steel elbows shall be used in buried PVC conduit runs.

2.3. Specifications shall state to use primer/cleaner for gluing joints.

3. Flexible Metal Conduit: Use of flexible conduit shall be limited to recess lighting luminaries, motors and equipment. All metal conduit fittings shall be galvanized steel or malleable iron.

4. Conduit Fasteners: Straps, hangers and other hardware shall be compatible with the atmosphere of the area in which they are installed.

5. Underground Raceways

5.1. Install underground raceways in excavated trenches with proper bedding and backfill. Detail these requirements on drawings.

5.2. To prevent corrosion, protect direct-buried conduits with a tape-wrap material or non-metallic conduits.

5.3. To locate concealed utilities in the future, install wiring for street lighting services within 24 inches of inner curb lines. Install wiring for site lighting within 6 inches of walkways.

5.4. Conduit can be routed parallel to but not under walkways and/or driveways, unless perpendicular crossing. Where necessary, protect the conduit against soil movement.

5.5. Outdoor conduit lighting shall be sized 1 inch or larger.

6. Parking Facilities: Electrical conduit for parking facilities shall be surface-mounted (not placed within any cast concrete).

7. Utility Requirements for the Duluth Campus

7.1. Gopher State One Call must be contacted before starting any excavation on university property.

7.2. Utility Easements

7.2.1. Any time a non-university utility is installed or relocated on university property, there shall be a corresponding easement agreement that grants the respective utility company, city and other appropriate entities the right to construct, use and maintain their utilities. When preparing an easement, the following is needed:

A. A legal description of the utility easement area
B. A map or sketch that shows the location and run of the proposed line
C. Suggested term (20 years or other)
D. The size and type of the utility (for example, an 8-inch water main)
E. Any other important or unusual requirements imposed by utility such as minimum building distance near high voltage power lines

7.2.2. This information shall be forwarded to Gregory Ewig, Real Estate Specialist, UM Real Estate Office, 424 Donhowe Building, 319 15th Ave. S.E., Minneapolis, MN 55455; (612) 626-0565 who will then prepare the agreement and circulate it for signature.

7.3. Forms

7.3.1. An Appendix LL form titled University Utility Location Register must be submitted to Erik Larson, 241 DAdB, 1049 University Drive, Duluth, MN 55812; no later than two business days prior to backfilling any new or relocated underground utility. The contractor and/or the A/E still are responsible for supplying As Built information for utilities.

7.4. Installing Underground Utilities for Future Locating

7.4.1. Light poles shall have hand holes for access to wires.

7.4.2. Grounding wires for light poles shall be located in the front of the hand hole so they are accessible for locating in the future.

7.4.3. All non-metallic lines shall have tracer wires installed with the lines and have access boxes for the tracer wire ends or protection when they come out of the ground.

7.4.4. Deep-buried, large-diameter or non-straight lines shall have locatable tracer tape installed above the lines at a depth of 24 inches to 30 inches, but below finished grade. Locatable tracer tape shall have access boxes for the tracer wire ends or protection when they come out of the ground.

7.4.5. All buried utilities shall have APWA color-coded tracer tape installed above the utility (traceable or non-traceable depending upon the utility).

7.4.6. Storm and sanitary sewer lines shall join existing lines in manholes; not blind connections. Corners of 45 degrees or greater shall be made inside of a manhole.

7.4.7. Water valves for branch lines shall be located approximately 24 inches off of the main line when possible.

8. Corrosion Protection: Specify the protection requirements for electrical systems exposed to corrosive atmospheric conditions.

9. Empty Conduit: Empty conduits shall have nylon pull cord installed with temporary caps and/or plugs.

16132 - BOXES

1. General Requirements

1.1. PROHIBITED: Floor outlets due to safety hazards and maintenance problems.

1.2. Surface boxes used on or in exterior building surfaces, or on the site, shall be rated for outdoor use and weather-tight.

2. Installation

2.1. Provide tile rings over outlet boxes in glazed tile walls and wood paneling.

2.2. To reduce sound transmission, wall outlet boxes shall not be installed back-to-back in partitions.

2.3. Mount boxes that are installed in concrete block walls at the block joint.

16140 - WIRING DEVICES

1. General Requirements

1.1. Minimum quality for devices shall be specification grade.

1.2. Receptacles and switches shall be side- and back-wiring type. Any wire connection shall be screw-clamp type.

1.3. Recommended mounting heights above the floor for devices:

A. Nominal 18 inches for electrical and communication/data outlets
B. Nominal 42 inches for light switches and wall phone outlets

1.4. Receptacles must be provided on the ground floor of all stairwells and elevator lobby banks in parking facilities.

1.5. Provide light and duplex GFCI receptacle mounted 42 inches above each floor in all pipe spaces, pipe shafts, duct shafts, attic space, tunnels and mechanical equipment space so equipment can be easily repaired.

2. Device Color: General-purpose wiring devices shall be brown or gray. Receptacles on emergency power circuits shall be red.

3. Receptacles: General-purpose receptacles shall be rated 20 amps.

4. Switches: Toggle and key type wall switches for lighting loads shall be AC, quiet type, rated 20 amps at 120/277 volts.

5. Floor Maintenance Equipment Receptacles

5.1. For corridors, large assembly areas and other areas where floor maintenance equipment is used, locate receptacles so that a 45-foot cord will reach any part of the floor. Each receptacle location shall have a duplex, 120V, 20 amp outlet, served by two circuits. Receptacles shall be hospital grade. On each floor, these receptacles shall be served with #10 AWG circuits from a panel on the same floor.

5.2. Provide at least one duplex receptacle in each room where floor maintenance equipment is needed and receptacles are not otherwise available for floor maintenance.

6. Wall Plates

6.1. Wall plates shall be satin finish stainless steel. No. 430 magnetic stainless steel in non-corrosive locations and No. 302 non-magnetic type stainless steel in corrosive locations such as pools and laboratories.

6.2. Identify special purpose receptacles such as emergency power and isolated ground by engraved and filled lettering on the wall plate.

16220 - MOTORS

1. Coordinate mechanical and electrical specifications so that the responsibility for wiring of equipment, motors and controls is clear and not duplicated.

2. With the exception of portable maintenance equipment, motors more than 1/3 horsepower shall be of three-phase design.

3. Provide phase loss protection for motors per industry standards.

4. Specify inverter duty motors for VFD applications. Specifications shall clearly assign responsibility for VFD and motor compatibility to the contractor or specific equipment supplier. If VFDs using IGBT output devices or high carrier frequency are permitted by specifications, address requirements for motor over-voltage and surge protection in the design. Provide auxiliary switch in any load side disconnect and interlock with VFD.

5. Specify that bearings that need lubrication have approved grease fittings extending to a readily accessible location for servicing.

16230 - GENERATOR ASSEMBLIES

1. Basic Minimum Requirements

1.1. Consult with University Energy Management to determine whether provisions for peak shaving shall be included in the generator system design. Provisions for peak shaving include:

A. Noise and vibration control measures
B. Load and transfer equipment compatible with the normal operation of the connected load
C. Electronic ignition for generators greater than 1,000 kW
D. Exhaust evaluation for compliance with Ambient Air Quality Standards (AAQS)
E. Emissions control options and costs for stack discharges that cannot model in compliance with AAQS if applicable

1.2. All generator sets shall be located to disperse exhaust fumes and noise without affecting the normal functions of the building and surrounding site. Specify a method of damping vibrations to acceptable levels. Ensure that exhaust will not be re-entrained by nearby air intakes, including adjacent buildings. Confirm with DEHS that exhaust models are in compliance with ambient air quality standards before determining final design. In general, exhaust stacks must be located approximately 10 feet above the highest roofline to disperse the exhaust and avoid building downwash, which can cause ambient air quality problems. The ambient air quality standards are listed in Minnesota Rules 7009. DEHS shall provide modeling for compliance with ambient air quality standards. Refer to Division 1 - Program Information/General Requirements, Basic Design Requirements 3. Permits. Due to the time required to obtain air emission permits, the A/E shall specify the engine powering the generator with no substitutions. (PROVIDE LINK HERE TO DIVISION 1)

1.3. Generator and prime mover shall be direct-coupled.

1.4. Consult the university for fuel selection.

1.5. On-site fuel source shall provide for a minimum of 12 hours of running time.

1.6. Refer to Division 15 - Mechanical for requirements for ductwork, piping and exhaust flues.

1.7. Provide contacts for remote indication of generator status, alarm and shutdown, and battery charger alarm.

1.8. Voltage and frequency steady state regulation, electronic speed regulation and transient performance shall be specified for all classes of load and load application and rejection.

2. Automatic Transfer Equipment

2.1. Provide a minimum of two sets of auxiliary form C contacts for normal and emergency transfer switch positions.

2.2. Provide 250 degree or digital, 2.0 percent accuracy, switchboard-type indicating ammeter, phase selector switch and current transformers for the load side feeder from each automatic transfer switch.

2.3. The building program requirements will determine whether integral bypass/isolation capability is required.

16260 - VARIABLE FREQUENCY CONTROLLER (VFD)

1. The design shall address the effects of VFD input current harmonics on the distribution system. Specify harmonic criteria and require field testing of harmonic performance when appropriate. Minimum level of performance shall be compliant with IEEE 519 criteria for a general distribution system, modified as appropriate for the specific project.

2. Where specifications permit high-carrier frequency or IGBT output devices, address requirements for motor over-voltage surge protection as part of the design.

3. Clearly assign responsibility for VFD/motor compatibility in the specifications.

4. Specify the following VFD performance and features:

A. Automatic extended power dip ride-through of control circuits with auto restart
B. Operation not affected by harmonic distortion or notching of the input voltage
C. Minimum efficiency at full load: 95 percent
D. Minimum displacement PF at full load: 95 percent
E. Overload capability: 110 percent for variable torque application, 140 percent for constant torque application
F. Carrier frequencies (in excess of 3,000 Hz) shall be adjustable
G. DC line reactor to reduce input harmonics
H. Automatic restart and ability to start into rotating motor

I. Separate acceleration and deceleration rates available
J. Ability to operate with motor disconnected for troubleshooting and maintenance
K. Minimum of five critical frequency lockout ranges
L. Minimum of two programmable digital contact outputs for status and VFD failure
M. Minimum of two programmable digital inputs for preset speed selection
N. Integral closed-loop PID controller
O. English language display: alphanumeric codes not acceptable
P. RS485 serial communication port programmed to interface to DDC system
Q. Field wiring terminal boards (identified on the drawings) for all customer connections
R. Manual speed control potentiometer and Hand/Off/Auto switch
S. 24-month factory warranty

5. Include requirements for factory-certified field services for startup and training in the specifications.

16262 - STATIC UNINTERRUPTIBLE POWER SUPPLY (UPS)

1. Intent: Provide reliable and maintainable UPS installations.

2. General Requirements

2.1. Verify type of UPS operation needed for application and user needs.

2.1.1. Makeup of offline or line interactive operation:

2.1.1.1. The inverter is on standby and switches into circuit when needed.

2.1.1.2. It costs less and is more efficient.

2.1.1.3. It needs verification on issues relating to system harmonics, as well as capabilities of the standby generator.

2.1.1.4. The units typically are smaller (desktop and up).

2.1.2. Make up of online or double conversion operation:

2.1.2.1. There is full load rectification and inverting.

2.1.2.2. It is more adaptable to almost any system application.

2.1.2.3. It has greater reliability.

2.1.2.4. It is required for building automation system applications.

2.2. Review the voltage, bypass configuration, protection time and transfer characteristics of UPS systems with the university.

2.3. Include integral bypass/isolation circuit breakers for all stationary, hard-wired UPS equipment. This inclusion allows the unit to be serviced without interrupting the load.

2.4. Specify startup and acceptance testing, including battery testing and full load testing.

3. Harmonics

3.1. The design shall address the effect of input current harmonics on the distribution system and on standby generation equipment that serves UPS units. In general, the design shall comply with IEEE 519-1992 requirements for a general system at the point of common coupling between the UPS and the building distribution.

3.2. Include the limits for harmonics, requirements for the input filter and a requirement for field-testing to verify compliance in UPS specifications.

4. Batteries

4.1. Clearly specify the type and required life expectancy of batteries. Require a straight pro-rated replacement agreement or better from the battery manufacturer. Sealed batteries shall provide a minimum 10-year life expectancy. Wet cells shall provide a minimum 20-year life expectancy.

4.2. The design shall address the environmental requirements for batteries. Provide adequate ventilation and cooling of battery rooms and battery cabinets to maintain full life expectancy.

4.3. If wet cell batteries are specified, provide a separate battery room with appropriate ventilation and safety features. Require a clear case for wet cell batteries.

4.4. Batteries on racks or in cabinets shall be accessible for testing and verifying torque for individual cells or unit terminals. Vertical access above batteries shall be a minimum of 6 inches for dry batteries and a minimum of 18 inches for wet batteries.

4.5. Each cell or unit shall be numbered for maintenance records.

16280 - POWER FACTOR CORRECTION

Review with the university whether any secondary voltage power factor correction is required. It may not be desired in most locations because medium voltage rated power factor correction is already in place at all main campus switchstations.

16289 - TRANSIENT VOLTAGE SURGE SUPPRESSION

Standard practice is to provide utility grade electric power. Some users may require transient voltage and frequency suppression. The designer shall review options with the user to determine specific needs. As a general practice, suppression should be as close to the application as possible. Since transients and frequencies of different magnitudes can originate anywhere on a system, suppression at a substation or circuit breaker panelboard may not provide the level of protection anticipated. Conversely, point of use devices could cause operation and maintenance problems. Specify that TVSS systems carry certified testing laboratory labels for the application.

16290 - METERING - ELECTRIC UTILITIES

1. General: Metering of electrical energy usage and demand shall be provided for all electrical services. Verify with University Energy Management if sub-metering is needed.

1.1. Meters on the Duluth Campus: Refer to Appendix NN – Utility Meter Report. This form must be filled out any time a meter is installed, removed or there is a change in billing responsibility. This form pertains to both internal UMD meters and utility company-owned meters.

2. Meters

2.1. The existing standard university meter is Square D “Powerlogic,” Model CM2350 with RS485 communications capability and optical communication port. New meters shall be Square D "Powerlogic" Model CM3350 with associated remote readout. Specifications shall require this meter or equivalent Square D "Powerlogic," approved by University Energy Management. No substitutions are permitted.

2.2. Connections for metering shall be made on the line side of the main secondary voltage service disconnect downstream from the service transformer. Provide a disconnect-type fuse block or a three-pole disconnect switch ahead of the fuses. If meters are required on the medium-voltage switchgear, possible connections also shall be on the line side of a switch.

2.3. For small services and sub-metering, verify with University Energy Management regarding other acceptable meters.

3. Instrument Transformers

3.1. Provide voltage transformers for voltage in excess of 300 volts to ground meter terminals unless the meter is rated for 480V connections.

3.2. Provide current transformers and short-circuiting terminal boards or shorting blocks.

4. Specifications

4.1. Specifications for metering shall include:

A. Required ANSI accuracy ratings of voltage and current transformers
B. Submittal of specifications for voltage transformers and current transformers, catalog data, current transformers saturation curves and thermal rating factors
C. Submittal of complete wiring diagrams for metering with shop drawings

4.2. Require that all meter terminals, including spare or unused terminals, be wired to terminal blocks for connecting field wiring.

4.3. Permanently label metering conductors with identification that corresponds to the wiring diagrams.

4.4. Elevation to the center of the case shall be between 48 inches and 72 inches.

4.5. Contract documents shall state that a circuit runs from the meter to a location that University Electric Utilities and BSAC designate for communicating with central monitoring. Provide auxiliary or secondary output to the Building Automation System. Coordinate specific requirements for each project with University Management. (PROVIDE A LINK TO BSAC IN DIVISION 15)

16300 - UNIVERSITY ELECTRIC UTILITY - ELECTRIC UTILITIES

1. Scope

1.1. Most university facilities are served by University Electric Utilities. The group is responsible for medium-voltage distribution and transformers, secondary feed and associated main and tie switches.

1.2. Within the context of a construction project on the university campus, University Electric Utilities performs essentially the same role that the electric

utility company does for an off-campus project. It is the organization responsible for providing safe and reliable electrical service to campus facilities.

1.3. Twin Cities Campus: University-owned switchstations that include Fulton, Fourth Street, West Bank, St. Paul and Como are supplied from various Xcel Energy electric substations. There also is parallel generation on the system.

16301 - ELECTRIC UTILITY DESIGN - ELECTRIC UTILITIES

1. General

1.1. Service to buildings from the campus distribution systems shall be underground. Refer to Section 16304 - Medium Voltage Distribution.

1.2. The design and operational philosophy of the University Electric Utility medium-voltage distribution is as follows:

1.2.1. Dual feed system to each service point.

1.2.2. Normal loads on each feeder are limited to accommodate emergency and maintenance transfer of loads for a service outage of alternate feed.

2. Electric Load Studies

2.1. Determine the electrical coincident summer peak demands for the following. The demands allow University Electric Utilities to identify the connection point(s), as well as identify which campus feeders are used.

A. Design connected demand - peak kW
B. Estimated operating demand - peak kW

2.2. Determine whether the coincident estimated winter peak demand is expected to be greater than summer peak demand.

2.3. Determine the electrical load usage in estimated kWh/month for a 12-month period. This figure can be used to develop a budget for facility utilities.

2.4. Submit estimates for the following project milestones: Schematic Design Phase, Construction Documents Phase, and Substantial Completion Phase.

2.5. Studies shall be submitted to University Energy Management.

3. Electrical System Studies

3.1. Short circuit calculations and the protective device coordination study for electrical service equipment shall be performed during the design phase. Specification of equipment short circuit current interrupting and withstand ratings, and proper over-current protection for all elements of the electrical service shall be submitted to University Energy Management for review at least two weeks before the project is advertised.

3.2. The A/E's responsibility for these studies shall not be delegated to the contractor within the contract documents. Contract documents may require the contractor to submit supplemental electrical system studies based on the specific equipment furnished to confirm the A/E's selection of equipment ratings and protective devices.

3.3. Submit results of electrical system studies in accordance with IEEE Standard 242 - Protection and Coordination of Industrial and Commercial Power Systems and IEEE Standard 399 - Power System Analysis.

3.4. Submit base short circuit calculations in order to select equipment ratings on the following information:

A. Primary System Capacity: 500 MVA at 13.8 kV 3-phase, 170 MVA phase-to-ground
B. Transformer Impedance: ANSI Standard minus 7.5 percent tolerance
C. Motor Contribution: Per IEEE Standard 242 recommendations for equipment substations

3.5. Protective device coordination studies and motor starting studies shall consider actual short circuit current available, as well as maximum fault current conditions. Consult with University Energy Management for values to be used for such studies, and to obtain campus feeder relay settings.

3.6. Phase over-current protective devices and settings shall be chosen to provide a selectively coordinated system from the building substation secondary feeder devices through the campus primary distribution feeder circuit breakers.

3.7. Ground over-current protective devices and settings shall be chosen to provide a selectively coordinated system between the building substation secondary feeder, tie and main disconnect devices. Time-band coordination is preferred. Zone-selective-interlocked systems shall not be specified without approval from University Energy Management.

4. Additional Requirements

4.1. The design shall not allow voltage flicker to exceed 2 percent of nominal voltage at the nearest university tap point serving its other loads. Consider using

IEEE Standard 141 as one guideline to determine the level of allowable voltage flicker.

4.2. University Electric Utilities medium-voltage manholes, hand holes and pullboxes outside of electric shall be assigned identification numbers available from University Electric Utilities. Identification shall include an upper case "U" followed by a four-digit number.

4.3. Perform cable-pulling calculations for each duct run to determine that pulling tension and sidewall pressure are within applicable limits for general applications (not higher-rated, utility applications). Calculations shall be available for review by University Electric Utilities, and shall be included in the project O and M manuals. If calculations indicate a restriction on the direction of pull or location of feed points, these restrictions shall be included in the contract documents.

4.4. All transformers and switchgear in electrical vaults shall have white enamel 3/8-inch wide mimic bus painted on the front of the assembly(s). This indicates the arrangement of primary feeder cable, equipment busing, arrestors, switches, fuses, current transformers, voltage transformers, meters and arrows for supply and load connections.

16302 - ELECTRIC UTILITY CONSTRUCTION - ELECTRIC UTILITIES

1. General

1.1. The project design shall include all elements required for primary service to the building. The contractor shall furnish and install all equipment except:

1.1.1. University Electric Utilities shall furnish and install manholes and ductbanks so they extend campus distribution feeders to the project site boundary.

1.1.2. The contractor shall furnish and install ductbanks from the project site boundary to the building. The A/E shall include the cost of this work in the project cost estimates.

1.1.3. University Electric Utilities shall furnish, install, splice and terminate all primary cables between the point of connection to the existing campus distribution feeders and the line side terminals of the first primary line interruptible switch in each feeder to the building.

1.1.4. University Electric Utilities shall be reimbursed its cost for this work by the project.

1.2. It is preferred that University Electric Utilities performs the medium-voltage ductbank, manhole and medium-voltage cable construction phase.

2. Safety and Proficiency

2.1. When working in areas with energized medium-voltage equipment, OSHA regulations for qualified workers shall apply. When the contractor is working in areas with energized medium-voltage equipment, one of the following two procedures shall apply:

2.1.1. Retain the services of a university-qualified electrician as an escort.

2.1.2. Determine acceptable proficiency for workers according to the contractor and University Electric Utilities.

2.2. Workers who install medium-voltage cable shall demonstrate proficiency acceptable to standards worked out between the contractor and University Energy Management.

2.3. Workers who splice cables shall demonstrate proficiency acceptable to standards worked out between the contractor and University Energy Management. Acceptable standards shall be based on accredited hours of training on types of splices used for the project.

3. Service Interruptions and Energizations

3.1. Electric service to the project shall not be energized until the electric service facilities of the building are substantially complete.

3.2. A minimum of four weeks prior to the first required new equipment service interruption or energization, the electrical subcontractor shall submit the following to University Electric Utilities and the owner's representative:

3.2.1. Provide a detailed sequence schedule of all required service interruptions and energizations for the project. The schedule shall identify the work sequence, length of interruption in calendar hours and affected equipment. The electrical subcontractor shall submit revisions to the original schedule whenever changes are made in the schedule of interruptions or energizations. The schedule shall accommodate University Electric Utilities work such as testing and commissioning.

3.2.2. The electrical subcontractor shall supply two sets of marked up As Built drawings in a hard copy format. Included in each set shall be the electric site plan, electric one-line diagram and mimic bus one-line diagram.

3.3. The electrical subcontractor shall submit a written request form to the owner's representative for each separate service interruption or energization. The form may be obtained from University Electric Utilities. The form shall:

A. Be submitted a minimum of 14 calendar days in advance of the required interruptions or energization.
B. Include an attachment that certifies that all material, tools and equipment are on hand. Also indicate that all preparatory work has been completed in advance of the request to minimize the length of the interruption.
C. Include other certifications as University Electric Utilities requests.

3.4. Commissioning of the electrical installation shall be complete before connection to the campus distribution system and energization is scheduled. University Electric Utilities shall not accept requests for service interruption or energization until receiving written approval from the commissioning authority.

3.5. University Electric Utilities shall close the campus feeder circuit breaker(s) that correspond with the initial energization of supply conductors from the campus distribution feeders to the line side of the first primary switching device(s) in the building.

3.6. The qualified electrical subcontractor shall initially operate all switches and circuit breakers under the jurisdiction of University Electric Utilities. The subcontractor also shall perform initial energization of all equipment on the load side of the first primary switching device(s).

3.7. Following initial energization, only University Electric Utilities shall be in control of equipment and only its personnel shall perform primary switching.

3.8. The contractor and electrical subcontractor shall attend a project Electrical Service Construction Coordination Meeting with the university, the A/E, the commissioning authority and others within 30 days after the award of the electrical contract. The contractor and electrical subcontractor shall be prepared to review service interruptions and energization, along with substantial completion requirements in the coordination meeting.

3.9. Abandoned utilities shall be completely removed unless University Energy Management has provided written approval to leave the abandoned utilities in place.

3.10. Abandonment/Removal of Utilities for the Duluth Campus

3.10.1. Abandoned utilities shall be completely removed unless the utility owner provides written approval. Send approval letters to Erik Larson,

241 DAdB, 1049 University Drive, Duluth, MN 55812. Erik Larson must approve all university-owned utilities to be abandoned in place.

3.10.2. Any abandoned utilities not removed must be accurately tied in along the entire length of the abandoned utilities. Another option is to include access boxes so the abandoned utilities can be located. Actual dimensioned ties must be shown on the As Built drawings. Pictures of the abandoned utility end are desired. An Appendix LL form titled University Utility Register must be submitted prior to burying abandoned lines.

4. Substantial Completion

4.1. The following requirements represent a minimum definition of substantial completion of the electrical service installation and shall be part of the project specifications. Additional requirements may apply to specific projects:

4.1.1. In addition to the project record drawing distribution requirements in the Standards and Procedures for Construction, two sets of the As Built drawings of the electric service facilities installation shall be provided to the university in a hard copy, non-electronic format. Included in each set shall be the electric site plan, electric one-line diagram, electrical vault power and lighting plans and elevation views, mimic bus one-line diagrams, switchgear elevations and manhole drawings. The A/E shall field-verifiy, date and certify As Built drawings. Forward one set directly to University Electric Utilities and one set directly to Energy Management, 400 Donhowe Building. Forward one copy of the detailed transmittal of the set to the owner's representative. As Built riser diagrams are not acceptable in place of an As Built electric distribution system one-line diagram.

4.1.2. Building envelope and electrical room and electric vault walls, floors and ceilings shall be completed and provide protection of the equipment from wind, water, dust and physical damage. Floors shall be sealed. In addition, walls and ceilings shall be completed per room-finish schedule.

4.1.3. Security shall be in place to prohibit unqualified people from accessing the electrical vault.

4.1.4. Doors and locks shall be installed.

4.1.5. Heating, ventilation and lighting in the electrical rooms and vaults shall be operational.

4.1.6. Work on non-electrical trades in the electrical vault shall be completed.

4.1.7. The installation shall pass inspection and approval according to the University Electrical Code, as well as the fire code inspectors.

4.1.8. Vaults and all equipment in vaults shall be thoroughly cleaned, and all contractor storage removed.

4.1.9. Commissioning of the electrical service facilities shall be completed and ready for energization. Any corrective actions identified during commissioning shall have been resolved.

4.1.10. Training and demonstration of electrical service facilities equipment operation to university personnel shall be completed.

4.1.11. O and M manuals for the electrical service facilities equipment shall be submitted for review, approved and resubmitted in final form with the required number of copies. A minimum of one O and M manual set shall be returned to the project and shall be kept accessible in the electric vault.

4.l.12. Spare fuses, equipment, renewal parts and tools required for the electrical service facilities equipment shall be supplied and be on hand in the electrical vault.

4.1.13. Mimic bus diagrams on the front of electric service facilities equipment shall be completed and accepted.

4.2. The equipment shall be substantially complete prior to the electrical subcontractor's request for the first energization of building electrical service equipment from the campus distribution system. University Electric Utilities shall be notified in writing after substantial completion.

4.3. Any payment to the A/E and contractor for electric utilities record documentation shall be withheld until all the record documentation associated with substantial completion of electric utilities work is received and verified to be satisfactory. If for any reason the first energization of the building electric service equipment proceeds without the complete record documentation and without meeting any part of the foregoing requirement for substantial completion, subsequent partial payments for project electric utility work may be reduced.

4.4. The contractor shall secure a qualified electrician to serve as a full-time escort for unqualified personnel that is given access to the electrical vault during the remainder of the construction period.

4.5. The electrical vault shall not be used to store materials. It also shall not be used as an office space or breakroom, or for any other activity than its designed intent.

16303 - ELECTRIC UTILITY COMMISSIONING - ELECTRIC UTILITIES

1. Electrical utility facilities shall be commissioned prior to first energization of building electrical service facilities.

1.1. The university shall retain the commissioning agent. This cost shall be part of the project budget.

1.2. Incurred commissioning costs shall be billed to the project.

2. An independent commissioning authority that the university retains shall coordinate commissioning. The commissioning authority shall perform the following functions:

2.1. Review the contract documents that the A/E has prepared at the Schematic Design, Design Development and Construction Documents phases.

2.2. Prepare commissioning specification for inclusion in the contract documents that identifies the contractor's required commissioning activities.

2.3. Review the equipment shop drawings and O and M manuals during the construction phase to become familiar with the installation requirements and operating characteristics of the specific equipment furnished on the project.

2.4. Prepare verification test procedures for the contractor to execute.

2.5. Observe/witness the commissioning tests, interpret results and identify conditions requiring corrective action.

2.6. Provide a set of the following listed paragraphs 2.6.1. and 2.6.2. documentation at least one week prior to the electric subcontractor’s request for initial outage and/or energization of the primary electric service facilities. Documentation shall be given to University Electric Utilities and to Engineering Records, B11 Donhowe Building. A copy of the letter in 1.6.1. and the document transmittal in 1.6.2. shall be sent to the owner’s representative and University Electric Utilities to review the project.

2.6.1. A letter stating that the equipment installation is substantially complete, has been commissioned satisfactorily, and is ready for energization. The letter shall include a list of any minor electrical service

work items remaining to be completed. These items shall not interfere with the energization and operation of the equipment.

2.6.2. An electrical distribution system one-line diagram of the primary and secondary electrical service facilities from the project connection to the campus distribution systems through the secondary main bus. The A/E and registered engineers at the commissioning authority shall certify and date the one-line diagram. The diagram shall serve as their field-verified record of the As Built primary feeder cable, relays, equipment busing, arrestors, cable terminators, switches, fuses, breakers, power and instrument transformers, meters, connections, hinges and other related equipment. The diagram shall be provided in an 11-inch by 17-inch minimum B format. It shall include the same symbols of the electrical distribution system one-line diagram that the A/E uses. Include pertinent data regarding the equipment nameplate for the major items of equipment on the diagram or on attachment(s) to the diagram. Include a brief description of operation for protective relaying schemes and switching schemes that are not intuitively obvious on the diagram or on attachment(s). As Built riser diagrams are not acceptable in place of an As Built electric distribution system one-line diagram. A detailed transmittal shall accompany each set of documents.

2.7. The A/E's commissioning responsibilities shall include:

A. Professional fees from the commissioning authority and construction costs from the contractor for commissioning in the project cost estimates
B. Contract documents that clearly identify the design intent and define all operating sequences and functional requirements of the electrical service equipment, including protective schemes and automatic transfer schemes
C. Obtaining responses to questions or comments from the commissioning authority during the design review and shop drawing review phases to clarify design intent
D. The commissioning specification in the contract documents of the project
E. Resolution of deficiencies identified during the commissioning process as project punch list items
F. The contract documents that specify that the contractor shall provide all labor, material, tools, test instruments and other related services and items required for commissioning specification and verification tests. The documents also shall specify the contractor’s responsibilities for correcting deficiencies identified during commissioning.

2.8. As identified in the commissioning specification, the contract documents shall specify that the contractor is required to retain the services of a field service engineer of the equipment manufacturer or a qualified independent testing agency to perform verification tests.

2.9. The commissioning authority shall inspect all manhole and ductbank construction after forming, and prior to concrete encasement and backfill. The commissioning authority shall have the option to be present during encasement. The contractor shall remove and replace construction that is concealed without such inspection with no cost to the university.

16304 - MEDIUM VOLTAGE DISTRIBUTION - ELECTRIC UTILITIES

1. Ductbanks

(PROVIDE LINK TO DIVISION 3 - CONCRETE)

1.1. Electrical medium-voltage distribution shall be underground and encased in concrete.

1.2. Concrete encasement of ductbanks shall include the following:

A. Steel reinforcement
B. Concrete forming for the sidewalls
C. Continuous concrete pour between manholes and between manholes and buildings/vaults
D. Minimum spread of ductbank since underground space is a premium in many locations
E. Spacers/chairs placed no more than 7 feet apart. Spacers/chairs that properly support change in direction

1.3. All ductbanks shall be sloped to drain away from buildings and equipment entrances and in to manholes. The slope shall be a minimum of 4 inches per 100 feet of horizontal run. Avoid trapped runs. Conduits shall not enter indoor equipment directly from the ductbank. Provide a pullbox or other break to prevent water from flowing from the ductbank into the equipment. The pullbox shall be large enough to accommodate cable drip loops.

1.4. Ductbanks shall be run with the top at a minimum elevation of 30 inches below grade unless required otherwise by obstructions or entrances to manholes or structures.

1.5. Ductbanks or conduits shall not be located within 5 feet of a buried steam line in any direction. If it becomes necessary to cross a steam line, University Energy Management must approve acceptable insulation of the crossings.

1.6. Ducts in ductbanks shall be 5-inch trade size with end bells at ends of each section for PVC conduit. Ends of rigid steel conduit shall have a grounding bushing. Minimum radius of bends shall be 60 inches.

1.7. Straight sections of duct can be PVC, minimum Schedule 40. Bends, kicks, offsets and entrance to manholes or structures shall be galvanized steel to reduce damage from pulled cable. Galvanized steel conduit shall be used where core-drilling penetrations are made. PVC conduit is acceptable where ductbank continues through a window opening.

1.8. The following requirements for ductbanks shall be included in the construction documents:

A. Applicable NEMA standards for ducts
B. (Maximum) Dimensions between spacers
C. Required overlap of reinforcing steel
D. The A/E and University Energy Management commissioning process
E. Cleaning of ducts using a stiff wire brush and mandrel or other approved duct cleaning method prior to installation of cable. Use of rags is not acceptable.
F. Grounding of steel conduits at entrances to structures
G. A pull string in all unused ducts
H. A pull through of a properly sized arbor or mandrel for the duct
I. Proper concrete forming size and thickness
J. Ductbank plan and profile
K. A typical ductbank section that shows space between conduit, reinforcement size and location, and concrete cover
L. Ductbank sections
M. Details for ductbank connection to manholes and structures

1.9. Ductbank concrete fill shall not be put in place until the duct bank has been inspected by both the University Code Office and University Electric Utilities.

2. Manholes

2.1. PROHIBITED: Manhole covers and valve boxes that are buried, sunken more than 1 inch or left above the surrounding grade.

2.2. Manhole covers shall be made of heavy duty, solid cast iron. They shall have a 36-inch diameter clear opening with a removable center access lid that is 22 inches in diameter. They shall be labeled with an “ELECTRICAL” legend, Neenah Casting No. R1740-D2 or equivalent.

2.3. Manholes shall be provided as required for cable pulling, elevation changes and just before entering a building. The maximum distance between manholes shall be 350 feet.

2.4. Manholes shall be pre-cast or cast-in-place construction. Minimum load rating of manholes and covers shall be AASHTO HS-20.

2.5. Manholes shall have a sump with a concrete bottom that can be used with a portable de-watering pump, grounding provisions, pulling irons, knockouts for ductbank entries in the future, and embedded anchors for cable and splice support hardware.

2.6. Manholes shall be provided with two internal ground rods in opposite corners and an internal ground bus that is a nominal 12-inches long and tied to each ground rod. An alternate is an external #4/0 CU ground loop if approved by University Energy Management for connecting cable shield grounds and protective ground cables. Ground rod shall be driven down a nominal 8 feet and have 6 inches above the manhole floor.

2.7. Construction drawings shall include manhole plan and section views.

2.8. Review layout, dimensions and route of cable in all manholes with University Energy Management during design to provide access, maintainability and space for extending feeders in the future.

2.9. Manhole Covers and Valve Boxes on the Duluth Campus

2.9.1. PROHIBITED: Depressions around drains that slope more than 30 degrees.

2.9.2. Manhole covers and valve boxes shall not be located in sidewalks or plaza areas if possible. If it is not avoidable, a floating manhole shall be used (NEENAH R-1955 or approved equal).

2.9.3. Catch basins located in mulched areas shall have vertical screening to keep mulch material out of the catch basins.

2.9.4. Castings for the following types of manholes have not yet been determined:

A. Electrical
B. Sanitary
C. Steam
D. Storm - Area Drain
E. Storm - Pedestrian Area
F. Storm - Street Area
G. Water

3. Conduit and Pullboxes

3.1. Exposed conduits, pullboxes and other raceways that contain primary cable shall be painted safety orange with the operating voltage stenciled at minimum 10-foot intervals.

3.2. Medium-voltage conduits that extend into electrical equipment shall have a minimum 36-inch radius.

16305 - ELECTRIC VAULTS - ELECTRIC UTILITIES

1. For the purpose of the 2002 Standards and Procedures for Construction, the term "electric vaults" is defined as transformer rooms and/or electrical equipment rooms that contain medium-voltage service equipment of more than 600 volts.

2. General Requirements

2.1. PROHIBITED: Equipment that requires access or maintenance by units other than University Electrical Utilities such as ventilation fans, distribution panelboards and drain lines in electric vaults.

2.2. PROHIBITED: Telecommunications equipment, phone panels, standby generators, transfer switches and related equipment, small secondary transformers and related panelboards, and fire alarm boards in electric vaults.

2.3. PROHIBITED: Foreign piping, clean-outs and/or ductwork in electric vaults. An entire electric vault shall be defined as an “electric vault” to exclude foreign piping and ductwork.

2.4. PROHIBITED: Fire protection sprinkler systems in electric vaults. The A/E shall design an electric vault room and equipment therein so that a fire protection sprinkler system is not required by NFPA 13-5-13.11 exception, 1999 edition and/or any other applicable codes.

2.5. Provide outside access and egress for equipment. The A/E shall identify the route on the drawings. Electric service areas shall be adjacent to an outside wall or vent shaft that can easily accommodate rigging equipment.

2.6. Provide a minimum of two means of personnel access and egress within the working space to each electric vault.

2.7. Doors shall be self-locking with panic bar or lever handle exit hardware. One door lock shall be a stand-alone card access, ILCO Unicam 9950. Refer to Division 8, Section 8700 - Finish Hardware. Coordinate locks with University Electric Utilities.

2.8. Lighting and receptacle circuits shall be split between emergency and normal power in buildings with an emergency power system. If there is no emergency power system, provide battery backup for emergency lighting.

2.9. Seal concrete floors of electric vaults and electrical service equipment rooms. The pads shall extend a nominal 3 inches in all directions beyond enclosure. Seal the top surface of equipment pads for open-base equipment before the installation of the equipment. Refer to Division 3 – Concrete, Section 03200 – Concrete Reinforcement for more information.

3. Equipment Clearance

3.1. To provide safe operating space for hot stick operation, a minimum of 6 feet of clearance is required in front of all doors. In addition, a minimum of 6 feet of clearance is required in front of any removable panels where grounding clusters may be applied or an exposed live part may exist.

3.2. Provide a minimum of 30 inches in front of any removable panel or ventilation space.

3.3. Provide detail on the working and ventilation space for equipment in electric vaults on the drawings.

4. Heating and Ventilation Requirements

4.1. Provide adequate ventilation in electric vaults to maintain an indoor air temperature below 104 degrees F at an outside air design temperature of 95 degrees F.

4.2. Control ventilation via thermostat to prevent overcooling in vaults during cold weather. Provide a manual hand off automatic (HOA) over-ride switch in electric vaults.

4.3. Provide outside air louvers with low-leakage dampers that open when the ventilation system is operating.

4.4. Provide removable filter elements that are a minimum of 2-inches thick to filter outside air.

4.5. Provide adequate heating to maintain an indoor air temperature above the dewpoint at all times to prevent condensation in equipment.

5. Additional Requirements: Provide a plan and a minimum of two full-length detailed elevation views for each electrical vault. At a minimum, provide detail to scale for the following: equipment plan and elevation outlines, concrete equipment pads, medium-voltage raceways and pull boxes, ground buses and secondary busways. Show which

covers are removable on medium-voltage pull boxes. Hinge removable covers where possible.

16340 - MEDIUM VOLTAGE SWITCHING AND PROTECTION - ELECTRIC UTILITIES

1. Switchgear Arrangements

1.1. Dual feeds to a building shall have the following switchgear arrangements:

A. Single transformer load: common bus primary selective. Two, incoming, non-fused switches with transformer fuse off of common bus
B. Multiple-branch feeders/transformers: split bus primary selective. Two, incoming, non-fused switches and a non-fused tie switch. Fused branch feeder/transformer switches split between each primary bus. An alternate would be as outlined for a single transformer load for each transformer.

1.2. Single feed

A. Single load: fused switch
B. Multiple-branch feeders: non-fused main switch and fused branch feeder switches
C. Transformer out of sight from switchgear lineup: non-fused switch

1.3. Transformers out of sight from switchgear lineup shall have a non-fused switch at the transformer.

1.4. Only a single feed to the transformer is needed if the transformer is served from a primary switchgear lineup in the building.

2. Switchgear Operation

2.1. Primary switchgear with double feed service shall be arranged to transfer load when maintenance is needed without interrupting service. Provide Kirk-type key interlocks for all duplex switches, as well as for switches that can be closed in combination to parallel campus distribution feeders. Specifications shall require that a spare key for each interlock be provided to the university for maintenance switching.

2.2. Refer to Section 16305 - Electric Vaults, B. Equipment Clearance for space requirements around switchgear.

2.3. Provide means for hot-stick application of protective ground cables to the switchgear bus and the load side of each switch. Standard grounding connection

is an A.B. Chance Standard Ball Stud, Catalog Number C600-2102. Locate grounding points so they are readily accessible from the front of the switchgear.

3. Switchgear Construction

3.1. Medium-voltage switching equipment shall be indoors. It shall be enclosed in metal, air-insulated, manually operated and contain load-interrupter switchgear, similar to that manufactured by S&C Electric, Inc. Switchgear shall include fuses as required to protect conductors and transformers.

3.2. Construction shall include:

A. Copper bus with full voltage insulated sleeves and removable boots over bolted connections
B. Fully grounded metal barriers between bays with insulating bushings for bus penetrations
C. 2-inch by 1/4-inch copper ground bus that continues through all bays or larger if needed to accommodate proper ground protection
D. External operating handle with padlock that clearly indicates switch position. The switch shall be lockable in both open and closed position
E. Phase arrangement A-B-C, left-to-right, top-to-bottom, front-to-back and viewed from the front
F. Construction that is fully accessible and replaceable from the front
G. Adequate cable training, termination space and mechanical support for 500 kcmil, 100 percent insulation, 15 kV single-conductor cables at incoming circuit termination points
H. Porcelain stand off insulators and bushings
I. Safety glass observation windows that allow all switchblades to be seen in open and closed positions
J. Warning signs and labels in accordance with NEC and OSHA regulations

4. Switchgear Minimum Ratings

A. Operating (Nominal) Voltage: 13.8 kV
B. Maximum Design Voltage: 15 kV
C. Basic Impulse Level (BIL): 95 kV
D. Continuous Current: 600 A
E. Loadbreak Current: 600 A
F. Short Circuit Current: 25,000 A RMS SYM
G. Momentary Current: 40,000 A RMS ASYM
H. Close and Latch Current: 40,000 A RMS ASYM

5. Fuses: General Requirements

5.1. Furnish and install fuse disconnect mountings that can be operated with a hookstick. Hinge mountings on the load side of the fuses. Provide three spare fuses or fuse refill units for each type and rating of fuse used. S&C brand is required.

5.2. Store spare fuses or refill units in a spare fuse cabinet (not inside the switchgear).

6. Fuses: Minimum Ratings

A. Operating (Nominal) Voltage: 13.8 kV
B. Maximum Design Voltage: 15.0 kV
C. Continuous Current: As required
D. Short Circuit Interrupting Current: 25,000 A RMS SYM

7. Specifications for Primary Switchgear

7.1. Specification for primary switchgear shall include:

A. Compliance with the relevant ANSI, IEEE and UL standards. List standards applicable to the equipment for the project
B. Complete electrical ratings of switchgear and fuses
C. A requirement for certified factory test reports prior to shipping
D. A requirement to anchor switchgear in areas indicated on the manufacturer's drawings
E. Spare keys for the university to provide maintenance on all interlock schemes
F. A requirement that the switchgear include a metal nameplate that is mounted on the exterior of the equipment, and contains the following information and minimum ratings:

1. The manufacturer's name
2. The assembly number or drawing number
3. Operating (nominal) voltage
4. Maximum design voltage
5. Basic Impulse Level (BIL)
6. Continuous current
7. Short-circuit interrupting current
8. Short-circuit current
9. Momentary current

G. A requirement that each bay with a switch includes a metal nameplate on the exterior of the bay that lists the following switch information and minimum ratings:

1. The switch manufacturer

2. A drawing and/or catalog number
3. Continuous current
4. Loadbreak current
5. Close and latch current

H. A requirement that each switch bay with fuses or any bay with fuses only include a metal nameplate on the exterior of the bay that lists the following fuse information and minimum ratings:

1. The name of the fuse manufacturer
2. The fuse or fuse holder catalog number or style number, including:

2.1. Maximum fuse or fuse holder continuous amperes
2.2. Holder loadbreak amperes (if any) and voltage

3. The catalog number or style number for the installed fuse refill unit (if applicable), including:

3.1. The ampere size of installed fuse unit
3.2. The voltage rating of installed fuse unit
3.3. Continuous current
3.4. Short-circuit interrupting

I. An OSHA-compliant, fuse-handling tool and hook-stick for each switchgear lineup that is wall-mounted on hangers or clips in an accessible location inside the electric vault
J. A painted steel spare fuse cabinet with minimum dimensions of 36 inches high by 36 inches wide by 12 inches deep that is wall-mounted in the electric vault

16360 - MEDIUM VOLTAGE TRANSFORMERS - ELECTRIC UTILITIES

1. General

1.1. For a facility where continuous electrical service is essential, arrange medium-voltage transformers as double-ended, unit substations to provide backup in case the transformer fails and to accommodate maintenance without completely shutting down a building.

1.2. A medium-voltage transformer shall not exceed the following air-to-air (AA) or fan-to-air (FA) ratings: 120/208-volt service – 750/1,000 AA/FA, 277/480-volt service – 1,500/2,000 AA/FA. Second and additional transformers shall be used, if needed.

1.3. Respective primary switching and secondary distribution may be detached, but a secondary distribution tie is essential.

1.4. Fault current ratings of the double-ended unit substations shall be sufficient for the secondary switchgear tie switch to be closed with both transformers operating.

1.5. Refer to Section 16340 - Medium Voltage Switching and Protection for more information on primary switching.

1.6. Refer to Section 16430 - Main Secondary Protection.

2. Transformer Considerations

2.1. PROHIBITED: Padmount mineral oil or other liquid-insulated outdoor transformers.

2.2. Transformers shall be located indoors and shall be of dry-type construction.

2.3. The A/E shall select transformer type, construction and ratings with consideration for the following:

A. Ease of removal and replacement
B. Environmental conditions
C. Provisions for ventilation
D. Economical operation
E. Impact of a transformer failure
F. Maintenance requirements

2.4. Primary bus and tap connections shall be on the front side of the transformer installation. Provide a minimum clearance of 60 inches in front of the transformer.

2.5. Transformers shall be installed with a minimum space of 30 inches from walls or from other equipment to the rear. Refer to Section 16305 - Equipment Clearance to determine required space around transformers.

2.6. Transformers without a primary switch attached shall have grounding connections that are accessible either in the transformer enclosure or in the primary cable transition enclosure for the transformer. Grounding connections shall be the same as required for medium-voltage switchgear. Refer to Section 16340 - Medium Voltage Switching and Protection.

3. Dry-type Transformers: General Requirements

3.1. The transformer core and coil shall:

A. Comply with ANSI C57.12.01 requirements.
B. Be tested per ANSI C57.12.91.
C. Be UL listed and labeled.
D. Have a 220-degree C Vacuum-Pressure-Impregnated (VPI) insulation system.
E. Be designed with a 115 degree C temperature rise or comply with Minnesota Energy Code.
F. Have 95 kV primary BIL without the use of surge arrestors.
G. Contain Delta primary and Wye secondary windings.
H. Include two, 2 1/2 percent taps FCAN and two, 2 1/2 percent taps FCBN.

3.2. Provide vibration isolation between core and mounting structure and flexible bus connections to primary and secondary terminals to minimize noise transmission.

3.3. Include a knockdown enclosure that allows core and coil assembly to be removed without disturbing adjacent equipment sections.

3.4. Include internal ground bus that continues through unit substation line-up.

3.5. Transformers shall be rated AA/FFA. Fans may be omitted, but provisions shall be made for installation in the future.

3.6. Each transformer shall have a solid state fan controller with a temperature sensor in each winding. The fan controller shall have manual and automatic control, along with temperature readout. In addition, the fan controller shall have two adjustable temperature alarm points with dry contact outputs.

3.7. When fan cooling is supplied with the transformer, one fan controller temperature alarm point shall be tied to the BSAC monitoring system and the other alarm point shall be tied to the shunt trip of the main breaker.

3.8. The transformer assembly shall qualify for UL label.

4. Cast Coil, Dry-Type Transformers

4.1. For applications in adverse environmental conditions or where extended periods of de-energization are anticipated such as chillers for seasonal use, cast-coil type transformer winding construction shall be considered. For these applications, the A/E shall submit a cost analysis to University Energy Management and recommend whether a cast coil transformer is economically justified.

4.1.1. For transformers applied to seasonal-use chillers, verify that needed year-round accessories such as chiller heaters and purge pumps are on another power source.

4.2. The manufacturer shall certify the transformer units as capable of being immediately energized following an extended period of de-energization without the need for testing or drying out procedures. Each unit enclosure shall have an externally mounted, inscribed nameplate that the manufacturer provides, which states this certification.

4.3. Transformers shall comply with applicable requirements for standard dry-type transformers.

5. Surge Arrestors: Transformers shall be provided with surge arrestors located within the transformer enclosure and be located as close to the primary terminals as practical with a direct connection to the equipment ground bus. Provide adequate working space if rear access is needed for servicing. Arrestors shall be distribution class, MOV-type, with polymer housing, 8.4 kV MCOV, rated for use on an effectively grounded 13.8 kV Wye system.

6. Minimum Transformer Impedance, Non-ANSI Standardized: Transformer sizes and types for which ANSI standards do not establish a standard impedance value shall be specified to have a minimum impedance of 5 percent unless specific design considerations dictate otherwise. Note: getting up to 5 percent for transformers below 250 KVA could be difficult. 500 KVA may be close to 5 percent. 750 KVA and above 5-3/4 percent is common.

7. Tests

7.1. Specifications shall require that the results of certified design tests per ANSI C57.12.91 be submitted for review upon request, and that routine tests per ANSI C57.12.91 be performed on all transformers.

7.2. The A/E shall review and approve factory-certified reports of routine tests prior to shipping the transformer. The reports also shall be included in the O and M manuals.

16400 - SERVICE AND DISTRIBUTION (600 VOLT AND BELOW)

1. General Requirements

1.1. Secondary service and distribution shall be of adequate size to provide for load growth during the life of the building. Consider the facility type and use to determine needed capacity in excess of initial demand.

1.2. Identify to the university the reserve capacity provided in the design.

2. Ground Fault System

2.1. Design a ground fault protection system, when required by code, that greatly minimizes the possibility of power outage to critical building facilities. Consider a coordinated system on the feeders that permits incremental settings and provides reasonable continuity of electric service. Additional ground fault protection may be required to provide personal protection.

2.2. Specify the range for current pickup and time delay for all sensors. When the project is turned over to the university, the A/E shall select the values of the two settings.

2.3. Submit date on tripping curves and characteristics to the university.

2.4. The contractor shall test the system ground fault performance when first installed and submit a written record of the test to the university. A university representative shall witness the test. A copy shall be included in final project data submittals.

2.5. Identify the method to be used to test ground fault protection in the field.

16410 - SAFETY SWITCHES AND CIRCUIT BREAKERS

1. Safety switches shall be heavy duty.

2. To remove or repair equipment and provide an immediate and observable point of electrical disconnect, locate a disconnect switch near each piece of fixed electrical equipment.

16420 - ENCLOSED CONTROLLERS

1. Clearly indicate who on the construction documents is responsible for supplying motor control equipment.

2. Do not locate motor starting switches in cabinet unit heaters or enclosed unit ventilators. Contract documents shall indicate locations for these switches. Where accessible to the public, provide key-operated switches.

3. Motor Control

3.1. In areas where there are a reasonable number of three-phase motors, provide a motor-control center.

3.2. Brace the MCC bus work and cabling to withstand the available short-circuit current. Specify values.

3.3. Starters shall have fusible disconnects rather than circuit breakers or MCPs.

3.4. Motor controllers shall be NEMA-rated.

3.5. Control circuit voltage shall be 120 volt or less.

3.6. Each motor starter shall have its own control power source within reason. Control circuit voltage shall be 120 volts or less.

3.7. Duplex Pumps: Each unit shall be labeled and have its own on/off control. Incorporate an alternator, software or mechanical, that allows it to stop and automatically restart via the building automation system. Provide an auto-backup feature.

3.8. Specify hand/off/automatic control for fan motors operated via BSAC. All safety control devices such as freezestats shall be in the control circuits at all times.

3.9. Incorporate a minimum of two auxiliary contacts (1 N.O. and 1 N.C.) in magnetic starters in addition to what is being used.

3.10. Include a schedule for the motor control center on the electrical drawings.

3.11. Design each motor control center section so starter units may be rearranged, removed or added after installation.

16430 - MAIN SECONDARY PROTECTION - 600V CLASS - ELECTRIC UTILITIES

1. General Requirements

1.1. Provide a visible break in the electrical circuit for secondary main and tie switches and circuit breakers. To do so, provide draw-out mountings on circuit breakers.

1.2. Where draw-out circuit breakers are provided, specifications shall require that the contractor provide a portable lifting and transport device compatible with the circuit breakers.

1.3. Provide Kirk-type key interlocks between secondary switches or circuit breakers so they will close simultaneously with parallel sources. Specifications shall require that a spare key for each interlock be provided to the university for maintenance switching.

1.4. Provide each secondary source with a power-failure alarm relay and Form C contacts that transfer when any phase of the supply voltage drops below a dropout setting. The dropout setting is adjustable from 50 percent to 95 percent of nominal voltage. The relay shall have a minimum deadband of 3 percent of nominal voltage between dropout and pickup. Wire relay contacts to field wiring terminal board for connection to remote monitoring.

1.5. Specifications shall require that complete schematic and wiring diagrams be submitted for control, protection and transfer schemes. The specifications also shall require that all wiring be permanently labeled at both ends with identification that corresponds to the wiring diagrams.

1.6. Specifications shall require that the contractor furnish the switchgear for all circuit breakers that have solid-state trip units, as well as the manufacturer's test set for portable secondary current that calculates calibration and proper operation of the trip units.

1.7. Include a continuous copper ground bus with secondary switchgear or switchboards that are bonded to the primary equipment ground bus.

1.8. Provide main and tie switches and circuit breakers with auxiliary contacts (ANSI devices 52a and 52b) that are wired to field wiring terminal boards for connection to remote monitoring.

2. Secondary Surge Arrestors: Secondary surge arrestors or TVSS shall have a means of isolation where needed and shall be readily accessible for maintenance and inspection. Label the compartment that contains the arrestors or TVSS.

3. Anchoring: Specifications shall include requirements for anchoring switchgear to the concrete equipment pad at locations indicated on the manufacturer's drawings.

16440 - DISTRIBUTION SWITCHBOARDS

1. General Requirements: Each new building shall have a distribution switchboard.

2. Construction

2.1. Specify copper phase, neutral and ground buses.

2.2. The phase arrangement on three-phase buses shall be A-B-C from left to right, top to bottom, front to back, as viewed from the front of the switchboard.

2.3. Specify provisions for future circuits. Provide provisions for future increases in electrical requirements. To increase flexibility, provide usable space in lieu of spare devices.

2.4. Include continuous ground bus the full length of the switchboard that is equipped with bolted pressure clamp-type lugs.

2.5. The design shall include provisions for extension of main bus in the future.

3. Wiring: Group together, laced or tie wrap meter and control wiring from measuring device to indicating unit. Identify wire terminals and terminations on both ends.

4. Identification

4.1. Identify switchboards and distribution boards on the drawings. Indicate on the drawings the main service transformer feeding each board.

4.2. Identify which circuit is served for the circuit protective devices, circuit controlling devices and meters on switchboards and distribution boards.

16441 - PANELBOARDS AND CABINETS

1. General Requirements: To accommodate additional wiring in the future, provide spare conduit stubs from flush panels into suspended ceiling space or other accessible space. Determine the quantity by the spare circuits and space available in the panel.

2. Panelboard Construction

2.1 PROHIBITED: Door-in-door panelboard covers.

2.2. Rough-in boxes shall have a minimum width of 20 inches and a minimum depth of 5-3/4 inches.

2.3. Phase, neutral and ground bus shall be copper.

2.4. Use flat oval head truss-head screws in tapped holes in rough-in box flanges to install cabinet door trim. Drill flanges on the job to ensure plumb, square and true trim appearance.

2.5. Provide hinged trim with full-length piano-type hinges for panelboards. Provide a latch, lock and key set at the door covering the circuit protective devices. Consult with the university for the key requirements.

3. Identification

3.1. Furnish each electrical panel with a clear, plastic-covered, typed-circuit schedule mounted in a metal cardholder. The schedule shall identify circuits by room number using final numbers that the university furnishes. Verify room numbers with the university.

3.2. Provide a number designation on each circuit protective device. Odd numbers shall be used in sequence down the left side and even numbers in sequence down the right side.

3.3. Provide cross breaker connectors and bus for breakers in the future. Indicate the designated space in panelboard schedules for panelboards to accept maximum capacity.

3.4. Identify the panelboard ID and power origin on each panelboard on the outside or inside door.

4. Schedules: Show the schedule for panelboards and cabinets on the drawings, preferably on the same sheet as the power riser diagram. Include the following information as a minimum:

A. Voltage, phase and wire
B. Main bus rating
C. Main breaker rating
D. Short circuit rating
E. Circuit numbers
F. Branch breaker current rating and number of poles
G. Load description
H. Connected loads

16450 - BUS DUCT

1. Plug-in and feeder buses 225 amp and larger shall have built-in ground bus.

2. Plug-in devices shall have an integral, built-in ground connection for attachment to bus ground.

3. Specify concrete curbs and fire barriers where duct runs pass through concrete floor slabs and fire-rated walls.

4. Bus shall be copper.

16460 - LOW VOLTAGE TRANSFORMERS (600V OR LESS)

1. General Requirements

1.1. Locate distribution, buck/boost, signaling, isolation, control and autotransformers in accessible, ventilated, cool, dry and clean areas.

1.2. Where these conditions cannot be provided, specify transformers that are suitable for the environment.

2. Efficiency and Temperature Rise: Transformers for all buildings shall comply with the Minnesota Energy Code, minimum efficiencies. For exceptions to the Energy Code, specify dry type transformers 25 KVA and above, for a maximum of 115 degrees C temperature rise above a 40 degrees C ambient temperature, with a 220 degrees C-rated insulation system.

3. Sound Levels: Sound levels of transformers shall be consistent with the use of the building areas adjacent to the transformer. Sound levels shall not exceed ANSI standards. In areas of very low ambient noise level such as libraries and reading rooms, use transformers with lower sound levels.

16490 - OVERCURRENT PROTECTIVE DEVICES

1. PROHIBITED: Tandem branch circuit breakers.

2. General Requirements: The design engineer shall conduct studies on short circuit and coordination to determine protective device ratings and requirements. The design engineer shall not assign this responsibility to the contractor.

3. Fuses

3.1. Specify each size and type of fuse required.

3.2. Specify rejection type fuse holders where current-limiting fuses are used.

4. Bolted Pressure Switches: Fused switches that are 800 amps and larger, and mounted on panels and switchboards shall be UL-approved, of bolted-pressure type and have a 600-volt rating.

5. Circuit Breakers: Circuit breakers on branch circuit panelboard shall be bolt-on type or secured by a bolt(s).

6. Fused Switches: Fused switch circuit protective devices shall be heavy-duty rated.

16500 - LIGHTING

1. General Requirements

1.1. Provide aiming diagrams for luminaries, and require that the contractor aim the luminaries. The A/E shall witness the aiming.

1.2. Show and identify lighting luminaries on the electrical drawings.

2. Exit Signage: Light Emitting Diode (LED), high-intensity type lamps shall illuminate exit signage.

16510 - INDOOR LUMINARIES

1. General Requirements: Include a corridor night light system in the design.

2. Lighting Criteria: Determine foot-candle levels per the latest IES recommendations.

3. Fixture Lenses: Metal halide luminaries shall have tempered glass or high-impact safety lenses. Refer to Section 16582 - Lamps.

4. Fixture Mounting: Provide details of supports for lighting luminaries on the drawing.

5. Lighting Control

5.1. Provide three-way and four-way controls in long corridors, gymnasiums, auditoriums and other vast areas.

5.2. The designer shall review and determine how many automatic controls for lighting are needed based upon the amount of natural daylight.

5.2.1. Allow fluorescent luminaries to be switched from inboard to outboard and vice versa in private offices, classrooms, laboratories and conference rooms.

5.2.2. Mount occupancy sensors on the ceiling, and integrate them in the control schemes of classrooms, restrooms and office areas that have many occupants. Use sensors with combined ultrasonic/infrared technology, and are provided with an integral manual over-ride switch.

16520 - EXTERIOR LUMINARIES

1. PROHIBITED: Bollard and underground luminaries in sidewalks and roadway areas.

2. General Requirements

2.1. Refer to the University Exterior Design Standards for fixture types. Verify the historical and non-historical areas for fixture application with the university.

2.2. General area and security lighting shall be metal halide. Lighting in parking lots shall be high-pressure sodium. Refer to Appendix Q - Design Standards for Parking Structures for complete information on lighting standards for parking facilities.

2.3. Construction Site Lighting: Provide temporary exterior lighting with 0.3 foot-candles around the perimeter fence line of construction sites for the safety of pedestrians traveling to and from adjacent facilities.

2.4. Determine foot-candle levels per the latest IES recommendations.

3. Poles and Standards

3.1. Describe poles in the fixture schedule. Provide complete details for bases on the electrical drawings. Anchor bolts shall be galvanized.

3.2. Include required grounding. Provide a copper grounding rod or equivalent as part of the pole base.

3.3. Provide in-line fuses that are readily accessible via hand holes in the base of the pole.

3.4. Verify fixture and standard placement and style with the owner's representative and University Landcare.

3.5. Poles and standards on the Duluth campus: Refer to Appendix NN – UMD Light Pole Report. This form must be filled out for each light pole (or sets of electrical poles) that is installed, removed or modified.

4. Exterior Lighting Control: Provide a photocell with bypass switch for fixture equipment.

5. Fixture Lenses: Polycarbonate lenses shall be high-impact, ultraviolet stabilized.

16570 - DIMMING SYSTEMS

1. PROHIBITED: Due to high maintenance costs and reduced lamp life, metal halide and high-pressure sodium lamps with dimming systems.

2. General Requirements

2.1. Provide the university with a detailed written description of the sequence of operation and control modes of all dimming systems.

2.2. Specify startup, demonstration and training to university personnel.

3. Features

3.1. Incorporate filtering of radio frequency interference (RFI) in equipment to slow the current rise time.

3.2. Incorporate series inductance to limit noise of lamp filament.

3.3. Specify the acceptable operating range of ambient temperature for the equipment.

16582 - LAMPS

1. PROHIBITED: Incandescent lamps for general lighting.

2. PROHIBITED: Low-pressure sodium lamps for safety and disposal waste.

3. PROHIBITED: Mercury-vapor lamps due to low efficacy.

4. PROHIBITED: Fluorescent T12 lamps.

5. Lamp Types

5.1. Lamps shall have a correlated color temperature of 3,500 K.

5.2. To prevent a hazardous failure mode where metal halide lamps are used, make provisions for switching off luminaries a minimum of 15 minutes per week. Review this requirement with the university.

16584 - BALLASTS

1. General Requirements

1.1. Provide ETL-certified ballasts that conform to applicable CBM certification.

1.2. Ballasts shall comply with FCC and NEMA limits for Electromagnetic Interference (EMI) and Radio Frequency Interference (RFI). They also shall not interfere with the operation of other building equipment.

2. Fluorescent Ballasts

2.1. Fluorescent ballasts shall be efficient solid-state electronic ballasts with an A sound rating, and a true power factor of .90 or greater with 20 percent or less total harmonic distortion.

2.2. Fluorescent ballasts for outside applications or in areas where ambient temperature is lower than 50 degrees F shall have a minimum starting temperature of -20 degrees F.

3. HID Ballasts

3.1. Specify high power factor regulator-type HID ballasts that have a minimum power factor of 90 percent over the life of the lamp. Also specify that the ballasts provide less than 1-percent variation of lamp wattage per percent of line voltage variation.

3.2. HID ballasts for outside applications shall have a minimum starting temperature of -40 degrees F.

4. Remote Ballasts

4.1. Luminaries mounted in areas that are difficult to access shall have remote ballasts.

4.2. Remote-mounted ballasts shall be located in an accessible, cool, dry location with adequate ventilation. Each ballast shall be labeled to correspond to its fixture location.

5. Removal and Disposal of PCB Ballasts

5.1. The designer shall consult with the Department of Environmental Health and Safety (DEHS) for requirements on handling and disposing PCB ballasts.

5.2. Remove and dispose ballasts that contain PCB per EPA requirements.

5.3. The contractor shall examine existing ballasts that are to be removed from service. If a ballast does not clearly indicate that it does not contain PCB, it shall be assumed to contain PCB.

5.4. DEHS shall provide a ballast collection container at or near the project site. Ballasts that contain PCB shall be placed in the ballast collection container as they are removed. The university shall dispose of the container and its contents.

16620 - EMERGENCY LIGHT AND POWER

1. The preferred standby power source is an engine-driven generator. Refer to Section 16230 - Generator Assemblies.

2. Refer to Appendix Q - Design Standards for Parking Structures for complete information on emergency power for parking facilities.

16640 - CATHODIC PROTECTION

Cathodic protection is required for certain underground piping systems. Review the need for cathodic protection with the university for each project.

16670 - LIGHTNING PROTECTION SYSTEMS

1. The A/E shall consider the building design, site elevations, and other site conditions and make recommendations to the university as to the merits of providing a lightning protection system.

2. If installed, lightning protection systems shall carry the Master Label as defined by the Underwriters' Laboratory.

16680 - FIRE ALARM SYSTEMS

1. General Requirements

1.1. The University Building Code Division, as designated by the Board of Regents of the University of Minnesota, is the authority having jurisdiction in regards to requirements for fire alarms at the University of Minnesota.

1.2. Verify the specific requirements such as pre-signal alarm, outside fire alarm signal, proprietary signal system and special key boxes with the University Building Code Division.

1.3. Fire alarm signal systems shall meet the design requirements of the latest applicable codes.

2. Submittals

2.1. Submit the fire alarm shop drawings in accordance with Division 1, Section 01300 - Submittals. Include a riser diagram, sequence of operation, wire size and type, battery calculations, voltage drop calculations, a floor plan that shows all the devices, data sheets for the devices and copies of fire alarm specifications as required by applicable state codes.

2.2. The contractor shall provide record documents of the fire alarm installation to the owner. The documents shall include all shop drawing information, the device-to-device wiring scheme, a revised floor plan showing any devices added or relocated during the construction project, final sequence of operations, final voltage drop calculations and an owner's manual regarding required maintenance and testing.

3. Operational Plan and Test

3.1. Confirm with the owner's representative if the fire alarm and the interface to related systems will be commissioned.

3.2. If the A/E is to commission the systems, use the following procedures and those identified in Division 1, Section 01650 - Commissioning.

3.2.1. Within the project manual, the A/E shall include a test manual for the specific testing requirements for the fire alarm and related systems.

3.2.1.1. The test manual shall include test procedures to verify that the fire/life safety interface is operating correctly for the following systems:

A. Door closures
B. Elevators
C. Fire alarm system and devices, test every device
D. HVAC systems
E. Smoke/fire damper activation and reset
F. Sprinkler flow and tamper switches

3.2.1.2. Each test procedure shall include a detailed description of the following items:

A. Recording format
B. Sequence of operations for control functions of the fire alarm system
C. Test equipment required
D. Test participants

3.3. Construction drawings and shop drawings shall have a sequence matrix of operation for initiating devices. The following table is a sample:

	Water-flow	Sprinkler tamper	Dry Pipe Hi-Low Air	Manual Pull Station	Smoke Detector	Duct Smoke Detector	Circuit or Panel Trouble	120V Loss at FACP
Alarm annun. at FACP and BSAC	X			X	X			
Supv. Annun. at FACP and BSAC		X	X			X		
Tbl,. Annum. at FACP and BSAC							X	X
Shut Down HVAC Close Smoke Dampers						X		
Activate NAC'S Notification Applic. Circuits	X			X	X			
Drop Door Holders	X			X	X			X

The following parties shall sign off with date, indicating the system performed according to the required sequence of operations:

Fire alarm vendor _____ Date _____
Electrical contractor _____ Date _____
Fire protection contractor _____ Date _____
Mechanical contractor _____ Date _____
A/E _____ Date _____

3.4. The final acceptance test shall be conducted in the presence of the University Building Code Division fire inspector, Facilities Management operations representative and the A/E. A typed NFPA 72 Certificate of Completion shall document the installation and acceptance test.

3.5. The A/E shall specify that the acceptance of the fire protection system be based upon completion of the necessary testing as outlined in the state and national fire codes. All testing must be documented on certificate forms. The fire protection contractor is responsible for maintaining the equipment in service after the acceptance test, as well as minimizing impairments to the system for the remainder of the project. During remodeling or after Certificate of Occupancy or substantial completion, coordinate impairments with the owner's representative.

4. Material

4.1. All fire alarm equipment shall be UL listed.

4.2. Fire alarm systems shall be the addressable type. If the system has more than 10 smoke detectors, they shall be analog addressable type and have alarm verification set at 60 seconds.

4.3. All devices associated with the fire alarm system shall operate through the fire alarm main panel instead of as independent systems tied into the building fire alarm system. Examples include special releasing device controls and pre-action systems.

4.3.1. Other independent fire alarm/control systems shall report via the building fire alarm system with three common points: alarm, supervisory and trouble.

4.4. The fire alarm system shall have 24 hours of battery capacity even with generator backup.

4.5. The fire alarm control panel shall have three Form C contacts: trouble, supervisory and alarm for connection to BSAC. Refer to Division 15, Section 15950 - Controls and Instrumentation. The BSAC system wires will terminate in the fire alarm control panel.

4.6. The minimum size conductor for door holder circuits, horn and strobe circuits shall be 14 AWG. Provide raceways or cable tray for fire alarm wiring to minimize costs over the operating life of the building. Paint raceway junction box covers red for identification.

4.7. Speakers are preferred over horns to better accommodate maintenance and testing. Specify ANSI S3.41, Audible Emergency Evacuation Signal temporal-code-three. Exception: Speakers are acceptable for large assembly buildings, large laboratory buildings, high rises and hospitals. Microphones are preferred on speakers for broadcasting purposes.

4.8. Specify CAT 30 keys for building main control panel and associated, lockable panels. Fire alarm systems within telecommunication rooms may require a different key type.

5. Execution

5.1. PROHIBITED: Wire nut connections in control panels.

5.2. Water flow detection devices shall have one device per address.

5.3. In buildings with all sprinklers, specify the minimum number of manual pull stations (usually one) to comply with code.

5.4. Tamper supervision devices shall be within reasonable proximity for grouping.

5.5. Each control relay operated by the fire alarm system shall be supervised and within 3 feet of the device operated, in addition to being numbered and labeled.

5.6. Locate the fire alarm main control panel for a building in a non-public area. Locate an annunciator at the fire department entrance to the building.

5.7. Specify mounting height for devices to comply with ADA and NFPA requirements.

5.8. The contractor shall program the fire alarm control system to operate according to the design matrix.

5.9. Organize alarm and notification circuits by floor or area to accommodate troubleshooting.

5.10. Do not load signaling line circuits with greater than 75 percent of capacity. The panel shall have one spare signaling line circuit or capacity for 50 additional initiating devices.

5.11. Notification appliance circuits shall be designed with a minimum of 20 percent spare capacity. System performance shall include the capability to silence audible appliances without affecting visual appliance operation. It shall be either two, 2-wire systems or a 2-wire addressable system.

5.12. Where speakers are used, provide fire fighters handset at fire alarm annunciator panel to allow emergency responders to communicate with building occupants. Speakers to be zoned by floor, and include general alarm conditions and temporal-code-three signal.

5.13. All circuits shall be Class B. Locate the end of line resistor at the last device of the circuit, and identify it on the drawings and in the field. Limit circuits to one floor or major area. Label terminal strips. Provide terminal boards in control panels.

5.14. Use door hold open circuits from fire alarm panel in lieu of auxiliary contacts in the detector base.

5.15. Concealed initiating devices such as duct smoke detectors and tamper switches shall have remote alarm indicators that identify the location of the devices. Locate remote indicators in public spaces such as corridors. Duct smoke detectors shall have remote indicators with test stations.

5.16. A weatherproof exterior horn/strobe shall be mounted above the sprinkler system fire department connection, and be powered by a notification appliance circuit. Refer to Division 15, Section 15325 - Standpipe, Sprinkler and Other Fire Suppression Systems.

5.17. Provide an electrical outlet within 10 feet of the fire alarm control panel.

5.18. Provide adequate lighting around area where fire alarm is serviced.

5.19. Paint fire alarm junction box covers red.

5.20. Document the fire alarm address for each device, along with wire and cable identification numbers, on record drawings.

16700 - TELECOMMUNICATION SYSTEMS

Refer to Appendix T - Office of Information Technology Wiring Standards.

16722 - CENTRALLY MANAGED AND HARDWIRED ACCESS CONTROL SYSTEMS

1. All questions on equipment approvals in this section shall be forwarded to the Department of Central Security, 2038 University Ave., Suite 200, (612) 624-1750.

2. Incorporate a minimum of two doors with hard-wired card access and a controlled perimeter for all new buildings.

3. Submit all remodeling projects with estimated construction costs in excess of $100,000 and/or projects that effect building access to the Department of Central Security or a security audit as early in the project as possible.

3.1. The purpose of the security audit shall be to:

A. Determine whether or not a card access system shall be incorporated into the scope of the project
B. Determine whether or not an electronic security system shall be incorporated into the scope of the project

3.2. The security audit shall be done without cost to the project.

4. All card reader controller panels shall have a minimum 12-hour battery backup, and battery standby power supplies to maintain database programming and card reader operation. Electric locking devices on perimeter doors with electric strikes operated by card readers shall have battery standby power supplies if determined by a security audit.

5. The University Card Access front end Management System is a Sensormatic Software House C-Cure 800 System. All card readers on perimeter doors, perimeter door access control systems, and door monitoring systems shall interface with this system. The aforementioned security audit will determine if other card readers or door access control systems will be required.

6. Use conduit and raceways on system installation. They shall comply with conduit and raceway standards specified in Section 16131 - Raceways, and the manufacturer's requirements of the access control systems.

7. System installation shall use wire and cable that complies with wire and cable standards specified in Section 16120 - Wires and Cables, and the manufacturer's requirements of the access control systems.

8. Refer to Division 8, Section 08700 - Finish Hardware for system hardware requirements.

9. Access control systems shall have the following components/capabilities:

9.1. Magnetic Stripe Cards: Access control systems must be able to read and reference university-manufactured, encoded and issued identification cards adhering to ISO standards 7811/2 and 7811/4.

9.2. Magnetic Stripe Card Readers: Card readers shall be Sensormatic (Software House) RM1-MP Magnetic Stripe Readers.

9.2.1. Exterior card readers shall have a manufactured heater kit.

9.3. Nominal Card Reader Mounting Height: Card readers shall be mounted at the following heights:

A. Interior: 42 inches to center above the finished floor
B. Exterior: 31 inches to center above the finished floor
C. Elevators: 31 inches to center above the finished floor
D. Bollard Mount: Reader may be mounted

9.4. Card Reader Controller Panels: Card reader controller panels shall be Sensormatic advanced processing Controller (apC). No substitutions are permitted. The controllers shall support a minimum of eight card reader interface options. Card reader controllers shall have the following components/capabilities:

9.4.1. Support eight card readers in a star configuration with independent addresses.

9.4.2. A star coupler module that is capable of supporting eight independent card readers, eight unsupervised inputs and eight additional relay outputs.

9.4.2.1. A mini star coupler module is acceptable if the eight unsupervised inputs and the additional eight-relay output capacity are not required.

9.4.3. The Sensormatic apC will be connected with the University Access Management System via ether jack connection. The Office of Information Technology shall install the connection at least two weeks prior to being required. Locate the apC in the panel. A LANtronic server must be provided.

9.5. Card Reader Controller Standby Power: The standby power systems for card reader controllers shall be Alarm-Saf AS/PS5-BFS-12-UL. The power systems shall have 12 hours of battery backup.

9.6. Electric Lock Power Supply: Electric lock power supply shall be Alarm-Saf AS/PS5-BFS-24-UL. This shall include electric door strikes, electric door control and exit devices on perimeter doors or interior doors determined to require power supply by the aforementioned university security audit. Electric lock power supply shall have the following components/capabilities:

A. Twelve hours of battery backup for all perimeter doors
B. A minimum of one 38 AH battery set
C. Support all perimeter electric door control and exit device functions for a minimum of six hours

9.7. Elevator Control: Elevator control shall be managed from the University Card Access Management System with the following components/capabilities:

A. One apC per elevator that services four or more floors
B. Cable and wire that connects the card reader to the apC and the apC to the elevator controller, if elevator controller is required. Refer to Division 14, Section 14200 - Elevators
C. A door position switch on all door installations. Do not use the exit motion detector to unlock the doors.
D. A request exit motion detector on all door installations

9.8. Electric Battery Card Operated Mortise Locks: Refer to Division 8, Section 08700 - Finish Hardware. Electric battery card operated mortise locks shall be ILCO Unican System 9950 Electronic Commercial Lock System or ILCO Unican

System 920 Electronic Commercial Lock System when it is used in conjunction with an exit device. No substitutions are permitted. The locks shall have the following components/capabilities:

A. Software that provides the following for each lock:

1. One thousand users per lock
2. An 800 entry audit trail. Unlimited user levels
3. Master level access
4. Programmable passage mode, auto unlock, re-lock and lockout
5. Time zones for weekends and holidays
6. Automatic updating of access card

B. The ability to read and reference university-manufactured, encoded and issued identification cards adhering to ISO standards 7811/2 and 7811/4
C. The ability to operate independently and be powered by six AA batteries
D. Independent programming from a 386 notebook computer that operates on MS DOS 5.0 or newer version with two MB RAM and 80 MB hard disk through an infrared communication adapter
E. The ability to fit into a standard mortise lock opening without altering the fire rating of the door
F. Lever handles and optional finishes
G. Mechanical key override to accept Best 7 pin interchangeable core

10. The design of electronic security systems shall be incorporated into new construction and renovation projects to meet a variety of personal and property security needs. Each design shall be considered unique and require that the Department of Central Security review and approve each design.

10.1. Despite each unique design, all electronic security systems shall have alarm systems with control panels that have the following components and capabilities:

10.1.1. FBI brand XL-4 model control panels shall be used for hardwire sensor systems.

10.1.2. ITI brand UltraGard model control panels shall be used for wireless sensor systems.

10.1.3. One dedicated analog telephone line shall be required for each control panel.

10.1.4. One dedicated 120 volt AC power source with a minimum of 24-hour battery backup shall be provided for each control panel.

10.1.5. Control panels shall be programmed to communicate with the Phoenix alarm server and Phoenix monitoring software located at the University of Minnesota Police Department. Programming specifications shall be coordinated with Brian McDonald at the Department of Central Security.

10.2. In addition, all electronic security systems shall have video surveillance systems with the following components and capabilities:

10.2.1. Video surveillance systems shall include digital recording, multiplexing and Internet-based server capabilities.

10.2.2. Exterior cameras shall be both environmentally protected and heated. Provisions for preventing snow and ice build-up shall be included. Daytime and nighttime cameras that are equipped with an electronic auto iris are required for all exterior applications.

10.2.3. Interior cameras shall be premium grade and provide high-resolution color images. Applications that have variable lighting conditions shall require an electronic auto iris on each interior camera.

10.3. Below-Grade and Tunnel Communication: Radiating cable technology shall be provided for emergency radio communication below-grade and in tunnels. Contact the University Police Department at (612) 624-3550 for requirements.

16723 - INTERCOMMUNICATION SYSTEMS

1. Coordinate equipment specifications and locations with the Office of Classroom Management, Classroom Technical Services as the owner’s representative directs.

2. Equipment shall be of solid-state type. Locate head end equipment in a lockable, controlled area.

3. Run wiring for systems in raceway.

16820 - PUBLIC ADDRESS SYSTEMS

1. Coordinate equipment specifications and locations with the University Department of Media Resources as the owner's representative directs.

2. Equipment shall be of solid-state type. Locate head end equipment in a lockable, controlled area.

3. Run wiring for systems in raceway.

16850 - TELEVISION/RADIO SYSTEMS

1. Confirm equipment specifications and locations with the University Department of Media Resources as the owner's representative directs.

2. Equipment shall be of solid-state type. Locate head end equipment in a lockable, controlled area.

3. Run wiring for systems in raceway.

16900 - CONTROLS AND INSTRUMENTATION

Building Systems Automation Center (BSAC): Refer to Division 15, Section 15935 - Building Systems Automation Center for an overall description of BSAC, and Division 15, Section 15950 - Controls and Instrumentation.

End of Division 16 - Electrical
University of Minnesota Facilities Management
November 2002 (Revised: December 2006)