Division 16 – Electrical

General

This standard sets forth the minimum requirements for basic electrical materials and methods used in construction on University projects. It is not intended to be used as a complete specification or to preempt the professional judgment of the Design Professional.

Engineering Services of the Texas Tech's Operations Division will be responsible for coordinating the work between the Contractor and Lubbock Power & Light (LP&L). Contact TTU Operations at (806) 742-2761.

The work shall be performed by a contractor with a current Texas license. This contractor shall be fully responsible to meet project requirements, including items exceeding those specifically illustrated or mentioned in the contract documents. The contractor shall have a minimum of 5 years of experience in the installation of electrical system of the type specified for this project. References will be made available upon request.

At a minimum, each Contractor and all materials/equipment suppliers shall guarantee all labor and materials furnished by respective entity for a period of one year unless otherwise noted. Warranty period shall extend from the date of substantial completion or upon written directive from the Owner, whichever occurs first. The warranty shall cover the repair or replacement, at the Contractor's expense, of any defective material or faulty workmanship.

The utility company provides and installs all transformers, primary conductors, and metering equipment for billing purposes. Contractor may be required to provide concrete pads, trenching, and/or a metering rack and raceway from the transformer to a remote location for the utility company to install the meter.

All supports shall be from structural members of the facility. No conduit, wire, devices, etc., shall be supported from suspended ceiling or support cables of suspended ceilings.

Contractor will typically be responsible for providing all secondary cable, conduit, and other devices other than metering equipment. It shall be the responsibility of the Contractor to coordinate with the utility company for connection to the utility company's transformer and/or meter.

All surfaces shall be restored where surface finish damage is evident. Physical material damage will require replacement of part.

The Contractor shall insure that all work has been accomplished to the satisfaction of the Architect/Engineer prior to energizing any circuit or new equipment.

All materials and equipment, where applicable, shall be listed by Underwriters Laboratories and FM Approved and the installation shall be in accordance with the manufacturer's recommendations and FM Global Recommended Good Practices.

The manufacturer's published directions shall be followed in the delivery, storage, protection, installation, and wiring of all equipment and material. The Contractor shall promptly notify the Architect/Engineer, in writing, of any conflict between the requirements of the Contract Documents and the manufacturers' directions, and shall obtain the Architect/Engineer's instructions before proceeding with the work. Should the Contractor perform any such work that does not comply with the manufacturers' directions or such instructions from the Architect/Engineer, he shall bear all costs arising in connection with the deficiencies.

Contractor shall provide temporary construction power and lighting to/at the site for the use of all trades.

Where conduit, raceway, cable trays, wiring, etc. pass through floors, walls, partitions or ceilings having a required smoke and/or fire resistive rating, such penetrations shall be constructed to provide the required fire resistive rating. Where routed through non-rated floors, walls, partitions or ceilings, such penetrations shall be caulked or otherwise sealed to achieve a smoke tight condition in a manner acceptable to the Architect/Engineer.

At a minimum, provide access panels where required by codes and for maintenance or service.

Clean lamps, reflectors and lenses of all lighting fixtures. Clean panelboards and equipment cabinets inside and out. Apply touch-up paint of the specified color to any scratches or mars on the finish of all equipment, raceway, etc.

Provide a preliminary study and a complete short-circuit study and protective relay and device coordination study from the 12.47kV utility service by Lubbock Power and Light through the main disconnect(s) of the branch circuit panelboards and motor/loads to 10 HP. This work is to be performed by the manufacturer of the electrical gear and shall include the generator skid mounted circuit breaker to the largest branch device on the volt emergency and standby panelboards. Provide arc-flash calculations and labels for each piece of electrical equipment modified
or provided in this contract.

Basic Electrical Materials and Methods

A conduit sleeve shall be two standard sizes larger than the size of conduit it serves, except where "Link Seal" casing seals are used in sleeves through walls below grade. All sleeves in floor shall extend a minimum of 2 inches above the finished floor. All conduit passing through concrete masonry walls above grade shall have 18-gauge galvanized steel sleeves. Sleeves set in concrete floor construction shall be at least 16-gauge galvanized steel except at conduit supports. Sleeves set in concrete floor construction

supporting conduit risers shall be standard weight galvanized steel. Sleeves supporting conduit risers 3 inches and larger shall have three 6 inches long reinforcing rods welded at 120 degree spacing to the sleeve and shall be installed embedded in the concrete or grouped to existing concrete. Where the conduit passes through a sleeve, no point of the conduit shall touch the sleeve. Seal around penetrations through sleeving as indicated under fire stopping as specified and in compliance with the requirements of Division 07 specifications.

Power Metering

If required, power metering system at switchgear shall be PowerLogic that is compatible with existing PowerLogic software.

Wire and Cable

Wire, cable, and connectors shall be new and of manufacturer's standard materials, as indicated by published product information. Provide wire, cable, and connector of design and construction as required for the installation.

Provide factory-fabricated wire of the size, rating, material and type as indicated for each service. Where not indicated, provide proper selection as required to comply with installation requirements and with NEC standards.

Marking:

1. Provide new insulated conductors marked according to NEC Article 310.
2. All wire and cable shall be UL listed. In addition to other standard labeling, all wire and cable shall be marked UL on the outer surface indicating UL certification.

All insulated wire and cable shall conform to the minimum requirements of ICEA Standards for Cable Installed in Wet Locations, with the cable subjected to all degrees of moisture conditions. Wire and cable shall comply with the applicable requirements of the NEC, latest edition, in regards to cable construction and usage.

The conductors of wires and cables shall be of copper (tinned where specified), and have conductivity in accordance with the standardization rules of the IEEE. The conductor and each strand shall be round and free of kinks and defects.

Grounding conductors, where insulated, shall be colored solid green or identified with green color as required by the NEC.

Conductors intended as a neutral (i.e. grounded conductor) shall be colored solid white, or identified as required by the NEC.

All power conductors installed on cable trays shall be in conduit rated for use in that space.

All low voltage power and control cable shall be plenum rated, with insulation rated at 300 volts. Where tray cable is not available in size and type required, conductors shall be installed in conduit unless otherwise approved by TTU's Project Manager.

Torque all mechanical connections per manufacturer's recommendations.

600-VOLT Insulated Conductors:

1. Conductor: Soft-drawn, annealed copper.
    a. Use solid conductor for No. 12 and No. 10 AWG.
    b. Use stranded conductor for No. 8 AWG and larger.
2. Insulation:
    a. Unless otherwise noted on the drawings, use THHN/THWN-2 for general wiring.
    b. Use XHHW-2 conductors where installed in duct or conduit underground.
3. For control circuits use 98% conductivity, soft-drawn, annealed, stranded copper conductor, 600 volt insulation, THWN-2 No. 14 or larger strand conductors.
4. For general wiring use No. 12 minimum.
5. Home Runs. Except where specifically indicated, design branch circuits according to NFPA 70 Article 310. Use home run circuit numbers as indicated for panelboard connections. Each isolated ground circuit shall include a neutral for each phase conductor. Properly calculate the size of conductor needs for voltage drop on long circuit runs.
6. Neutral conductors. Provide neutral conductors as required for branch and feeder circuits, or as indicated on drawings, in full compliance with the requirements of the NEC.
7. Color Code. Use factory-colored insulated conductors for No. 10 and smaller conductors and color code larger insulated conductors with an approved field-applied tape. Follow the color scheme below.

Line	208/120	208/120 (ISOL.GND.)	480/277
A or L1	Black	Black/Yellow	Brown
B or L2	Red	Red/Yellow	Orange
C or L3	Blue	Blue/Yellow	Yellow
Neutral	White	White/Yellow	Gray
Ground	Green	Green/Yellow	Green
Switch Leg	Pink or Violet		Pink or Violet

Color code low-voltage security control cabling Orange.
Color code low-voltage telephone/data cabling Purple.
Color code low-voltage fire alarm cabling Violet.

    a. Where more than one conductor of the same phase or more than one neutral or ground conductor occurs at the same outlet or junction box, these conductors shall be

identifiable from each other by use of stripes or distinguishing markings.

b. All wiring associated with isolated ground receptacles (line, neutral, ground) shall have a yellow tracer on each conductor.

c. The neutral tracer color shall match the phase conductor color with which it is associated.

d. Use different colors for control wiring.

2-Hour UL-Listed Fire Rated System: For fire pump circuits, fire detection/alarm/suppression circuits, and other critical circuits to remain in service for a period during a fire.

1. Size shall be No. 12 AWG minimum.
2. Soft-drawn, annealed copper. Solid for No. 12 and No. 10 AWG. Stranded for No. 8 AWG and larger with Class-B stranding.
3. Insulation shall be Type RHH, 600 volt, 90-degree (C). Rubber insulated with silicone ceramification. Insulation classified low smoke per ASTM-E-662-97.
4. Sheath shall be nonmetallic, moisture, sunlight and corrosion resistant, and flame retardant, specifically approved for this application.
5. Conduit:
    a. Two-hour fire-rated systems shall be installed in rigid metallic conduit as required to conform to UL-listing. Provide rigid metallic conduit system for installation of 2-hour fire-rated conductors where circuits pass through and into the boundaries of the building.
    b. Rigid Galvanized Steel Conduit (RGS), size three-quarter inch or larger. Use RGS conduit, unless noted otherwise on drawings.
6. Use Electrical Metallic Tubing (EMT), size three-quarter inch or larger, for 2-hour fire-rated systems only where approved in writing by the Engineer and the Owner.
7. Electrical circuit protective system shall be approved for vertical installation, including cable support mechanism.
8. Electrical circuit protective system shall be approved with a fire rated seal used to prevent smoke from entering unwanted areas.
9. For elevator controller supply conductors, emergency feeder circuits, and other circuits where indicated on Drawings, where specified, or where required per NEC-700.9(D)(1).
10. Listings:
    a. UL 2196. Exposure up to 1850 degrees (F) with immediate application of water hose stream and maintenance of full utilization voltage and electrical load throughout the duration of the test.
    b. UL 83.
    c. UL Fire Resistance Directory:
        1. Electrical Circuit Protective system (FHIT) No. 27, 25, or accepted substitution.
    d. 2-hour fire-rated circuit system shall be UL listed with steel pullbox, steel conduit body, conduit couplings, ground wire, pulling lubricant, and supports, in accordance with the applicable UL electrical circuit protective system (FHIT).

1. Where 2-hour fire-rated circuit system UL-listing does not include pullbox or conduit body, provide 2-hour fire-rated construction for termination of raceway at pullbox or conduit body.
2. Where 2-hour fire rated circuit system UL-listing does not include ground wire provide ground wire of same construction as ungrounded circuit conductors.
3. Where 2-hour fire rated circuit system UL-listing does not include pulling lubricant, provide UL-listed 2-hour fire rated circuit system with conductors suitable for installation without pulling lubricant.

11. Other UL-listed two-hour fire rated circuit protective systems may be used where approved by the NEC and where proposed substitutions are accepted in writing by the Design Professional and the Owner. Refer to Division 01 requirements for submittals and substitutions.
    1. Mineral-insulated (MI) cable per NEC-332.
    2. UL-listed fire-wrapping for conductors rated 600 volt and below.
    3. Concrete encasement.
12. Where indicated on plans or specifications, provide UL-Listed 2-Hour Fire-Rated system for circuit(s) rated 600 volts or below.
13. Install 2-hour UL-Listed, fire-rated system in rigid galvanized steel (RGS) conduit, unless otherwise noted on drawings. Where accepted in writing by Engineer and Owner, 2-hour UL-Listed fire-rated system may be installed in electrical metallic tubing (EMT). Refer to raceway requirements.
14. Install 2-hour UL-Listed fire-rated system in accordance with manufacturer's instructions, the requirements of the NEC and UL.
15. Substitutions. Where substitution of alternate 2-hour UL-Listed fire-rated systems are accepted in writing by the Engineer and the Owner, provide alternate systems in accordance with manufacturer's instructions and the requirements of the NEC, UL Listing, NFPA, and Owner's standards. Alternate systems include, but are not limited to, mineral-insulated (MI) cable, concrete encasement, and fire-wrapping of designated cable and conduit systems.

Wiring Connections and Terminations:

1. Provide factory-fabricated, compression-type metal connectors of the size, rating, material, type and class as indicated for each service. Where not indicated, provide proper selection as required to comply with installation requirements and with NEC standards. Select from only following types, classes, kinds and styles:
2. Type:
    a. Solderless pressure connectors.
    b. Insulated spring wire connectors with plastic caps for 10 AWG and smaller.
    c. Insulated ring- or spade-type compression terminals for termination of stranded conductors at wiring devices and terminal blocks.
    d. Crimp.

e. Threaded.

3. Class: Insulated.
4. Material: Copper (for CU to CU connection).
5. Style:
    a. Insulated terminals. Use ring-terminal for control wiring. Use flange (fork) spade compression terminal for termination of stranded conductors at wiring devices, including ground connection.
    b. Split bolt-parallel connector.
    c. Pigtail connector.
    d. Pre-insulated multi-tap connector: NSI Industries “Polaris” series, Ilsco Corp. “Clear Tap” type PST, Burndy /FCI “Unitap”, or accepted substitution.
6. Install splices, taps and terminations which have both mechanical strength and insulation equivalent to or better than the conductor. Make splices, taps and terminations to carry full ampacity of conductors without perceiving temperature rise.
7. Conductor splices and taps shall be made only in junction boxes or wireways, and shall be accessible. Conductor splices and taps shall be kept to the minimum necessary to completely wire each branch circuit and feeder as indicated on the drawings. Conductor splices and taps shall generally be made and installed above grade.
8. Splices below grade shall be in water-tight handholes, pull boxes, or manholes approved for this use, and shall be made watertight with epoxy resin type splicing kits similar to Scotchcast. Under no circumstances, however, shall the Contractor make or install splices or taps below grade without having first secured the written approval of the Owner's duly authorized representative.
9. Use splice, tap and termination connectors which are compatible with the conductor material. Use compression (pressure-type, full circumferential) lugs or connectors for terminations or splices of all stranded conductors. Use ring-tongue type terminators on all control wiring. Use flanged spade type terminators for termination of stranded conductors at wiring devices, including ground connection. Connect all conductors No. 6 AWG and larger using high conductivity, wrought copper, color-keyed compression connectors.
10. Crimping tools, dies, and connectors shall be products of the same manufacturer.
11. Electricians installing compression connectors must have current certification for using crimping tool with which they are working.
12. Thoroughly clean wires before installing lugs and connectors.
13. Terminate spare conductors with electrical tape.
14. Make grounding (earth) conductor approximately 2 inches longer than the ungrounded (phase) and grounded (neutral) conductors at both ends. This extra length of grounding conductor shall be provided at each splice and termination point to ensure the continuity of the grounding conductor in the event that splices or terminations of the phase or neutral conductors inadvertently separate under strain.

Armored Cable:

1. Size. No. 12 AWG minimum.
2. Construction:
    a. Conductor. Soft-drawn, annealed copper. Solid for No. 12 and No. 10 AWG. Stranded for No. 8 AWG and larger.
    b. Insulation. THHN.
    c. Armor. Flexible, spiral-wound, square-locked, hot-dipped galvanized steel strip or aluminum strip.
    d. Sheath. Nylon or plastic outer sheath between insulated conductors and armor.
3. Use. For branch circuits only where accepted in writing by the Engineer and by the Owner's Representative for each specific location and application proposed for installation by the Contractor.
4. Listing. UL 4, type ACT HH.
5. Install armored cable in accordance with NEC Article 333. Do not install armored cable in thermal insulation. Use fittings specifically designed for armored cable.
6. Obtain permission in writing from the Owner and from the Design Professional prior to using or installing armored cable.

Provide factory-wrapped water-proof flexible barrier material for covering wire and cable wood reels, where applicable; and weather resistant fiberboard containers for factory packaging of cable, wire and connectors, to protect against physical damage in transit. Damaged cable, wire or connectors shall not be used and shall be removed from project site. Store cable, wire and connectors in their factory-furnished coverings in a clean, dry indoor space elevated above grade, which provides protection against the weather and sunlight.

Install electrical cable, wire and connectors as indicated, in accordance with the manufacturer's written instructions, the applicable requirements of NEC and as required to ensure that products serve the intended functions.

Select conductors on the basis of their purpose and UL listing:

1. Generally, use types THHN/THWN-2 in building interiors and other dry locations.
2. Outdoors and underground in raceways, use type XHHW.
3. Conductors subject to abrasion, such as in lighting poles, shall be type THHN/THWN-2.

Neatly and securely bundle or cable all conductors in an enclosure using nylon straps with a locking hub or head on one end and a taper on the other.

Torque conductor connections and terminations to manufacturers recommended values.

Perform continuity test on all power and equipment branch circuit conductors. Verify proper phasing connections and phase rotation, where applicable.

Conductors may be run in parallel on sizes 1/0 AWG to 750 kcmil inclusive, provided all paralleled conductors are the same size, length, and type of insulation. Except as otherwise shown on drawings, no more than three line conductors and on neutral conductors may be run in one circuit, and they shall be arranged and terminated to ensure equal division of the total current between all conductors connected in parallel. Where parallel connection is contemplated, obtain approval from the Owner's representative and Engineer prior to installation.

Prior to final acceptance, make voltage, insulation, and load tests necessary to demonstrate to the Engineer and to the Owner's Representative the satisfactory installation and proper performance of all circuits.

Electrical Service

Electrical service will be provided by Lubbock Power and Light with a utility transformer. The secondary voltages typically available are 480Y/277v 3f and/or 208Y/120v 3f.

Schedule power outages to avoid interference with the Owner's activities. Obtain approval from Owner at least 30 days prior to the requested outage. Demonstrate that all materials and equipment are on site prior to making outage request. Provide to the Owner and Engineer a schedule showing sequence and duration of all activities during the requested outage. At the Owner's option, outages may be scheduled at night or weekends. Outages and overtime incurred in support of outages shall be scheduled and provided at no additional cost to Owner.

All electrical service charges shall be at the expense of the Contractor.

Grounding and Bonding

Grounding Conductors

1. Material: copper.
2. Equipment Grounding Conductors: Insulated with green-colored insulation.
3. Isolated Ground Conductors: Insulated with green-colored insulation with yellow stripe. On feeders with isolated ground, use colored tape, alternating bands of green and yellow tape to provide a minimum of three bands of green and two bands of yellow.
4. Grounding Electrode Conductors: bare solid conductors.
5. Underground Conductors: Bare, tinned, solid, unless otherwise indicated.
6. Bare Copper Conductors:
    a. Solid Conductors: ASTM B 3.
    b. Assembly of Stranded Conductors: ASTM B 8.
    c. Tinned Conductors: ASTM B 33.
7. Copper Bonding Conductors:
    a. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG copper, ¼" diameter.
    b. Bonding Conductor: No. 4 or No. 6 AWG, stranded copper conductor.

c. Bonding Jumper: Bare copper tape, braided bare copper conductors, terminated with copper ferrules.
d. Tinned Bonding Jumper: Tinned-copper tape, braided copper conductors, terminated with copper ferrules.

8. Grounding Bus: Bare, annealed copper bars of rectangular cross section, with insulators.

Connectors

1. Comply with IEEE 837 and UL 467; listed for specific types, sizes, and combinations of conductors and connected items.
2. Bolted Connectors: Bolted-pressure-type connectors or compression type.
3. Welded Connectors: Exothermic-welded type, in kit form, and selected per manufacturers written instructions.

Grounding Electrodes

1. Ground Rods: Copper-clad steel.
2. Chemical Electrodes: Copper tube, straight or L-shaped, filled with nonhazardous chemical salts, terminated with a 4/0 bare conductor. Provide backfill material recommended by manufacturer.

Bonding Materials

1. Bonding lugs, bonding rings, and other bonding material installed as recommended by manufacturer.

Application

1. Use only copper conductors for both insulated and bare grounding conductors.
2. Make connections to prevent galvanic action or electrolysis.
3. Exothermic-Welded Connections: Use for connections to structural steel and for underground connections unless otherwise noted.
4. Grounding Bus: Install in electrical and telephone equipment rooms, in rooms housing service equipment, and elsewhere as indicated.
5. Underground Grounding Connections: Use copper conductor, no. 2/0 AWG minimum. Bury at least 24 inches below grade or bury 12 inches above duct bank when installed as part of the duct bank.

Equipment Grounding Conductor Installation

1. Comply with NFPA 70, Article 250, for types, sizes, and quantities of equipment grounding conductors, unless specific types, larger sizes, or more conductors than required by NFPA 70 are indicated.
2. Install insulated equipment grounding conductor with circuit conductors for the following items, in addition to those required by NEC:

a. Feeders and branch circuits.
b. Lighting circuits.
c. Receptacle circuits.
d. Single-phase motor and appliance branch circuits.
e. Three-phase motor and appliance branch circuits.
f. Flexible raceway runs.
g. Armored and metal-clad cable runs.

4. Busway Supply Circuits: Install insulated equipment grounding conductor from the grounding bus in the switchgear, switchboard, or distribution panel to equipment grounding bar terminal on busway.
5. Computer Outlet Circuits: Install insulated equipment grounding conductor in branch-circuit runs from computer-area power panels or power-distribution units.
6. Isolated Grounding Receptacle Circuits: Install an insulated equipment grounding conductor connected to the receptacle grounding terminal. Isolate grounding conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service, unless otherwise indicated.
7. Isolated Equipment Enclosure Circuits: For designated equipment supplied by a branch circuit or feeder, isolate equipment enclosure from supply raceway with a nonmetallic raceway fitting listed for the purpose. Install fitting where raceway enters enclosure, and install a separate equipment grounding conductor. Isolate equipment grounding conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service, unless otherwise indicated.
8. Nonmetallic Raceways: Install an equipment grounding conductor in nonmetallic raceways When called out for specialized equipment installations.
9. Air-Duct Equipment Circuits: Install an equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners and heaters. Bond conductor to each unit and to air duct.
10. Water Heater, Heat-Tracing, and Antifrost Heating Cables: Install a separate equipment grounding conductor to each electric water heater, heat-tracing, and antifrost heating cable. Bond conductor to heater units, piping, connected equipment, and components.
11. Signal and Communication Systems: For telephone, alarm, voice and data, and other communication systems, provide No. 4 AWG minimum insulated grounding conductor in raceway from grounding electrode system to each service location, terminal cabinet, wiring closet, and central equipment location.
    a. Service and Central Equipment Locations and Wiring Closets: Terminate grounding conductor on a 1/4-by-2-by-12-inch grounding bus.
    b. Terminal Cabinets: Terminate grounding conductor on cabinet grounding terminal.
12. Metal Poles Supporting Outdoor Lighting Fixtures: Provide a grounding electrode in addition to installing a separate equipment grounding conductor with supply branch-circuit conductors.
13. Common Ground Bonding with Lightning Protection System: Bond electrical power system

ground directly to lightning protection system grounding conductor at closest point to electrical service grounding electrode. Use bonding conductor sized same as system grounding electrode conductor, and install in conduit.

Ground Rod, Grounding Conductor, Bonding Equipment Installation

1. Ground Rods: Install at least three rods spaced at least one-rod length from each other and located at least the same distance from other grounding electrodes.
    a. Drive ground rods until tops are 2 inches below finished floor or final grade, unless otherwise indicated.
    b. Interconnect ground rods with grounding electrode conductors. Use exothermic welds, except at test wells and as otherwise indicated. Make connections without exposing steel or damaging copper coating.
2. Grounding Conductors: Route along shortest and straightest paths possible, unless otherwise indicated. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.
3. Bonding Straps and Jumpers: Install so vibration by equipment mounted on vibration isolation hangers and supports are not transmitted to rigidly mounted equipment. Use exothermic-welded connectors for outdoor locations, unless a disconnect-type connection is required; then, use a bolted clamp. Bond straps directly to the basic structure taking care not to penetrate any adjacent parts. Install straps only in locations accessible for maintenance.
4. Metal Water Service Pipe: Provide insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes by grounding clamp connectors. Where a dielectric main water fitting is installed, connect grounding conductor to street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
5. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with grounding clamp connectors.
6. Bond interior metal piping systems and metal air ducts to equipment grounding conductors of associated pumps, fans, blowers, electric heaters, and air cleaners. Use braided-type bonding straps.
7. Bond each aboveground portion of gas piping system upstream from equipment shutoff valve.

Raceways and Conduits

Wiring Installation in Raceways

1. Wire and cable shall be pulled into clean, dry conduit.
2. Pull conductors together where more than one is being installed in a raceway.
3. Use UL listed pulling compound or lubricant, when necessary. Compound must not deteriorate conductor and insulation.
4. Do not use a pulling means, including fish tape, cable or rope which can damage the raceway.

5. Install wire in raceway after interior of building has been physically protected from the weather and all mechanical work likely to injure or damage conductors has been completed.
6. Line and load conductors of motor starters, safety disconnects, and similar devices shall not be contained in the same conduit or raceway. Provide separate raceway for line and load conductors of motor starters, safety disconnects, and similar devices.

Conduit and Fittings

1. Conduit fittings shall be designed and approved for the specific use intended. Conduit fittings, including fittings for flexible conduit, shall have insulated throats or bushings. Rigid conduits shall have insulated bushings, unless grounding bushings are required by NEC Article 250. Grounding bushings shall have insulated throats.
2. Rigid Metal Conduit.
    a. Conduit. Rigid hot-dipped galvanized steel (RGS) conduit with zinc-coated threads and an outer coating of zinc chromate.
    b. Fittings. Threaded steel or malleable iron, either cadmium plated or hot-dipped galvanized. Expansion fittings shall be OZ Type DX, or approved equal.
3. Rigid Aluminum Conduit:
    a. Conduit. Rigid aluminum conduit (RAC), alloy 6063, temper designation T1.
    b. Fittings. Threaded aluminum. Connectors shall be insulated-throat type. Expansion fittings shall be OZ Type DX.
    c. Listing:
        1. Rigid aluminum conduit: UL 6A.
        2. b. Fittings: UL 514B.
4. Electrical Metallic Tubing (EMT):
    a. Conduit. Galvanized electrical steel tubing.
    b. Fittings:
        1. 1” and Smaller: Steel compression type, either cadmium plated or hot dipped galvanized. Connectors shall have insulated throat bushings.
        2. Larger than 2”: Double set screw, either cadmium plated or hot-dipped galvanized.
        3. Expansion fittings shall be OZ Type TX or approved equal.
5. Rigid Nonmetallic Conduit:
    a. Conduit:
        1. Schedule 40 polyvinyl chloride (PVC).
        2. Schedule 80 polyvinyl chloride (PVC), where indicated on drawings or required by electric utility company (AEP) service standards.
    b. Fittings. Solvent weld socket type.
    c. Temperature. Nonmetallic conduit and fittings shall be suitable for temperature rating of conductor but not less than 90°C.
6. Flexible Metal Conduit:
    a. Conduit. Spiral-wound, square-locked, hot-dipped galvanized steel strip.

b. Fittings. One-screw and two-screw for 1-1/2 inches and larger, double-clamp steel or malleable iron, either cadmium plated or hot-dipped galvanized.

7. Liquid-tight Flexible Steel Conduit:
    a. Conduit. Single strip, continuous, spiral-wound, flexible square-interlocked, double-wrapped steel, hot-dipped galvanized inside and outside, forming a smooth internal wiring channel with a bonded, liquid-tight outer jacket of flexible polyvinyl chloride (PVC).
    b. Fittings. Compression type, malleable iron, with insulated throat, either cadmium plated or hot-dipped galvanized.
8. Liquid-tight Flexible Non-metalic Conduit:
    a. Conduit, liquid-tight jacket of flexible polyvinyl chloride (PVC) jacket over rigid PVC core.
    b. Fittings. Compression type, malleable iron, with insulated throat, either cadmium plated or hot-dipped galvanized.
9. Sealing Fittings. Where conduit sealing fittings are required, they shall be of malleable iron, copper-free cast aluminum, ferroalloy, or other suitable construction. Provide wide fill fitting to facilitate insertion of sealing compound. Provide fitting closures, unions, and adapters of the same manufacturer that are compatible with the selected sealing fitting.
    a. Orientation. Unless specifically noted otherwise, provide conduit sealing fittings suitable for installation in both horizontal and vertical raceways.
    b. Combination Drain/Seal Fitting. Where drain/sealing fittings are required, they shall be of malleable iron construction with an internal drainage path which provides a visual means to ensure that the compound chamber is properly filled. The installation shall enable the drain/breather fitting and filler plug to be installed immediately after the sealing compound is poured.
    c. Finish. Hot dipped galvanized.
    d. Compound. Provide sealing compound compatible with the specified sealing fitting, and in compliance with the requirements of NEC-501.15(C).
    e. Listing. UL 886.

Wireways

1. Material not less than 16-gage sheet steel.
2. Cross section dimensions not less than 4” by 4”.
3. Provide dividers to separate wiring of different signal types (e.g.: power, data, communications, control, etc.).
4. Provide all sheet metal parts with a rust-inhibiting phosphatizing primer coating and finished in gray enamel, minimum of two coats. All hardware shall be cadmium plated to prevent corrosion.
5. Type:
    a. Indoors. NEMA 1.
    b. Outdoors. NEMA 4X.

Conduit, wireway, and other raceway systems shall not serve as branch circuit grounding conductors.

Minimum Trade Size:

1. General. 3/4 inch, except that 1/2-inch flexible metal conduit may be used in lengths not exceeding 72 inches for tap conductors supplying luminaires.
2. Below Grade, Direct-Buried, or Concrete-Encased; 1 inch.

Use rigid steel conduit (RGS) throughout the project except as permitted or specified below:

1. Use EMT in standard trade sizes in the following areas:
    a. Interior walls or ceiling spaces.
    b. Where exposed when installed more than 8 feet above finished floor in open work areas, mechanical rooms or electrical rooms.
    c. Conduit which enters or leaves the top of panelboards or enclosures may be EMT, provided the top of the panelboards or enclosures are a minimum of 5 feet above finished floor and such panelboards and enclosures are located in mechanical or electrical rooms.
2. Rigid Aluminum Conduit (RAC). Where accepted in writing by the Owner's Representative and the Design Professional, use of rigid aluminum conduit is permitted in the following areas and locations:
    a. Corrosive environment. Exposure to salt air in coastal areas constitutes a corrosive environment.
    b. Exposed outdoor locations.
    c. Wet and damp locations.
    d. Other locations as per design drawings.
3. Below Grade:
    a. Use RGS or rigid nonmetallic conduit.
    b. All horizontal to vertical transitions shall be made using RGS elbows and RGS conduit stub-ups. All RGS in-contact with earth shall be PVC wrapped.
    c. Use direct-buried schedule 40 PVC conduit where installed below grade for branch circuits, and feeder circuits as indicated on plans.
    d. Separation from other below-grade utilities and systems. Twelve inches minimum. Relaxation of this requirement must be approved in writing by the Owner's Representative.
4. Rigid Non-Metallic Conduit (PVC):
    a. Non-metallic conduit installed above ground shall be approved in writing by the Owner's representative and the Design Professional prior to installation. Use PVC Schedule 80 where installed above ground or otherwise exposed.
5. Install flexible conduit connection such that vibrations are not transmitted to adjoining conduit or building structure.
    a. Install liquid-tight flexible metal conduit for connections to all electrical equipment subject to vibration or movement, including dry-type transformers. Maximum length

72 inches; 36 inches for connection to dry type transformers. Provide liquid-tight flexible metal conduit with proper liquid-tight fittings for exterior locations or in wet areas.

b. Install flexible metal conduit (not liquid-tight) for connections to electrical equipment located in a duct or plenum used for environmental air. Maximum length 48 inches.
c. Minimum size shall be 3/4-inch except for lay-in luminaires, where it may be 1/2-inch flexible steel pre-manufactured fixture whips not exceeding 72 inches.
d. Chain-Hung Luminaires. Provide flexible steel conduit from a junction box directly above the luminaire. Conduit length shall be such that the luminaire weight is not borne by the conduit and does not cause excessive sag; 72 inches maximum.
e. Lighting Troffers. Provide 6 feet of flexible steel conduit for connection from recessed troffer to a junction box mounted at the structure.

Where conduit penetrates fire-rated walls and floors, provide pipe sleeve two standard sizes larger than conduit. Coordinate with Division 7 to fire-seal penetrations of fire-rated walls and floors; pack void around conduit with oakum and fill ends of sleeve with fire-resistive compound or provide mechanical fire-stop fittings with UL listed fire-rating or seal opening around conduit with UL listed foamed silicone elastomer compound equal to fire-rating of floor or wall.

Cable Trays

Specify ladder type cable trays, in compliance with current applicable EIA/TIA standards for communications pathways. Tray to be 6063-T6 aluminum extrusion with aluminum allow 2024 fasteners, fittings, and accessories. Basket type trays will only be permitted with FP&C PM permission.

Provide covers on tray where exiting the top of control cabinets, communication/data cabinets, distribution panelboards and switchboards which covers vertical sections of tray and 90 degree bend.

Provide warning signs every 50 feet with 1/2 inch high black letters on yellow plastic with the following wording:

WARNING! DO NOT USE CABLE TRAY AS
WALKWAY, LADDER, OR SUPPORT.
USE ONLY AS MECHANICAL SUPPORT
FOR CABLES AND TUBING!

Install cable trays, where shown, according to NEC Article 392 and NEMA requirements. Install cable trays in accordance with manufacturer's written instructions and recommendations.

Automatic Transfer Switches

Specify a UL 1008 factory-assembled automatic transfer switch which is electrically operated and mechanically held in each direction, and which is true double-throw.
Provide switch in a UL listed, free-standing NEMA 12 enclosure suitable for floor mounting. Enclosure shall provide wire bending space as required by NEC. The cabinet door shall be key-locking. Provide LED-type switch position indicator lamps and power available lamps for both sources (4 total) on exterior face of cabinet door.
Transfer switches shall be rated for continuous duty at 100 percent of rated current, in the specified enclosure at rated temperature without de-rating. Transfer switches shall conform to the applicable requirements of UL 1008 for emergency system total load. The automatic transfer switches shall be fully rated to carry and protect all types of loads, inductive and resistive, without de-rating. Circuit breaker type transfer switches are not acceptable.

Transfer switch equipment shall have withstand and closing rating in RMS symmetrical amperes greater than the available fault current at the distribution panelboard providing normal (utility) service to the transfer switch. Series rating is not acceptable.

All pilot devices and relays shall be of the industrial type with self-cleaning contacts and rated 10 amperes, minimum.

Transfer switches shall be double throw, electrically and mechanically interlocked, and mechanically held in both positions.

The contact assemblies shall be actuated by two non-fused electric operators or stored energy mechanism and be energized only momentarily during transfer, providing inherently double throw switching action, and connected to the transfer mechanism by a simple over-center type linkage. Control power for all transfer operations shall be derived from the line side of the source to which the load is being transferred.

Transfer switches shall be equipped with permanently attached manual operating handles and quick break, quick make over center contact mechanisms suitable for safe manual operation under load. The manual operator shall provide the same contact-to-contact transfer time as provided under normal automatic operation to prevent possible flashovers from switching the main contacts slowly.

Transfer switches shall be of open-transition (break-before-make) design. Each transfer switch shall be positively interlocked both mechanically and electrically to prevent simultaneous closing of both sources under either automatic or manual operation. Main contacts shall be mechanically locked in position in both normal and emergency positions. Provide transfer switch with delayed transition center-neutral position and dual-motor operator mechanism for switching highly inductive loads. Each transfer switch shall have a manual neutral position for load circuit maintenance. A transfer switch position indicator shall be visible from the front of the switch to show to which source the transfer switch is connected.

Main switch contacts shall be high pressure silver alloy. Contact assemblies shall have arc chutes for positive extinguishment. Arc chutes shall have insulating covers and arc barriers to prevent inter-phase flashover.

All three-phase four-wire transfer switches used on system with ground fault equipment shall be true four-pole switched neutral type, with neutral pole fully rated and connected to a common, insulated shaft. The fourth (neutral) pole contacts shall be identical construction as, and operate simultaneously with, the main power contacts. Add on or overlapping neutral contacts are not acceptable.

Where a solid neutral is indicated, provide a neutral bar with the same ampere capacity as the ampere rating of the switch.

Drawout Mechanism (as required for critical circuits):

1. Provide transfer switches with drawout mechanism to allow easy access for preventative maintenance, testing or inspection. The drawout mechanism shall provide visual indication of the position of the switch (i.e., Connected, Disconnected, Withdrawn) during the drawout operation.
2. Provide transfer switch with a true drawout configuration which does not require disconnection of any electrical or mechanical devices by personnel performing maintenance upon and/or operation of the switch. Provide the automatic transfer switch with rollers or casters to allow removal from enclosure by simply rolling out the unit.

Make transfer switch suitable for busway and/or conduit & wire connection to normal source, emergency source, and load terminals as indicated on construction drawings and other applicable contract documents. Make transfer switch suitable for top entry, bottom entry, or both as indicated on construction drawings and other applicable contract documents.

Terminal blocks shall conform to NEMA ICS 4. Terminal facilities shall be arranged for entrance of external conductors from the top or bottom of the enclosure.

Automatic Solid State Controller:

1. Controller shall be solid state and designed for a high level of immunity to power line surges and transients, demonstrated by test to IEEE Standard 587. The controller shall have optically isolated logic inputs, high isolation transformers for AC inputs, and relays on outputs.
2. The controller shall be equipped with self diagnostics, which performs periodic checks of the memory, input/output (I/O), and communication circuits, with a watchdog/power fail circuit.
3. The controller shall be accurate to within 1 percent of full-scale value for measured parameter. Voltage and current for all phases shall be sampled simultaneously to assure high accuracy in conditions of low power factor or large waveform distortions.
4. Voltage sensors shall allow for adjustment to sense partial loss of voltage on any phase.
5. Automatic controls shall signal the engine generator set to start upon signal from normal

source sensors indicating loss of normal source. Battery voltage starting contacts shall be gold, dry type contacts factory-wired to a field wiring terminal block.

6. The switch shall transfer when the emergency source reaches the set point voltage and frequency.
7. The controller shall be capable of storing records in memory for access either locally or remotely for up to 100 events. The reports shall include date, time and a description of the event, and shall be maintained in a non-volatile memory.
8. If the controller is supplied with an automatic exercise feature (engine start, power transfer, and cool down/shut down) this feature shall be disabled. TTU employs personnel to maintain all engine/generator sets on campus.

Factory and field test the complete automatic transfer switch assembly to ensure proper operation and compliance with the requirements of this specification and with UL 1008, Automatic Transfer Switches. Provide a copy of the factory and field test report to the Owner.

Specify to provide the services of the manufacturer's factory-trained representative(s) on-site for testing and start-up of the automatic transfer and switches, and associated components of the emergency electrical distribution system. Verify data communication and functionality of interface with Energy Management System, HVAC / DDC controls, remote devices, and engine-generator set.

Provide, at no cost to the Owner, on-site training for Owner's designated personnel in the construction, operation, maintenance, troubleshooting and repair of the automatic transfer switch. Formal training for the operation and maintenance of all equipment and systems specified herein shall be given by factory trained and certified personnel.

Electrical Generating Plant

This Section specifies the furnishing, installation, and acceptance testing of a complete and operable packaged electric generating plant for standby service. Include all devices and equipment specified herein, as shown on the drawings, or required for the service. Equipment shall be new, factory tested, and delivered ready for installation. Equipment shall meet applicable requirements of NFPA-110, Type 10 and EPA Tier 3 emissions requirements for non-road diesel engines. Cummins should be the Basis of Design.

Provide a no deductible warranty for products against defects in materials and workmanship for a five-year or 1500-hour period from the start-up date, per the manufacturer's Basic Extended Coverage Limited Warranty.

The supplier shall be the manufacturer's authorized distributor, who shall provide initial start-up services, conduct field acceptance testing, and warranty service. The supplier shall have 24-hour service availability and factory-trained service technicians authorized to do warranty service on warrantable

products. The supplier shall have locally available service technicians. Locally available shall be understood as available onsite within 2 hours' notice, 24 hours per day, and 365 days per year. Provide a complete, packaged, diesel engine-electric generating plant which is prewired, pre-piped, assembled and aligned on a single skid-type base. Make the packaged system of new, unused equipment of the manufacturer's latest design. Include necessary instruments, devices, switches, and other appurtenances for proper operation of the unit. Supply steel safety guards around all external rotating parts. Provide a unit on which adjustments, repairs and normal maintenance are possible without the use of special tools. Provide an overall, weatherproof housing as further described in this section. The Contractor will be responsible for the proper performance of the complete unit and support systems. Transition time from the instant of failure of the normal power source to the generator source shall not exceed 10 seconds per NEC 700, Life Safety Code (LSC, NFPA 101) and NFPA 110.

Provide a stationary, liquid-cooled, full diesel, compression ignition engine, either naturally aspirated or turbocharged, with forged steel crankshaft and connecting rods. The cylinder block shall be cast iron with a minimum of two valves per cylinder. Supply a unit suitable for operation on No. 2 diesel fuel oil. Direct-injection diesel engine meeting the requirements of this Section shall be acceptable upon review of submittal data.

Provide an engine with brake horsepower, at minimum tolerance level, not less than 10 percent greater than required to drive the generator at full load rating, including losses, and with all accessories attached

An electronic governor system shall provide automatic isochronous frequency regulation. Speed must not exceed 10 rpm above generator rated speed. Provide governor of the full hydraulic type, Woodward EGP3 with a 2301A electronic speed controller, or an accepted substitution, to maintain frequency stability of any constant load, including no load, within plus or minus 1/4 percent, and to maintain frequency regulation between no load steady-state and full load steady-state within plus or minus 1/4 percent. Speed droop must be isochronous from no load to full load.

Specify standard wet-cell lead acid batteries or absorbed glassmatt (AGM) sealed valve-regulated lead-acid (VRLA) batteries. Gel-cell batteries using a gelled electrolyte in a sealed battery case are NOT acceptable.

Specify a static, solid-state type battery charger unit which automatically controls the charge rate and which has an adjustable charging rate. Include a charging rate ammeter, a voltmeter, and a manual reset, thermal overload circuit breaker to protect the rectifier assembly and transformer. Size charger to recharge the battery from a fully discharged state to a fully charged state within 24 hours or less. Arrange charging system such that charging occurs from the normal source when the generator is shut down, and from the generator when the generator unit is supplying emergency power.

Specify closed-loop, liquid coolant system complete with unit-mounted radiator, fan, coolant manifold, coolant expansion chamber (overflow tank), temperature control valve, and engine-driven coolant circulating pump.

Specify an engine-mounted, corrosion-resistant, thermostatically controlled coolant heater(s) for each engine. Heater voltage shall be as shown on the project drawings. The coolant heater shall be UL499 listed and labeled.

Specify a high degree, critical-rated silencer (muffler) capable of passing rated engine exhaust gases with maximum silencing capacity.

Specify fuel tank to be tank-in-tank construction. Interstitial space shall have a fuel sensor to detect a leak in the inner tank. Provide leak detection and monitoring system for the fuel tank. The alarm shall be on the remote alarm panel. Fuel tank is to be sized for 12 hours of operation at maximum load.

Specify a direct-coupled, 4-pole, synchronous, low reactance, brushless-type generator (alternator) with amortisseur windings, revolving field permanent magnet generator (PMG), exciter, single pre-lubricated sealed bearing, air cooled by a direct drive centrifugal blower fan, and built-in static rectifier and statically regulated torque matched excitation system with automatic voltage regulator.

Specify a factory-fabricated, -wired, and -tested microprocessor-based monitoring, metering, and control system. The control system shall provide for operator interface, digital voltage regulation, digital governing, protective functions, automatic starting, automatic unloading and cool down, automatic shutdown, and communication of alarm and status signals.

The generator controller shall be capable of communicating all data, including alarm and trip data, in ModBus RTU format to the digital power meter in the Generator Emergency Switchboard. Where the controller does not incorporate or support ModBus communication, provide a ModBus gateway for communication between the generator controller and the 480-volt Generator Emergency Switchboard power meter.

At time of Owner's acceptance, provide one set of new, unused filters of each size and type required for 12 months of operation and maintenance. Provide filters in factory sealed containers or wrapping, clearly labeled for ease of identification. Deliver filters to location as directed by Owner.

Equipment shall be warranted from defective workmanship or materials for a period of 2 years after final acceptance.

Electrical Identification

Electrical identification means, methods, materials and devices required to comply with ANSI C2, NFPA 70, NEC, and OSHA standards.

Raceway and Cable Labels

1. Feeder conduits: Provide adhesive labels, preprinted, flexible, self-adhesive vinyl with legend over laminated with a clear, weather- and chemical-resistant coating.
2. Underground-Line Warning Tape: Permanent, bright-colored, continuous-printed, vinyl tape. See TTU Operating Policies and Procedures for Underground marking installation.
    a. Not less than 6 inches wide by 4 mils thick.
    b. Compounded for permanent direct-burial service.
    c. Embedded continuous metallic strip or core is not suitable for tracing and not approved.
    d. Printed legend indicating type of underground line.
3. Tape Markers: Vinyl or vinyl-cloth, self-adhesive, wraparound type with preprinted numbers and letters for all control wiring.

Nameplates and Signs

1. Safety Signs: Comply with 20 CFR, Chapter XVII, Part 1910.145.
2. Engraved Plastic Nameplates and Signs: Engraving stock, melamine plastic laminate, minimum 1/16 inch thick for signs up to 20 sq. in and 1/8 inch thick for larger sizes.
    a. Engraved legend with black letters on white face.
    b. Punched or drilled for mechanical fasteners.
3. Fasteners for Nameplates and Signs: Self-tapping, stainless steel screws or No. 10/32, stainless-steel machine screws with nuts and flat and lock washers.

Installation

1. Identification Materials and Devices: Install at junction boxes and other locations for most convenient viewing without interference with operation and maintenance of equipment.
2. Lettering, Colors, and Graphics: Nameplates shall contain the panel designation, voltage, phase, and the designation of “fed from (feed source)”.
3. Circuit Identification Labels on Boxes: Install labels externally.
    a. Provide pre-painted junction box covers for conduit associated with fire suppression circuits.
    b. For power circuits, provide the circuit designation on the junction box cover of each circuit contained in the box.
    c. Identify normal power circuits and emergency power circuits.
4. Paths of Underground Electrical Lines: During trench backfilling, for exterior underground power, control, signal, and communication lines, install continuous underground plastic line marker located directly above line at 12 to 16 inches below finished grade.
5. Secondary Service, Feeder, and Branch-Circuit Conductors: Color-code throughout the secondary electrical system.

Panelboards

Enclosure shall be proper NEMA type as shown on the drawings:

1. NEMA 1:
    a. Back box shall be galvanized steel for flush mounted branch circuit panelboards. Back box shall have enamel electro-deposited finish over cleaned, phosphatized steel for all other type panelboards.
    b. Where power monitors or metering are specified on the Drawings, the manufacturer shall cut the doors for field mounting of the unit.
2. NEMA 3R, 3S and 12:
    a. Enclosure and doors shall have enamel electro-deposited finish over cleaned phosphatized steel.
    b. Doors shall be gasketed and equipped with tumbler type vault lock and two trunk latches where required by UL standard. Interior trim shall consist of four pieces, each covering one gutter top, bottom and both sides.

Construct cabinets in accordance with UL 50. Use not less than 16-gauge galvanized sheet steel. Provide a minimum 4-inch gutter wiring space on each side.

Apply a finish to cabinet, trim, and doors. Exterior and interior steel surfaces shall be cleaned and finished with electrostatically applied "powder coat" thermoset enamel baked over a rust-inhibiting phosphatized coating. Exterior finish color shall be manufacturer's standard gray, ANSI 49 or ANSI 61. Interior finish shall be per Architect's schedule.

Provide breakers which are quick-make and quick-break on both manual and automatic operation. Use a trip-free breaker which is trip indicating. Incorporate inverse time characteristic by bimetallic overload elements and instantaneous characteristic by magnetic trip.

Provide circuit breakers with ground fault circuit interrupter (GFI or GFCI) trip feature as scheduled or indicated on drawing, or per NEC requirement.

Provide electronic grade panelboards as scheduled on drawings to provide effective transient voltage surge suppression, surge current diversion and high frequency noise attenuation in all electrical modes for equipment.

For each panelboard, provide a steel directory frame mounted inside the door with a heat resistant transparent face and a directory card for identifying the loads served. Prepare a neatly typed, computer-generated circuit index/directory inside the front door of each branch circuit panelboard and each distribution panelboard identifying each circuit as shown on Panel Schedule and electrical one-line drawings

At the completion of the electrical system installation, check each phase of all panels under full load and arrange so that all phases shall carry the same load as near as possible.

Siemens will only be allowed with the consent of TTU BMC.

Power/Electrical Monitoring

Motor Starters

Specify magnetic, full-voltage, non-reversing motor starters unless otherwise indicated.

Specify an ambient-compensated thermal overload relay in each phase leg. Solid state 3-phase RMS sensing overload relay with phase loss and unbalance protection shall be provided in lieu of bi-metallic or melting alloy type thermal overload relay.

Size contactors according to NEMA standards or as shown, minimum size NEMA 1. Provide main pole in each phase leg, the number and type of auxiliary contacts to perform the required functions, and two spare auxiliary contacts, one normally open and one normally closed. Use double break contacts of silver-cadmium oxide or similar material to minimize sticking or welding. Provide contactor coils suitable for continuous operation at the rated voltage, 60 hertz.

Provide a NEMA 1 enclosure unless otherwise indicated on Drawings. Enclosures for starters located outside the building conditioned envelope shall be NEMA 4 or 4X as required.

Transformers

Prior to installation, submit written procedures for field tests and adjustments to be performed. Include as part of procedure the test instruments, and forms with range of acceptance values for each parameter recorded.

Unless otherwise indicated, provide three-phase, energy-efficient, dry type transformers of the two-winding type conforming to the requirements of NEMA TP-1.

Transformers shall be rated for 60-hertz operation, self-cooled NEMA Class AA.

All transformers shall be designed, manufactured, and tested in accordance with all the latest applicable ANSI, NEMA, IEEE and UL standards, and shall be UL listed and bear the UL label.

Transformers shall be low loss type with minimum efficiencies per NEMA TP-1 when operated at 35% of full load capacity. Efficiency shall be tested in accordance with NEMA TP-2.0 and shall conform to the following minimum efficiency ratings.

Single Phase		Three Phase	
kVA Rating	Efficiency	KVA Rating	Efficiency
15	97.7	15	97.0
25	98.0	30	97.5
37.5	98.2	45	97.7
50	98.3	75	98.0
75	98.5	112.5	98.2
100	98.6	150	98.3
167	98.7	225	98.5
250	98.8	300	98.6
333	98.9	500	98.7

Use copper wire (bar stock) for coil windings, continuous without splice. Provide barrel-type coils, vacuum impregnated, with high grade insulating varnish, non-hygroscopic thermo-setting type.

Specify the transformer with copper terminals, with holes pre-drilled for 3/8 inch hardware using two-hole copper compression lugs. Provide quantity and rating of terminals suitable for the application and installation configuration indicated on Drawings, such as single or multiple conductors per phase. Specify quantity of terminals suitable for connection of phase, neutral, and ground conductors as indicated on Drawings.

Use non-aging silicon steel cores held together with steel channels or angles, with low flux density, quiet operating, and vibration isolated from enclosure and support channels. The core flux density shall be well below the saturation levels and well below the usual level for standard transformers.

Provide a 220°C insulation system which is the manufacturer's standard for a maximum 115°C rise over a 40°C ambient. All insulating materials are to exceed NEMA ST20 Standards and be rated for 220°C UL Component Recognized insulation system.

Average sound levels shall not exceed the following values as measured in accordance with NEMA ST 20-4.12.

kVA Rating	dB
0-9	40
10-50	45
51-150	50
151-300	55
301-500	60

Unless otherwise specified or indicated, install transformers in metal enclosures designed to provide air-cooling and to prevent accidental contact with live conductors. Enclosures shall be fabricated of heavy gauge, sheet steel construction:

1. Enclosure shall be indoor, ventilated, drip proof, ANSI/NEMA ST 20; NEMA Type 1.
2. Outdoor transformer shall be type 2.

The following factory tests shall be made on all transformers:

1. Transformer efficiency per NEMA TP-2.
2. Transformer losses per NEMA TP-2.
3. Ratio tests at the rated voltage connection and at all tap connections.
4. Polarity and phase relation tests on the rated voltage connection.
5. Applied potential tests
6. Induced potential test.
7. No-load and excitation current at rated voltage on the rated voltage connection.

Wiring Devices

Provide back- and side-wired, industrial-grade, factory-fabricated wiring devices in the type and electrical rating for the service indicated. Where type and grade are not indicated, provide proper selection to correspond with branch circuit wiring and overcurrent protection. Attachment of wires to devices shall be by screw pressure under the head of binding screws. Arrangements depending on spring pressure or tension are not acceptable. All binding screws shall be brass or bronze.

Occupancy/Vacancy Sensors

1. Provide an occupancy sensor based lighting control system which automatically extinguishes lighting after a programmable, user adjustable time delay when personnel vacate a room or area.
2. The occupancy sensor based lighting control shall accommodate all conditions of space utilization and all irregular work hours and habits.
3. All sensors shall be capable of operating normally with electronic ballasts, PL lamp systems and rated motor loads.
4. Coverage of sensors shall remain constant after sensitivity control has been set. No automatic reduction shall occur in coverage due to the cycling of air conditioner or heating fans.
5. All sensors shall have readily accessible, user adjustable controls for time delay and sensitivity. Controls shall be recessed to limit tampering. Controls shall be accessible without special tools or removal of the device from the wall or ceiling.
6. In the event of failure, a bypass manual override shall be provided on each sensor. When bypass is utilized, lighting shall remain on constantly or control shall divert to a wall switch until sensor is replaced. This control shall be recessed to prevent tampering.
7. All sensors shall provide a method of indication to verify that motion is being detected during testing and that the unit is working.
8. Where specified, sensor shall have an additional internal, isolated relay with Normally Open, Normally Closed and Common outputs for use with HVAC/EMS/DDC control, data logging and other control options. Sensors utilizing separate, external components, and units specially modified to provide this function, are not acceptable.

9. Sensors shall have UL rated, 94V-0 plastic enclosures. Adjustments and mounting hardware shall be concealed under a removable, tamper-resistant cover to prevent tampering of adjustments and hardware.

Wall Switch Timers

1. Provide a programmable digital time switch where indicated on drawings to turn lights off after a preset time delay.
2. Control circuitry shall employ zero crossing relay closure to increase the relay life, protect from the effects of inrush current, and increase sensor longevity.
3. Time switch shall be a 3 wire, completely self-contained control system that replaces a standard wall box toggle-type switch. Time switch shall have a ground wire for safety. Time switch shall be compatible with all electronic ballasts, compact fluorescent lamps, motor loads, and other inductive loads. Switching mechanism shall be a latching air gap relay. Triac and other harmonic generating devices shall not be allowed as the output or switching device of the time switch.
4. Time scroll feature shall allow manual overriding of the preset time-out period. Selecting time scroll ON shall allow time-out period to scroll up throughout the timer possibilities to the maximum. Time scroll OFF shall allow time-out period to scroll down to minimum.
5. Time switch shall have the option for a one-second light flash warning at one minute before timer runs out.
6. Time switch shall have the option for a beep warning that shall sound every 5 seconds once the time switch countdown reaches one minute.
7. Time switch shall have manual feature for timer reset where pressing the ON/OFF switch for more than 2 seconds resets the timer to the programmed time-out period.
8. Time switch shall be capable of operating as an ON/OFF switch.
9. Time switch shall have an electroluminescent backlit liquid crystal display which shows the timer countdown.
10. Time switch shall fit behind a decorator style faceplate.
11. Settings shall be selected by either a concealed detent to activate program mode through device touch-plate, or by concealed DIP switch. The DIP switch or program selection for setting time-out, time scroll, one-second light flash and beep warning shall be concealed behind device plate to prevent tampering of adjustments and hardware. Potentiometers and similar rotary-dial type adjustments are not acceptable, except where accepted in writing by the Design Professional.

For the safety of the workers and the spirit of LEED, mechanical rooms, fire pump rooms, and electrical rooms lighting shall be controlled by a programmable digital time switch. Specify the WattStopper TS-400 or approved equal. Motion or timer actuated lighting will not be allowed in elevator machine rooms and hoistways.

Install wiring devices in accordance with applicable requirements of the NEC, NEMA, ANSI, and the product manufacturer recommendations.

Where more than one device occurs in one outlet box, such that the voltage between adjacent devices would exceed 300 volts, provide a barrier for isolation to comply with the requirements of NEC Article 404.8(B).

Ground Fault Circuit Interrupter (GFCI):

1. GFCI receptacles shall be rated 20 amperes, 125 volt with integral ground fault current interrupter.
2. End of Life. GFCI receptacles shall include End-of-Life protection, such that when the GFCI device is incapable of passing the internal self-test function, and can therefore no longer provide ground fault protection, the GFCI receptacle will either render itself incapable of delivering power, or indicate by visual or audible means that the device must be replaced.
3. Reverse Line-Load Miswire. GFCI receptacles shall include reverse line-line protection, such that the GFCI device will deny power to the receptacle face if it is mis-wired with the connections to the line and load terminals reversed.
4. Listing. UL 943, current edition.
5. Do not use feed through feature.
6. GFCI receptacles are required throughout the building within 6 feet of sinks.
7. Each GFCI device shall control only one receptacle.

Surge Protection Devices (SPD)

This Section describes the electrical and mechanical requirements for a high-energy surge protection and power conditioning filter system incorporating transient voltage surge suppression (TVSS) and high frequency electrical line noise filtering, used as component of a facility-wide suppression/filter system implemented in conjunction with the electronic grade panelboards. When specified, the unit installed in the facility-wide suppression/filter system shall provide effective high-energy transient voltage suppression, surge current diversion, high-frequency attenuation, and line control in high-exposure ANSI/IEEE C62.41-1991 environments on the load side of the facility's meter or main overcurrent device.

Single pulse surge current capacity: 120kA per mode of protection for a combined rating of 240kA per phase. All protected modes are defined per NEMA LS 1-1992, paragraph 2.2.7. Following IEEE Standard 1100-1992, section 9.11.2 recommendations, surge protection devices shall provide protection in all modes. WYE configured systems shall provide Line to-Neutral (L-N), Line-to-Ground (L-G), Line-to-Line (L-L), and Neutral-to-Ground (N-G) protection.

The system shall provide a UL 1283 Listed Electromagnetic Interference Filter capable of attenuating noise levels produced by electromagnetic interference and radio frequency interference. The system's filtering characteristics shall be expressed per NEMA LS-1, 1992, Section 2.2.11.

Each unit shall be capable of withstanding temporary over-voltage events that may be encountered within the distribution system, without damaging any of the components within the SPD, especially MOVs and other non-MOV parallel-connected elements, in accordance with NEMA LS-1 Section 2 2.2.6 and 3.6. Each unit shall provide temporary over-voltage protection for 3600 cycles at 160% of rated voltage.

Monitoring shall include one set of status monitoring lights that will provide visual indication of voltage present to the SPD for each phase of protection. The lights shall also indicate when suppressor protection has degraded to any value of less than 50%. Status indicator lights that simply indicate the presence of voltage, and provide no indication of performance, will be unacceptable. Additionally, each unit shall include an audible alarm with battery backup, a current-sensing surge counter, and two sets of Form C contacts for remote alarm monitoring.

All units shall be UL 1449, Second Edition (2007), listed and labeled as a Surge Protection Device and shall be listed and labeled to UL 1283 as an Electromagnetic Filter.

General. Install surge protection device (SPD) as close as practical to the electrical distribution wiring system, in accordance with manufacturer's wiring diagrams and written instructions and the applicable requirements of the NEC, NEMA, ANSI, local codes, and Owner requirements.
Upon completion of installation, provide the start-up and testing services of a factory authorized and factory-trained local service representative. Field testing shall use procedures, forms, instruments and materials as submitted and accepted. The tests shall include:

1. Off-Line testing: Impulse injection to verify the system tolerances as well as verification of proper neutral-to-ground bond at the facility service entrance and at each separately-derived source. To be compared to factory benchmark test parameters supplied with each individual unit.
2. On-Line testing: verification that suppression and filtering paths are operating with 100% protection as well as verification of proper neutral-to-ground bond by measuring neutral-to-ground current and voltage and by visual inspection at the facility service entrance and at each separately-derived source.
3. Voltage measurements from Line-to-Ground (L-G), Line-to-Neutral (L-N), Line-to-Line (L-L), and Neutral-to-Ground (N-G), taken at the time of the testing procedure.

Submit to the Owner's Representative and to the Architect/Engineer copies of the startup test results and the factory benchmark testing results for confirmation of proper suppression filter system function.

The SPD system shall be warranted against defective materials and workmanship for a period of ten years.

Enclosed Safety Switches

Submit arc-flash calculations and associated incident energy levels on each type of switch.

Specify switches that are UL-98 listed.

Provide NEMA 1 switch enclosures for indoor dry locations and NEMA 4X, stainless steel for outdoor locations unless otherwise shown.

Provide an operating handle suitable for padlocking in the OFF position with as many as three padlocks of 5/16 inch diameter shank. Use a defeatable, front accessible, coin-proof door interlock to prevent opening the door when the switch is in the ON position and to prevent turning the switch ON when the door is open.

Provide incoming line terminals with an insulated shield so that no live parts are exposed when the door is open.

Provide each switch with an isolated, fully rated neutral block. Make provisions for bonding the block to the enclosure.

Provide each switch with a ground lug.

Where fusible switches are shown, provide switches with rejection-type fuse holders which are suitable for use with fuses 600 Volt and below. Provide permanent marking inside switch enclosure for fuse type and size.

Provide metal nameplates, front cover mounted, which indicate the switch type, catalog number and horsepower rating (with both standard and time delay fuses).

Where used to serve motors, safety switches shall bear the horsepower rating equal to or exceeding that of the motor which they serve regardless of the size or type specified on the drawings.

Where enclosed safety switches/disconnects are shown serving exterior and/or roof mounted mechanical equipment, they shall be mounted separately from the equipment on unistrut where mounting to the equipment will obstruct airflow or maintenance and/or where required by the Owner. All racks/supports installed outside of the building shall be constructed of galvanized steel with cold galvanizing applied to any field cuts, welds, etc. unless noted otherwise.

Where safety switches/disconnects are shown serving interior air handling equipment they shall be mounted on the nearest wall or supported from structure above.

Install all safety switches/disconnects within sight of the motor they serve.

Install safety or disconnect switches where indicated, in accordance with the manufacturer's written instructions, and the applicable requirements of NEC. Install safety and disconnect switches in accordance with the directions of the Owner's Representative.

Include manufacturer's label indicating incident energy levels associated with calculated arc-flash event(s) for motor starter fault conditions.

Interior Lighting

This section includes interior luminaires with lamps, ballasts and accessories.

Design all lighting using IESNA (Illuminating Engineering Society of North America). Illumination levels will be determined in design meeting with the Project Team based on task and other criteria. Apply the information from IESNA Recommended Practice, Design Guide and Handbook publications.

Interior lighting shall be LED unless noted otherwise.

Lighting Controls

Emergency Egress Lighting

Exterior Lighting

This section includes exterior luminaires with lamps and ballasts, luminaire-mounted photoelectric relays, and poles and accessories.

Design all lighting using IESNA (Illuminating Engineering Society of North America). Apply the information from IESNA Recommended Practice, Design Guide and Handbook publications. Illumination levels will be determined in design meeting with the Project Team based on task and other criteria. Apply the lighting distributions set out in the Dark Sky International guidelines to minimize sky glow.

Exterior lighting to be LED unless noted otherwise.

Design should have limited wall packs.

Verify normal operation of lighting units after installing luminaires and energizing circuits with normal power source.

Measure light intensities at night. Use photometers with calibration referenced to NIST standards. Comply with the IESNA testing guide(s) for the applicable lighted task.

Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.

Special warranty to be manufacturer's standard form in which manufacturer agrees to repair or replace products that fail in materials or workmanship; that corrode; or that fade, stain, perforate, erode, or chalk due to effects of weather or solar radiation within specified warranty period. Manufacturer may exclude lightning damage, hail damage, vandalism, abuse, or unauthorized repairs or alterations from special warranty coverage.

1. Warranty Period for Luminaires: Five years from date of Substantial Completion.
2. Warranty Period for Metal Corrosion: Five years from date of Substantial Completion.
3. Warranty Period for Color Retention: Five years from date of Substantial Completion.
4. Warranty Period for Lamps: Replace lamps and fuses that fail within 24 months from date of Substantial Completion.
5. Warranty Period for Poles: Repair or replace lighting poles and standards that fail in finish, materials, and workmanship within manufacturer's standard warranty period, but not less than five years from date of Substantial Completion.

Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Lamps: 10 for every 100 of each type and rating installed. Furnish at least one of each type.
2. Glass and Plastic Lenses, Covers, and Other Optical Parts: 10 for every 100 of each type and rating installed. Furnish at least one of each type.
3. Ballasts: 10 for every 100 of each type and rating installed. Furnish at least one of each type.
4. Globes and Guards: 10 for every 50 of each type and rating installed. Furnish at least one of each type.

General requirements for poles and support components

1. Structural Characteristics: Comply with AASHTO LTS-4.
2. Wind-Load Strength of Poles: Adequate at indicated heights above grade without failure, permanent deflection, or whipping in steady winds of 90 mph, with a gust factor of 1.3.
3. Mountings, Fasteners, and Appurtenances: Corrosion-resistant items compatible with support components.
4. Concrete Pole Foundations: Cast in place, with anchor bolts to match pole-base flange. Concrete. Reinforcement, and formwork are specified in Section 3.
    a. Bases installed in parking lots in curbed planters that prevent vehicle contact shall be set at 4” above the curb height.
    b. Bases installed in parking lots that are subject to vehicle contact shall be set 36” above the pavement.
    c. Bases installed adjacent to sidewalks shall be set flush against the walk and 4” above the edge of the walk.

Steel Poles

1. Poles: Round, tapered. Comply with ASTM A 500, Grade B, carbon steel with a minimum yield of 46,000 psig 1-piece construction up to 35 feet in height with access handhole in pole wall. Poles shall be four-bolt mounted to a concrete foundation.
2. Steel Mast Arms: Single-arm type, continuously welded to pole attachment plate. Material and finish same as pole.
3. Brackets for Luminaires: Detachable, cantilever, without underbrace; match pole finish and material.
4. Pole-Top Tenons: Fabricated to support luminaire or luminaires and brackets indicated, and securely fastened to pole top.
5. Grounding and Bonding Lugs: Welded 1/2-inch threaded lug, complying with requirements in Standard for "Grounding and Bonding," listed for attaching grounding and bonding conductors of type and size listed in that Standard, and Accessible through handhole.
6. Powder-Painted Finish: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
    a. Surface Preparation: Clean surfaces to comply with SSPC-SP 1, "Solvent Cleaning," to remove dirt, oil, grease, and other contaminants that could impair paint bond. Grind welds and polish surfaces to a smooth, even finish. Remove mill scale and rust, if present, from uncoated steel, complying with SSPC-SP 5/NACE No. 1, "White Metal Blast Cleaning," or SSPC-SP 8, "Pickling."
    b. Interior Surfaces of Pole: One coat of bituminous paint, or otherwise treat for equal corrosion protection.
    c. Exterior Surfaces: Manufacturer's standard finish consisting of one or more coats of primer and two finish coats of Sherwin Williams "Texas Tech #99 Dark Bronze." Manufacturers with a dark bronze finish as standard shall submit a color sample of 4” square on similar materials as the construction of the pole for TTU to determine an acceptable match to the standard.

Aluminum poles to be 14' aluminum round tapered with pedestal base bolted to concrete foundation manufactured by:

1. Lexington Standard Corporation or
2. Hapco Lighting Company

Cast concrete poles to be embedded in tamped earth (typ.) or embedded in concrete manufactured by:

1. Wasau Tile Terraform Div. of Wausau, WI
2. Custom Design Precast of Weston, WI
3. Stone Legends

Luminaries and Equipment

1. Pole-top for 14' Lexington round tapered aluminum pole:
    a. Lumec #Z14-100H-TYPE-VOLT-VP-1-MCTX-LMS13270B with Double-T

b. Lumec #Z14-100H-TYPE-VOLT-VP-1-MCTX-LMS13270D without Double-T
Note: The Double-T shall only be used on Athletic Facilities.

2. Pole-top for TTU concrete Light Pole:
   a. Lumec #Z47A-100H-TYPE-VOLT-VP-1-MCTX-LMS13218B with Double-T
   b. Lumec #Z47A-100H-TYPE-VOLT-VP-1-MCTX-LMS13218D without Double-T
3. Parking lot fixtures:
   a. Lumark HPHR-400MH-MT, distribution as specified, arm mount as specified, on 35' round tapered steel pole;
   b. Lithonia KSF2-400MH-TB, distribution as specified, arm mount as specified, on 35' round tapered steel pole;
   c. Other manufacturer multi-tap, 400-watt metal halide "shoebox" style fixture, approved in writing by Project Manager, distribution as specified, arm mount as specified, on 35' round tapered steel pole.
   d. LED versions will be considered. These shall be submitted for approval on color, shape, efficiency, cost, etc.
4. Bollards: 50-watt metal halide, 8” diameter round, 42” tall, dark bronze finish, mounted on concrete foundation, fixture as specified per specific project or approved equal. Align units for optimum directional alignment of light distribution.
5. Ground-mounted accent or building lighting: Metal-halide, wattage & fixture as specified per specific project or approved equal.
6. Wall Packs: 70w and 100w metal halide, dark bronze housing. Wall mounted to light service docks and service drives. These shall not be used as area lighting around facility.
7. Photoelectric Control: Connect to the electrical system on the nearest facility and control all area lighting with a single photocell mounted on the building with the sensor oriented to a clear view of the North sky. .

Pole Installation

1. Align pole foundations and poles for optimum directional alignment of luminaires and their mounting provisions on the pole.
2. Concrete Foundations: Set anchor bolts according to anchor-bolt templates furnished by pole manufacturer. Concrete materials, installation, and finishing requirements are specified in Standard for "Cast-in-Place Concrete."
3. Foundation-Mounted Poles: Mount pole with leveling nuts, and tighten top nuts to torque level recommended by pole manufacturer.
4. Embedded Poles with Tamped Earth Backfill: Set poles to depth below finished grade as indicated on Drawings or per manufacturer’s recommendations.
5. Embedded Poles with Concrete Backfill: Set poles in augered holes to depth below finished grade indicated on Drawings or per manufacturer’s recommendations.
   a. Make holes 6 inches in diameter larger than pole diameter.
   b. Fill augered hole around pole with air-entrained concrete having a minimum compressive strength of 3000 psi at 28 days, and finish in a dome above finished

grade.

c. Cure concrete a minimum of 72 hours before performing work on pole.

Ground metal poles and support structures according to Division 16 Section "Grounding and Bonding."

1. Install grounding electrode for each pole, unless otherwise indicated.
2. Install grounding conductor pigtail in the base for connecting luminaire to grounding system.

Ground nonmetallic poles and support structures according to Standard 16 Section “Grounding and Bonding."

1. Install grounding electrode for each pole.
2. Install grounding conductor and conductor protector.
3. Ground metallic components of pole accessories and foundations.

Lighting Design Parameters

Luminaires indicated on plans and schedules are selected to accomplish the following average maintained illumination levels, as follows:

1. Offices, Workrooms, and Conference Rooms.
    a. Average = 50 – 75 foot-candles.
    b. Uniformity ratio (Max/Min) not to exceed 4:1.
    c. Configure luminaires for bi-level or multi-level lighting, as indicated on Luminaire Schedule and plans.
    d. Working height = 30 inches above finished floor.
2. Multi-Purpose Rooms:
    a. Average = 50 – 75 foot-candles.
    b. Uniformity ratio (Max/Min) not to exceed 5:1.
    c. Working height = 30 inches above finished floor.
3. Exercise Areas and Weight Areas:
    a. 75 foot-candles, maximum. 30 foot-candles, minimum.
    b. Uniformity ratio (Max/Min) not to exceed 5:1.
    c. Working height = finished floor (zero inches).
4. Restrooms:
    a. Average = 20 – 30 foot-candles.
    b. Uniformity ratio (Max/Min) not to exceed 6:1.
    c. Working height = finished floor (zero inches).
5. Corridors and Stairs:
    a. Minimum = 10 foot-candles.
    b. Uniformity ratio (Max/Min) not to exceed 10:1.
6. Emergency egress lighting along corridors, stairs, and other egress paths as designated by the Architect:
    a. Minimum = 1 foot-candle.
    b. Uniformity ratio (Max/Min) not to exceed 10:1.

c. Working height = finished floor (zero inches).

8. Mechanical Rooms, Electrical Rooms, and Elevator Equipment Rooms:
    a. Minimum = 20 foot-candles.
    b. Uniformity ratio (Max/Min) not to exceed 6:1.
    c. Working height = finished floor (zero inches).
    d. Data/Telecommunications /IT= 30 foot-candles.
    e. Uniformity ratio (Max/Min) not to exceed 5:1.
    f. Working height = 30 inches above finished floor.
9. Storage Rooms. Average = 15 foot-candles. Working height = 30 inches above finished floor.
10. Exterior Walkway Lighting:
    a. Average = 3-5 foot-candles.
    b. Minimum = 1 foot-candles.
    c. Uniformity ratio (Max/Min) not to exceed 10:1.
    d. Working height = finished grade (zero inches).
11. Building Perimeter:
    a. Minimum = 1 foot-candle, along perimeter of building exterior.
    b. Uniformity ratio (Max/Min) not to exceed 10:1.
    c. Working height = finished grade (zero inches).

Luminaires, as submitted and as installed, shall achieve the above illumination levels, subject to Owner's final acceptance of project.

Lighting level design shall be per IESNA (Illuminating Engineering Society of North America) recommendation.

The power consumption for interior and exterior lighting shall not exceed power allowance as per ASHRAE 90.1 latest revision.

Where indicated on drawings, provide emergency lighting units self-contained complete with batteries, charger, and lamps to provide automatic emergency lighting upon failure of normal power. Battery shall be 12 volts, maintenance free, lead calcium type, with 1.5 hours minimum capacity to supply the connected lamp load. Where larger capacity is indicated on plans or schedules, provide unit with larger capacity. Charger shall be solid state capable of maintaining the battery fully charged during normal conditions, and capable of recharging discharged battery to full charged within 12 hours. Emergency lighting units shall be compliant with UL924, NFPA 101 (Life Safety Code), NFPA 70 (National Electrical Code – NEC).

Provide LED-type vandal-resistant exit signs as scheduled. Incandescent and fluorescent exit signs are not acceptable. Exit signs shall have stencil face with 6-inch high letters. Provide red letters with smooth diffusion face, unless otherwise indicated or scheduled. Individual LED's shall not be visible through the diffusion material. Provide directional arrows as indicated. Provide exit signs with battery backup.

Battery shall be a maintenance free lead-calcium or nickel-cadmium, 4 to 6 volt, with 1.5 hour minimum capacity to supply connected lamp load. Where larger capacity is indicated on plans or schedules, provide unit with larger capacity. Exit signs shall be compliant with UL924, NFPA 101 (Life Safety Code), and Energy Star.

Provide enclosed, mechanically-held, latching, magnetic lighting contactor designed to withstand the large initial inrush current of tungsten and ballast lamp loads as well as non-motor (resistive) loads without contact welding.

Install luminaires in accordance with the manufacturer's written instructions, Owner's requirements, the applicable requirements of NEC and local and national Codes, Standards, and regulations.

Data/Communications

Design Professionals shall reference Texas Tech OP 61.12 "*Installation of Cabling in Buildings and Tunnels"* for more information.

Design Professionals shall reference Texas Tech OP Section 52 "*Information Technology*" for more information.

Reference the TTU Telecommunications Services
http://www.net.ttu.edu/standards/cablingdesigninfo.aspx for Communications Cabling Specifications.

Lightning Protection System

The Engineer of Record shall perform simplified risk calculations and will provide the owner with their recommendations on whether a lightning protection system is recommended. If required, the Lightning protection systems shall be designed by a Certified Lightning Designer/Installer. All connections to the grounding system shall be directed by the plans and specifications of the lightning design.

The system design shall equal or exceed the requirements of UL 96A for a Master "C" Label and FM Global Data Sheet 5-11. Upon completion, the lightning protection system shall be inspected and certified by a third party representative hired by the contractor and approved by the Owner. The lightning protection system shall pass inspection. If the system does not pass inspection, the lightning protection contractor must make corrections to the system to pass inspection. The master label shall be installed in the main electrical room near the door wall.

The subcontractor shall be one that is recognized as being regularly engaged in the design and installation of lightning protection systems. The subcontractor must be listed by Underwriters' Laboratories, Inc., and must employ competent personnel fully qualified in the field of lightning protection.

The system furnished under this specification shall be the standard product of a manufacturer regularly engaged in the production of lightning protection systems and shall be the manufacturer's latest approved design. Listing of the manufacturer in the lightning protection section of the current edition of Underwriters' Laboratories, Inc., Electrical Construction Materials List will be accepted as compliance with this requirement. Materials used in connection with the installation of the lightning protection system shall be approved for lightning protection systems by the Underwriters' Laboratories, Inc. No combination of materials shall be used that forms an electrolytic couple of such nature that corrosion is accelerated in the presence of moisture. Where unusual conditions exist which would cause deterioration or corrosion of conductors, conductors with suitable protective coatings or oversize conductors shall be used. If a mechanical hazard is involved, the conductor size shall be increased to compensate therefore, or suitable protection shall be provided. The conductors may be protected by covering them with molding or tubing, preferably made of nonmagnetic material.

Except where approved by Owner to be specified as aluminum, all conductors shall be copper and of the grade ordinarily required for commercial electrical work generally designated as being 98 percent conductive when annealed. Conductor minimum sizes are listed in Tables 3-4 and 3-5 of NFPA 780. Main conductor and secondary conductor cable sizes shall be the same. Where conductors are placed in contact with aluminum building materials such as parapet wall cap or siding, provide aluminum conductors. Transition to copper conductors where no longer in contact with aluminum building materials.

Air terminals shall be nickel-plated solid copper with tapered bullet point tips (in lieu of sharp point tips). Minimum air terminal size shall be 5/8-inch diameter by 24 inches long. Where air terminals longer than 24 inches are required, solid copper rods of the appropriate length with threaded ends may be securely attached to the air terminals for extensions. Provide a three-leg tripod brace for each air terminal at an open roof location. Secure the triangular brace to the roof in a manner approved by the roof vendor. All other air terminals shall have a bipod brace. Conductor connections to air terminals shall be bolted.

Lightning air terminals that employ early-streamer devices, radio-active rods or eliminators shall not be acceptable.
Ground rods shall be copper-clad steel, 3/4-inch diameter by 10 feet in length, or longer if required.

Specify a complete lightning protection system consisting of air terminals, conductors, connectors, attachments, grounding and necessary appurtenances to comply with minimum requirements listed in the referenced standards. The system shall be installed in a neat workmanlike manner and without interfering with other building systems.

All antennas shall be grounded.

Fire Alarm and Smoke Detection System

The system shall have a microprocessor based intelligent addressable fire alarm system with printer and voice evacuation. The fire alarm system and design shall be Fire Control Instruments E-3 Series or approved equal. The TTU Fire Marshall is the Authority Having Jurisdiction for the fire alarm system.

1. The system shall have the capabilities of sounding a digitally pre-recorded voice/audible fire evacuation message in English and Spanish and also a digital severe weather message that can be activated through a separate pull station or button labeled for severe weather. No strobes are required for weather alerts.
2. The system shall have the capabilities of flashing the strobes after the system has been silenced and until system reset has occurred.
3. The fire alarm system shall have the capabilities of shutting down all heating and air handling units during general alarm.
4. The fire alarm system shall monitor all ancillary life safety systems.
5. All corridors, stairwell and any other fire door that would tend to be propped open will be equipped with magnetic door hold open devices that will release on the activation of the fire alarm system or loss of power.
6. All fire alarm systems shall be tied into and monitored at Central Heating and Cooling Plant 1 (CHACP 1) emergency maintenance facility and Texas Tech Police Department through the U.L. Listed fiber loop system or Ethernet. The head-end monitoring equipment is Fire Control Instruments and all new equipment must be compatible and capable of interfacing with the current equipment. The fire alarm contractor is responsible for the purchase and installation of all of the equipment that is required to make the interface.
7. Fire alarm testing will be done only after the elevator has been certified by a State QEI Inspector.
8. Fire alarm duct detectors should be programmed for supervisory condition due to the dusty conditions of this area.
9. IDC and SLC circuits shall be allowed to be class “B” circuits, NAC circuits shall be allowed to be class “B” circuits unless a High Rise classification requires Class A circuit configuration.
10. Install plastic stopper covers for each manual pull station and weather alert button unless directed otherwise by the Owner.
11. Exit signs shall not be interfaced to the fire alarm system to flash on alarm. Strobes shall be located relevant to exit locations to draw attention to exit doors.

The system shall include, but not be limited to the following elements:

1. Master system CPU including all fire detection, voice/audio and visual evacuation alarm control modules, and supervised power amplifiers with the required back up modules.
2. Circuit interface panels including all modules.
3. Power supplies, batteries and battery chargers.
4. Pre-amplifiers, amplifiers, tone generators, and master microphone.
5. Equipment enclosures.
6. Intelligent addressable manual pull stations, heat detectors, analog smoke detectors, alarm

monitoring modules, and supervised control modules.
7. Beam smoke detection system.
8. Annunciator panel and printer.
9. Voice/Audible and visual evacuation signals.
10. Color graphic displays and historical archiving.
11. Software and firmware as required to provide a complete functioning system.
12. Wiring and raceway.
13. Installation, testing and certification and training.
14. Interface with air handling units and stairwell pressurization system.
15. Interface with Clean Agent Suppression System serving computer rooms.
16. Remote annunciator panel.

Before commencing work, submit data showing that the Contractor has successfully installed fire alarm systems of the same type and design as specified, or that they have a firm contractual agreement with a subcontractor having the required manufacturers' training and experience. The Contractor shall include the names and locations of at least two installations where the Contractor, or the subcontractor above, has installed such systems. Specify the type and design for each system and furnish documentation that the system has performed satisfactorily for the preceding 18 months.

Provide the services of a representative or technician from the manufacturer of the system, experienced in the installation and operation of the type of system provided. The representative shall be licensed in the State of Texas. The technician shall supervise installation, software documentation, adjustment, preliminary testing, final testing and certification of the system. The technician shall provide the required instruction to the Owner's personnel in the system operation, maintenance and programming.

The system shall be a complete, electrically supervised multiplex style fire detection and voice evacuation system with intelligent analog alarm initiation, to be device addressable and annunciated as described and shown on the Drawings. Fire Control Instruments is the acceptable manufacture. Other manufacturers meeting the requirements of this specification for design, function and performance will be considered upon submittal of manufacturer's data to the Texas Tech University Fire Marshal's Office.

The system shall support intelligent analog smoke detection, manual station, water flow, supervisory, security, and status monitoring devices. Fire alarm, supervisory, trouble, security and status shall each be treated as a separate level of alarm, each with its own level of priority. The system shall also support amplifiers, voice/visual circuits, and stairwell pressurization fans and dampers.

The system shall be programmed in the field via a laptop computer. All programmed information shall be stored in nonvolatile memory after loading into the control panel. No special programming terminal or prom burning shall be required and the system shall continue in service during reprogramming. Systems requiring on line terminal programming or not capable of mass reading of panel software for offsite documentation or editing will not be considered acceptable. Disabling of devices must be able to

be accomplished by push buttons located on the front of the main control panel and must be capable of doing this by device type, floor, zone etc. This disabling feature shall also include flow and tamper switches, etc., that may require maintenance. In the event of an alarm or power disruption this action of disabling shall remain intact after the reset function has been activated. The alarm panel shall alert the technician that devices have been disabled and give the option to keep them disabled. This will prevent the inadvertent clearing of these disabled devices and cause false alarms due to repairs or work in progress.

Each intelligent addressable device on the system shall be displayed at the fire alarm control panel by a unique alpha numeric label identifying its location.

Activation of any alarm verified smoke detector in a single elevator lobby or an elevator equipment room shall, cause the recall of the elevators to the terminal floor and the lockout of controls. In the event of recall initiation by a detector in the first floor lobby, the recall shall be to the alternate floor. Activation of any heat detector in the elevator machine room, elevator pit, or elevator shaft shall shunt trip the circuit breaker serving the associated elevators.

Unless otherwise allowed by the TTU Fire Marshall, all wiring shall be run in metal conduit throughout.

Paint all junction box covers red.

Perform work in accordance with the requirements of NEC, NFPA 70, NFPA 72, TTU Fire Marshall's Office, and Factory Mutual recommendations.

Coordinate with Telecommunications installer, with Division 15 subcontractors.

Complete and submit to the Owner a Certificate of Compliance in accordance with NFPA 72.
Fire pumps shall report a "general fire alarm" back to CHACP 1 upon operation.

A written acceptance test procedure (ATP) for testing the fire alarm system components and installation will be prepared by the Acceptance Inspector in accordance with NFPA 72, and the Owner's requirements. The Contractor shall be responsible for the performance of the ATP, demonstrating the function of the system and verifying the correct operation of all system components, circuits, and programming.

The Contractor shall warrant the entire system against mechanical and electrical defects for a period of 18 months. This period shall begin upon completed certification and test of the system. During this warranty period the contractor shall respond to a trouble call within 2 hours for problem determination, and resolution to the problem within 24 hours.

Construction documents for fire alarm systems shall be submitted for review and approval prior to system installation. Construction documents shall include, but not be limited to, all of the following:

1. A floor plan which indicates the use of all rooms.
2. Locations of alarm-initiating and notification appliances.
3. Alarm control and trouble signaling equipment.
4. Annunciation.
5. Power connection.
6. Battery calculations.
7. Conductor type and sizes.
8. Voltage drop calculations.
9. Manufacturers, model numbers and listing information for equipment, devices and materials.
10. Details of ceiling height and construction.
11. The interface of fire safety control functions.
12. Systems and their components shall be listed and approved for the purpose for which they are installed.

Access Control

Reference Texas Tech OP&P 61.14 "*Electronic or Keyless Locking Systems"* for design reference (security systems in housing facilities are not addressed in this OP). The TTU Operations Division is responsible for the management of all locking systems to university facilities through the university's security systems manager within the Texas Tech University Lock Shop (TTULS). Standards and programs have been established for the control and issuance of keys, development of keying systems, standardization of hardware, and maintenance programs for the upkeep of these systems. Installation of systems other than those approved in the standards or deviation from the standards may occur only with the approval of the Managing Director of BMC under the guidelines set forth in this OP.

Due to the large number of electronic or keyless security systems available on the open market, standards and limitations must be established for the use of these systems on the TTU campus. The selection of the two systems listed above provides departmental security and flexibility without jeopardizing existing security, and allows the TTU Operations Division and the Texas Tech Police Department to maintain the systems without heavy investment in inventories and equipment.

Two locking systems have been selected that will serve the requirements of most departments. Requests to install electronic or keyless locking systems will be limited to the selection of one of the systems described in OP 61.14. The elected systems allow any departmental requirement to be met. The TTULS and the Texas Tech Police Department will assist departments in making selections. The only locking systems allowed on campus will be either C-CURE for security or CS Gold for access. The two approved systems are limited to:

a. C-CURE

C-CURE is a scalable security management solution encompassing complete access control and advanced event monitoring. The system integrates with critical business applications including CCTV and video systems from American Dynamics (Intellex Digital Video Management Systems and VideoEdge NVR) and third party devices such as fire alarms, intercoms, and burglar and other alarms. This system is managed and maintained by the Texas Tech Police Department. The TTU official ID card can be used for access or specialized access devices are obtainable from vendors at the expense of each department on campus. The Texas Tech Police Department can assist in providing a list of vendors for purchasing these devices. The Texas Tech Police Department will maintain a list of authorized people who can request and approve access to employees or students. Access changes including removal, addition, or transfer will be completed through the KMS http://is.operations.ttu.edu/odkms/default.aspx. The Texas Tech Police Department is located at 413 Flint Avenue and will make changes to the system between the hours of 8 a.m. and 5 p.m. Monday through Friday.

b. CS Gold

CS Gold offers wireless or wired on-line locks, including biometric readers. CS Gold hardware within E&G facilities will be installed and maintained by the Electronic Maintenance Shop and the Lock Shop. Access changes including removal, addition, or transfer will be completed through the KMS (http://is.operations.ttu.edu/odkms/default.aspx). The CS Gold systems security features include Banner synchronization on a daily basis, lock down, and emergency modes. New employees, students, or existing staff can obtain new or replacement TTU ID cards from the TTU ID Office located at the Student Union Building, Room 103, between the hours of 8 a.m. and 5 p.m. Monday through Friday.

Any new electronic or keyless system will interface or coexist with the existing restricted keyway system. The existing master key will remain functional for service, custodial, police, and emergency access. If an electronic key/card system replaces the existing key/lock system, the university Lock Shop will control the issuance of key/cards under the same provisions outlined in OP 61.15 *"Control and Issue of Keys to University Buildings".*

All access control providers interested in bidding must have a valid license through the Texas Department of Public Safety and Private Security Bureau for their portion of the work. The awarded Contractor will be required to submit this information to the Texas Tech Police Department. The Texas Tech Police Department may validate the licensing submitted with the State at their option.

Base the specifications on the Software House C:Cure 9000 Security Management System. The existing security management system (C:Cure System) is located at Texas Tech Police Department. Contractor will be required to provide IP connection and programming of new software house security devices, camera system and controller to be accessed on Texas Tech Police Department existing C:Cure Security System. The Company of Record for the Texas Tech University C:Cure System is Firetrol. Firetrol will be the only company authorized to add or modify the existing system.

NOTE: TTU University Student Housing is currently using CBORD as their card access system and Bosch DVR's or ExacqVision for their video surveillance. The CBORD card access system is/has been used in existing academic/administration buildings where "security" is not needed but card access is needed. The Design Professional needs to clarify with the Owner and TTU Police Department on the type of system to specify.

The access control system will be a separate system from the video surveillance camera system. The access control system will operate from existing C:Cure software system at Texas Tech Police Department.

The access control system shall be from a single-source manufacturer that specializes in intrusion detection and access control systems with a minimum of 5 years' experience. Installer shall be a company specializing in intrusion detection and access control systems with a minimum of three years' experience on systems of similar size and scope. Technicians working on project must have been certified on the hardware and software used for this project.

A final inspection walk-through will be conducted with the Texas Tech Police Department to verify system operation and final acceptance of the work.

All equipment, materials, and labor shall have a two year warranty from the date of final acceptance by the Owner.

1. Provide any software maintenance updates or upgrades at no additional cost to the Owner for this period.
2. Perform two (2) scheduled preventative maintenance site visits per year during the warranty period.
3. Normal business hours shall be 8 AM to 5 PM Monday through Friday. Calls for service before noon shall be responded to on-site before the end of the day. Calls after noon shall be responded to on-site by noon the following business day.
4. The installer shall have duplicate system parts available within 50 miles of installation site should any part of the system fail.

Basic Central System Components

1. If a new installation at a regional campus is needed, a computer server running the CCure 9000 system will also be required. This server will control all of the buildings at the regional campus.
2. Security Controllers: Software House Istar Pro, Edge or Ultra. IP-enabled Control Panel. Unless otherwise noted, the Istar Pro should be a 16 door controller.
3. Input Modules: Software House I8-CSI. Enclosure: RM-DCM-CAN.
4. Output Modules: Software House R8 Output Module. Enclosure: RM-DCM-CAN.
5. Card Readers:
    a. HID
    b. SoftwareHouse
6. Door Strikes or electronic lock: TBD based on door configuration and TTPD recommendations.
7. Request-to-Exit: Bosch DS150i Series or approved equal.

8. Door Contacts: Sentrol or approved equal.
9. Overhead Door Contacts: Sentrol or approved equal.
10. Access Power Controllers: Supply: Altronix Maxim 33 or approved equal.
11. Panic Button: USP HUB2 Series or approved equal.
12. Proximity Cards: HID Corporate 1000. Contractor shall verify requirements with Texas Tech Police Department.
13. Motion Sensor: Sentrol or approved equal.
14. No substitutions. All Devices shall be compatible with existing system.
15. All security access and camera systems shall derive power from new emergency panels (fed from generator). 12 volt battery backup to provide 12 hours of standby power supply shall be provided.

Hardware Requirements

1. Controllers:
    a. Provide one (1) Software House Istar Pro which supports sixteen (16) readers. (if required)
    b. Provide one (1) Software House Istar Edge which supports two (2) readers. (if required)
    c. Provide one (1) Software House Istar Ultra which supports thirty-two (32) readers. (if required)
    d. Each Istar panel shall have an Ethernet network connection.
    e. Contractor shall provide installation, connection, 120V emergency power, patch cords, power supply conduit and wire.

2. Input Modules:
    a. Provide one (1) Software House C#I8-CSI (if required).
    b. Provide one (1) Software House enclosure #RM-DCM-CAN (If required).
    c. Contractor shall provide installation, input modules, enclosure, 120V emergency power, patch cords connection, power supply, conduit and wire.

3. Output Modules:
    a. Provide one (1) Software House #R8 output module. (if required)
    b. Provide one (1) Software House enclosure #RM-DCM-CAN. (if required)
    c. Contractor shall provide installation, connection, enclosure, modules, patch cords, power supply, 120V power, conduit and wire.

4. Card Reader:
    a. Proximity Card Reader:
        i. HID (Specific model dependent upon application).
        ii. Software HOUSE # RM2-LCD (with key pad).
    b. Refer to plans for exact number and location card readers.
    c. Proximity card reader shall be weatherproof exterior applications.

d. Provide proximity card reader in one (1) elevator. Coordinate requirement with elevator contractor.
e. Contractor shall provide installation, connection, back box, power supply, 120V emergency power, communication cable, programming and conduit.

5. Proximity Card:
    a. HID Corporate1000 card (Standard University ID cards will work with CCure9000)

6. Electric Door Strikes:
    a. Provide: TBD based on door configuration and TTPD recommendations
    b. Locking devices (electronic locks, electronic crash bars, etc.) must be 24 volt devices. 12 volt locking devices will not be accepted.
    c. Coordinate door strike with door frames.
    d. Mullion installations: Contractor shall provide a quick disconnect and pig-tail in the top of the mullion.
    e. Contractor shall provide quick disconnect, power supply 120V emergency power, relays, wiring and conduit.
    f. Electric door strike hardware for all exterior doors will be programmed to fail-secure in the event of building power loss.
7. Request-to-Exit (REX) Door Detector:
    a. Provide REX: PIR or approved equal
    b. Coordinate location of device with door and wall conditions.
    c. Refer to plans for exact number and locations of REX's.
    d. Provide installation connection power supply, 120V emergency power, relays, backboxes, wiring and conduit.

8. Door and Overhead Door Contacts:
    a. Provide Software House/Tyco door contacts.
    b. Contacts shall be hidden in the top of the door frame. Coordinate requirement with door manufacturer. Contacts behind the hinges are not acceptable.
    c. Provide Software House/Tyco overhead contacts.
    d. Contractor shall provide installation, connection, control wiring and power supply.

9. Access Control Power Controller/Supply:
    a. Provide one (1) dedicated circuit power supply for each Istar controller.
    b. Refer to plan for location of power supply.
    c. Contractor shall provide installation, connection, patch cords, 120V emergency power, wiring and conduit.

10. Panic Alarm
    a. Provide at least one (1) panic button by USP HUB2 Series or approved equal.

b. Coordinate location of button with owner.
c. Contractor shall provide installation, control wiring and conduit

11. Motion Sensor:
    a. Provide Sentrol/6E PIR # AP100PI or approved equal.
    b. Sensor shall be PIR Type.
    c. Sensor shall be adjustable to accommodate different size rooms.
    d. Contractor shall provide installation connection, communication cable as required.

Each card access controlled door shall include four devices:

1. card reader
2. door contact
3. electronic lock or crash bar
4. a request to exit.

Controlled doors not requiring card access shall include three devices:

1. door contact
2. electronic lock or crash bar
3. request to exit.

These doors should be set up in the system as a “door” and not an “output and two inputs”. No doors should have only a contact and electronic lock.

Install system in accordance with manufacturer's instructions.

Install wiring for detection and signal circuit conductors in conduit back to the building cable tray. An Ethernet network port shall be incorporated into the cost of the project and arranged through TTUNet or HSC Network services and coordinated with TTPD.

Coordinate connection requirements with Texas Tech Police Department. Texas Tech Police shall have capability of monitoring security access and video at Police Department site.

Test in accordance with Tyco security standards. The contracted security system provider shall maintain duplicate system parts inventory and make available within 50 miles on installation site.

Video Surveillance System

The video surveillance camera system will be a complete local system at the new building. Contractor shall provide software to monitor at different location via an IP connection. Contractor shall coordinate remote operation of camera monitoring system with Texas Tech Police Department.

1. Network Video Recorder (NVR)
    a. American Dynamics NVR approved equal to meet Owner and TTPD specifications.

b. NVR shall be capable of storing minimum of three (3) months of storage. Coordinate video storage requirements with Texas Tech Police Department. Provide raid storage system.
c. Provide 17" monitor or approved equal.
d. Provide uninterruptable power supply for DVR/Computer system. UPS shall provide 20 minutes of continued operation in the event of an AC power failure.
e. Provide 2 Ethernet network ports for system. (coordinated with TTPD and TTUNet or HSC Network Services)
    i. Private camera subnet
    ii. Public NVR port
f. Provide manufacture equipment rack if requested by owner.
g. Contractor shall provide installation, connection, software, programming patch cord, and conduit.

2. Cameras:
    a. All cameras shall be an IP camera that utilizes a minimum of 2MP native resolution. Higher resolution is preferred.
    b. Fixed Camera: TBD by Owner and TTPD. (ie. American Dynamics Illustria i610)
    c. Pan Tilt Zoom: TBD by Owner and TTPD. (ie. American Dynamics Illustra i625)
    d. Cameras may utilize Power over Ethernet (POE) for camera power. In specific cases, POE injectors may be utilized.
    e. Refer to plans for exact number and location of cameras.
    f. Contractor shall provide installation, connection, mounting plates, domes, cameras, power supply 120V power, and communication video cable, and conduit.
    g. Cameras should be wired to the closest TTUNet or HSC Network services building switch for communication to the NVR.

Emergency Telephones (Blue Light)

This section describes the materials and installation of the emergency blue phones installed outdoors for campus community use. The need for indoor emergency blue phones will be at the discretion of the Owner.

Project Design Team is responsible to coordinate need and location of emergency telephones with the TTU Exterior Lighting Committee.

Assistance Phone: Single button phone, line powered, uses POTS lines or PBX lines, strobe blue light upon activation, raised letter and Braille signage, auto dialer with two-number memory. Use Talk-A-Phone model ETP-400. Provide a 2-year factory warranty.

Phone Tower: Talk-a-Phone Model ETP-MT Rectangular steel with rounded edges, Dark Bronze-86BR, 3.25" high reflective white lettering "EMERGENCY" on all four sides, 9.5 feet tall, 120 volt LED blue light

on top, cutout to accept phone, LED panel lights to light face of phone and note-taking ledge. Mounting hardware (anchor bolts) to be shipped ahead. Provide a 5-year factory warranty.

Concrete foundation: Shall be round, 36” deep, and 14” diameter. Place anchor bolts in the concrete base using a template for proper placement. Set top of foundation 2” above an adjacent sidewalk, 2” above a curb, or 6” above finished grade in a field installation.

Install two 1 inch conduits from the building to the phone concrete base for the telephone line and constant 120 volt power line. Ground the tower with a ground rod driven adjacent to the foundation and opposite the access side of the tower. Connect a #6 bare solid copper conductor from the ground stud within the tower base to the ground rod. Connect the blue light to the phone unit to utilize the flashing function when the phone is call activated.