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#### Part 1 - General

Electrical Load Monitoring: Investigate the existing electrical service/distribution system and determine if sufficient capacity is available to accommodate the new loads. Meter readings are required per NEC.

Existing Electrical Installation: Investigate all existing electrical installations such as existing concealed conduit runs, conduit types/sizes, cable types/sizes, panelboard types/sizes, electrical equipment locations, etc., which potentially impact the new installation.

#### Calculations

The Design Professional shall submit the following calculations to NAU during the design process in the Basis of Design:

- Lighting calculations
- Size of each conductor
- Size of each overcurrent protective device
- Size of each equipment bus
- Size of each transformer
- Size of each generator and transfer switch
- Setting of each overcurrent protective device with adjustable characteristics
- Required PPE to meet arc flash incident energy levels
- Fault current calculations
- Protective device coordination study
- Arc flash calculations (when not required to be performed by the Contractor)
- Load calculations
- Generator and/or UPS sizing calculations
- Voltage drop calculations
- Harmonic distortion calculations
- Lightning protection system risk analysis

Fault Current Calculations: Prepare and submit calculations for all new projects and renovations to existing electrical distribution systems. The available fault currents shall be included on the riser diagrams, and shall show the available fault current (expressed in amperes, RMS symmetrical) at each overcurrent protective device and transformer in the system. Supporting calculations (such as those resulting from a SKM PowerTools™ analysis) that justify the summary available fault currents on the riser diagrams.

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**Coordination Study:** Prepare coordination curves to determine the required settings of overcurrent protective devices with adjustable trip characteristics. The Design Professional shall verify field settings at time of project completion.

**Arc Flash Calculations:** Perform, or specify, an arc flash analysis in accordance with Institute of Electrical and Electronics Engineers (IEEE) Std 1584a. For each bus analyzed, determine the following: Flash Hazard Protection Boundary, Incident Energy Level, Required Personal Protective Equipment Category, Type of Fire Rated Clothing, Limited Approach Boundary, Restricted Approach Boundary, and Prohibited Approach Boundary. Present, or specify to be submitted, the data determined by the analysis in a tabular format, and submit, or specify to be submitted, the preparation of arc flash warning labels for each piece of electrical equipment, showing the items listed above as well as the date of issue.

**Load Calculations:** Prepare and submit load calculations that justify the size of each branch circuit and feeder, overcurrent protective device, transformer, and equipment bus (panelboard, switchboard, switchgear, automatic transfer switch, etc.). Calculations shall be performed at all voltage levels. The method of calculation, including all applicable NEC diversity factors and non-coincident loads and their employment at various levels of the electrical system, as well as capacity reserved for future load, shall be clearly presented in the drawings. Calculations may be in panel schedule and switchboard schedule format. It shall be possible for the NAU reviewer to follow the load flow from the lowest level to the highest level of the riser diagrams.

**Generator Sizing Calculations:** Prepare and submit calculations that justify the size of each generator, including all loads downstream of the generator set(s) and the sizing impacts of proposed load steps, significant motor loads, non-linear loads, and capacity reserved for future loads.

**Voltage Drop Calculations:** Prepare and submit calculations demonstrating compliance with the following voltage drop limits: 2% for feeders, and 3% for branch circuits, taken at design load.

**Harmonic Analysis:** Prepare and submit calculations estimating the voltage and current total harmonic distortion (THD) for buses rich in non-linear loads. Use these calculations to justify active or passive components to mitigate harmonic distortion.

**Lighting Calculations:** Lighting calculations shall include the room name, room number, fixture type chosen for the room, number and type of lamps to be used in the room, required illumination level, calculated illumination level, and light loss and reflectance assumptions used. Calculations for most interior spaces may be performed using the zonal cavity method. Perform and submit point-by-point footcandle-level calculations for areas of greater architectural or luminous

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sophistication, and outdoor areas. The Design Professional shall submit exterior outdoor point-by-point footcandle-level calculations and accompanying luminaire cutsheets to the Dark Sky Committee for review. Calculations shall include demonstrated compliance with energy conservation measures and codes.

### **Design Requirements**

The DP must discuss the concept of a roof-mounted photovoltaic (PV) system with Owner on a per-project basis. It is Owner's desire to have PV on roofs, where feasible. Provide conduit path(s) from the roof to the electrical service entrance equipment to facilitate connection of roof-mounted photovoltaic systems. Building electrical service equipment shall have breaker space to accept connection of grid-tied photovoltaic systems.

All materials shall be new and previously uninstalled, listed and approved by Underwriters Laboratories.

Electrical equipment spaces shall not be located beneath toilets, showers, laboratories, kitchens, sinks, open courtyards, planters, roof drain leaders, or other areas where water service is provided. Electrical equipment spaces shall be designed to allow maintenance equipment access, and to facilitate equipment replacement without demolition and reconstruction other than removal of a door centerpost.

The Design Professional shall show electrical equipment footprints and accompanying National Electrical Code (NEC) working clearances on the drawings. Provide the same working clearance for non-fused switches as is required for fused switches.

Any wet pipe foreign to the electrical installation shall not enter or pass through an electrical equipment space. The Design Professional shall ensure that foreign piping such as water pipes, steam pipes, medical gas pipes, sanitary waste pipes, roof drains, A/C ducts and other unrelated piping systems containing liquids or gases are not installed or pass through electrical equipment spaces. Sprinkler piping shall not be routed through electrical rooms, unless it serves to protect the electrical installation.

Electrical equipment spaces shall have the necessary mechanical ventilation or cooling system to maintain the indoor temperature range required for proper operation of the equipment within its UL listing.

Electrical equipment spaces that contain freestanding electrical equipment shall be sized such that sufficient space is provided to add one additional section to each unit of freestanding equipment. Provide extended pad space and spare conduits that will facilitate future installation of equipment and conductors. Spare space shall be indicated on drawings.

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Electrical closets shall have 20% spare wall space for future installation of similar electrical equipment.

#### **Installation Requirements**

All electrical equipment, disconnects, starters, panels, devices and plates shall be installed plumb and true.

All electrical work shall be inspected and approved by Owner (Electrical Department or its designee) before being covered. All tests are to be observed by the Owner (Electrical Department or its designee).

Switchboards, panelboards, transformers, transfer switches, gutters, junction boxes and other electrical equipment with doors or removable covers shall not be painted other than with original factory paint and necessary touch-up paint.

#### **Submittals**

Provide complete submittals of all electrical and electronic equipment. Diagrams shall show installed component model numbers; block diagrams do not constitute an acceptable schematic. There shall be a separate submittal for each of the first-4 digits of the CSI divisions, as needed. For example, a separate submittal is needed for Division 26 05 as opposed to a submittal for Division 26.

#### **Licenses**

The electrical contractor shall furnish copies of State of Arizona high voltage license to Owner before proceeding with any work over 600 volts, including but not limited to conduits and ductbanks for medium voltage cables, switchgear, transformers, cabling, splices, or terminations.

#### **As-built Documents**

Contractor shall thoroughly mark the construction drawings to show as-installed circuiting, locations of major electrical components, panel schedules, and locations of major underground conduit and ductbank runs dimensioned from fixed surface features. As-builts shall be provided to DP to prepare record drawings.

#### **Electrical Systems Software**

All software installed as part of an electrical system shall be licensed to Owner. Owner will direct the Contractor as to the details of software licensing, update notifications, and locations where the software is to be installed.

### **26 05 00 Common Work Results for Electrical**

**Specific requirements for individual HVAC, Communications, FLS, or other components may be indicated in different divisions. It is the contractors responsibility to follow the requirements outlined in those divisions for conduits and wiring.**

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 26 05 13 Medium Voltage Cables

Refer to Division 33 for all components above 600 volts.

26 05 19 Low Voltage Electrical Power Conductors and Cables

Part 1 – General

Grounded (neutral) conductors shall be minimum #10 AWG. Refer to Division 27 for all low voltage communication wires (Ethernet).

Part 2 – Products

All wire shall be 600V soft-drawn annealed copper, of the type specified herein, and shall be brought to the job in unbroken packages showing the date of manufacture. Manufacture date to be within the past year.

Wire shall be type THHN (THWN in damp locations).

Minimum wire size for power and lighting wiring is #12 AWG, except for controls wiring. Minimum wire size for exterior lighting shall be #10 AWG. Wire of size #10 AWG and larger shall be stranded. All motor-related power and control wiring shall be stranded, regardless of size.

Type MC Cable shall be used only for light fixtures not rigidly supported.

Integral-color insulation shall be used with all wires, regardless of size.

Color code all wire throughout as follows:

PHASE	120/208 VOLTS	277/480 VOLTS
A	BLACK	BROWN
B	RED	ORANGE
C	BLUE	YELLOW
NEUTRAL	WHITE	GRAY
GROUND	GREEN	GREEN
ISOLATED GROUND	GREEN/ORANGE STRIPE	GREEN/ORANGE STRIPE

Wiring for switches shall be the same color as phase wire.

Prewired fixture whips, maximum six feet long, are acceptable when approved by the Design Professional.

Splices in wire #8 AWG and larger shall be made with compression-type connectors only. Twist-on connectors shall be used for wire #10 AWG and smaller.

Thermoplastic electrical insulating tape shall be 7 mil flame retardant and weather resistant, resistant to hot and cold weather, applies well at 0 degrees F, has an

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	operating range up to 220 degrees F, and meets the requirements of ASTM D-3005-72 Type 1, UL 510, HHI-595C, and CAS Bulletin No. 561A (105 degrees C.).

Approved wire lubricants shall be used for pulling. Lubricants shall not have a deleterious effect on wire or cable insulation, or on cable labeling.

Part 3 – Execution

All electrical power shall be installed in conduit.

Splices shall not be made in conduits or condulets.

No more than six circuits shall be in a single conduit, subject to NEC deration requirements.

Do **NOT** combine homeruns where shown separately on the drawings.

Mechanical splices shall be covered with a layer of rubber tape, then a layer of thermoplastic tape. When using twist-on wire connectors, wires shall be twisted together with pliers before applying connector.

Carefully train all wire in electrical enclosures in a neat arrangement. Leave wire loops not less than 6" long in each outlet box, even if wires do not stop in the box.

26 05 26	Grounding and Bonding for Electrical Systems
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Part 1 – General

All conduit and raceway systems that contain power and lighting conductors shall contain a ground wire, sized per NEC.

The non-current-carrying metal parts of all outlet boxes, pull and junction boxes, gutters, motor controllers, switchboards and switchgear, transformers, panelboards, and any other electrical enclosure shall be bonded to an equipment grounding conductor by a properly-sized bonding jumper.

Separately derived systems shall have the secondary neutral grounded to building steel with an exothermic weld at the fist downstream disconnecting device.

Part 2 – Products

N/A

Part 3 – Execution

N/A

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26 05 29 Hangers and Supports for Electrical Systems

Part 1 – General

16.5 gauge tie wire and ironworkers tie may only be used for securing horizontal conduit runs within stud walls.

Perforated strap iron or plumbers tape, drive-it anchors, plastic sleeve anchors, lead anchor, or power-driven anchors shall NOT be used for hanging conduit or boxes.

Single suspended conduits shall be on rings with rod hangers with self-drilling anchors or other approved methods. Runs of more than one suspended conduit shall be clamped to a strut trapeze with 300 lb. nut & bolt clamps. All- thread must be backed on both sides with washers, lock-washers and nuts (floating strut or hangers are not acceptable). Trapeze supports shall be 1-5/8" x 1-5/8" channel supported by minimum 3/8" rods.

Part 2 – Products

N/A

Part 3 – Execution

N/A

26 05 33 Raceway and Boxes for Electrical Systems

Part 1 – General

N/A

Part 2 – Products

Conduit

Minimum size of conduit is 3/4", except that 1/2" may be used for dead-end runs in walls, and for fire alarm system wiring.

All fittings for all metallic conduit types shall be steel. All bushings and connectors shall be insulated throat type.

Rigid Galvanized Steel Conduit (RGS) or Intermediate Metal Conduit (IMC) fittings shall be threaded; running threads are not permitted. Union fittings may be used as necessary. RGS threadless connectors or couplings, split couplings that bolt together, self-threading fittings, or couplings permanently attached to conduit shall NOT be used.



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Electrical Metal Tubing (EMT) fittings may be compression or setscrew type.

Rigid Non-Metallic Conduit (PVC) shall be Schedule 40 minimum.

Surface-mounted wire raceway shall be installed with manufacturer's accessory fittings. Field-made fittings are not allowed.

All conduits shall terminate with a box except communications, data, phone, etc. lines may terminate with metallic insulated throat threaded bushings at TTB or cable tray. Fasten conduit to cable trays. Owner has pre-approved the following manufacturer to be in compliance with these standards: GEDNEY CTC.

The following materials are prohibited: Aluminum flex flexible metal tubing, electrical non-metallic tubing (ENT), liquid-tight nonmetallic flexible conduit (LFNC), offset connectors, conduit bodies larger than 1-1/4", and SLB fittings.

#### Boxes

Boxes shall be galvanized steel, minimum 4" square. Use a plaster ring with boxes for receptacles, switches, telecommunications outlets, and fire alarm devices. Use of more than one extension ring is not acceptable.

FS/FD boxes with cast lugs and FS/FD covers shall be used where exposed to moisture or subject to mechanical damage.

Use masonry boxes of the proper depth in unplastered masonry walls. The face of all boxes shall be vertical and not more than 1/4" in from the finished surface. The mason and electrical contractor shall be mutually responsible for the proper execution of masonry work.

Ceiling outlet boxes shall be equipped with 3" round plaster rings. Provide fixture studs if fixture is to be mounted directly on box.

Handy boxes or handy box extension rings are prohibited.

All surface-mounted fire alarm pull station devices shall be mounted on red boxes specifically made for this purpose.

#### Pendant outlet boxes

Owner has pre-approved the following manufacturers to be in compliance with these standards: Daniel Woodhead 3000 series with cord strain relief. Plates shall match box and outlet used.

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Part 3 – Execution

Conduit

Metal conduit shall be used above grade.

Rigid Galvanized Steel Conduit (RGS) or Intermediate Metal Conduit (IMC) shall be used where exposed to weather or subject to mechanical damage, in tunnels, to house medium-voltage conductors in all above-ground locations, and in mechanical rooms below 10' above finished floor.

Flexible steel conduit shall be used only for connection to equipment which is moveable for adjustment, mounted on vibration isolation bases, or for connection to lay-in light fixtures in an accessible ceiling. Maximum length shall be six feet. Aluminum flex is prohibited.

Conduit shall be installed concealed except as noted on plans, or in equipment rooms and tunnels.

All feeder conduits for panels, switchgear, gutters, and pullboxes shall be terminated with grounding bushings bonded to the equipment grounding conductor.

Different electrical systems shall be run in separate, independent raceway systems. Examples of different systems are as follows: 120/208Vs, 277/480V, fire alarm, emergency electrical system, telephone and data, intrusion detection system, and building automation system.

Conduit bend radius shall be per NEC. Ninety degree bends in conduit 1-1/2" and larger shall be made with manufactured elbows or by hydraulic bender.

No more than three 90 degree bends (270 degrees) shall be used between pull, or junction, boxes on data, communications or phone conduits.

Change from one conduit type to another shall be at a box or enclosure.

Sleeves are required for floor penetrations. Sleeves shall extend a minimum of 1" above finished floor. Firestop penetrations through rated walls and floors per requirements of other Sections.

Conduits shall be installed such that no wrench or tool teeth marks are evident. Conduit ends shall be cut square, reamed to full size, shouldered in fittings, and fully seated in connector and couplings. Roller type tubing cutters shall not be used.

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Conduit installation shall be such that conduits are not abraded, scraped, flattened, dented or wrinkled and the interior diameter is not effectively reduced. Install conduit in such a way that condensation or water cannot be trapped.

Above flush-mounted panelboards, extend spare conduits to above suspended ceilings. For hard (non-accessible) ceilings, spare conduits shall extend to an accessible location and terminate in a labeled junction box with suitable blank cover. A minimum of (1) 1" spare conduit shall be provided for each 3 (or fraction thereof) one-pole spares/spaces, with minimum 3 spare conduits provided.

Surface-mounted conduit shall be painted to match the surface. Conduits concealed or installed in tunnels or equipment rooms shall not be painted.

Exposed conduits shall be grouped in neat parallel lines, properly supported, following the lines of the building structure as closely as possible.

Provide moisture-tight hubs for conduit entries to top or sides of exterior boxes, gutters, panelboards, switchboards, and other electrical enclosures.

All empty or spare conduits for all systems shall have a pull string installed, and be labeled at each as to the location of the other end. When spare conduits stub up from a floor slab, they shall extend 6" above finished floor.

Metallic conduit shall not touch any plumbing pipe, or pipe of other systems. Where contact between dissimilar systems is unavoidable, approved insulation shall be used between the piping systems.

Where telecommunications conduits terminate at a cable tray, a threaded bushing and connector shall be used. Owner has pre-approved the following product to be in compliance with these standards O-Z/Gedney CTC clamp. It shall be used to clamp conduit to cable tray.

Any conduit run that does not allow conductors to be pulled readily will be condemned and replaced with conduit whose workmanship is satisfactory to the Owner (Electrical Department).

All fire alarm system conduit shall be inspected and approved by Owner (Fire and Life Safety department) prior to covering the work. Inspection request shall be in accordance with Division 01.

Refer to Section 26 05 53, IDENTIFICATION OF ELECTRICAL SYSTEMS, for mandatory identification of fire alarm system conduits.

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HVAC control conduit shall follow this division, except that control wiring may be run through without conduits above ceilings if plenum rated cable is used. Additionally, within mechanical rooms EMT may be used for HVAC communication and control wiring instead of rigid as stated above.

Refer to Division 27 for communications conduit and raceway requirements.

Boxes

All boxes shall be grounded to the conduit system, and bonded to the equipment grounding conductor with a ground screw in the box.

Boxes shall not be installed back to back, even if associated with different systems.

Conduit runs shall not exceed 90 feet between boxes.

Bar hangers shall be used to support boxes in accessible ceilings.

Telecommunications outlet boxes shall be located at heights to match adjoining receptacles, unless otherwise noted.

In renovation work, box mounting heights shall match heights of nearby existing boxes, unless existing heights violate ADA requirements.

Do not compromise integrity of FD/FS boxes by drilling fastening holes in boxes.

In non-combustible walls or ceilings, boxes shall not be set back more than 1/4". In combustible walls, boxes shall be flush with the finished surface. There shall be no broken surfaces, gaps or open spaces at the edge of boxes.

Conduit shall enter boxes at right angles without binding. Offsets shall be used as necessary for proper fit.

When boxes are installed in acoustic walls, the Design Professional shall verify the required STC rating with Owner.

26 05 36 Cable Trays for Electrical Systems

Part 1 – General

All buildings except dormitories shall have cable tray for telecommunications wiring. Cable trays shall terminate in designated communication rooms. There must be adequate tray from the communications room(s) to the tunnel entry to the building, and adequate raceway from floor to floor.

Part 2 – Products

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All cable trays are to be continuously grounded.

Support for cable tray shall be every 5 feet and within 1-1/2 feet of terminations or changes of direction.

Part 3 – Execution

N/A

26 05 43 Underground Ducts and Raceways for Electrical Systems

Part 1 – General

N/A

Part 2 – Products

Underground pullboxes and lids for 120VAC to 480VAC systems shall be polymer concrete.

Part 3 – Execution

Rigid Galvanized Steel Conduit (RGS) shall be half-lap wrapped with Scotch Wrap #50 or approved equal when installed in concrete or in earth.

Non-Metallic Conduit (PVC) bends of 45 degrees or greater shall be taped RGS. EMT shall not be used underground.

Rigid Non-Metallic Conduit (PVC) shall be Schedule 40 minimum and may be used subject to all the following conditions: Bends of 45 degrees or more shall be made with RGS elbows; PVC may only be used in concrete duct bank or direct buried underground; and PVC shall convert to RGS before stubbing out of earth or concrete with a minimum of 18" of RGS in the slab or earth. RGS shall extend 3' beyond the building when penetrating exterior walls of footings.

Minimum burial depth shall be 18" for conduits containing wiring 600 volts or less, and 36" for conduits containing cables over 600 volts.

Electrical conduits, telecommunications conduits, water piping, and sanitary sewer piping shall be separated by 12" minimum.

Underground PVC conduit containing cables under 600 volts shall be surrounded with 6 inches of cinder sand shading all areas.

Underground PVC conduit containing cables over 600 volts shall be encased with a 3000psi minimum of 3" of integral-color red concrete slurry (one 50lb bag of dye per cubic yard of concrete) on all sides of each conduit. Concrete shall be with aggregate

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small enough to work around conduits. Concrete around duct banks shall be carefully vibrated to prevent voids around and under conduits.

For two or more conduits, use approved plastic base and intermediate spacers beginning no more than 18" from termination at manhole or building wall, and maximum every 5' thereafter. Stake and tie conduits down securely before concrete pour to prevent float.

3" wide locatable marking tape (with appropriate legend, e.g. ELECTRICAL, TELECOMMUNICATIONS) and a #12 stranded tracer wire shall be placed above all buried conduits and duct banks at 12" below finished grade. If duct bank is more than two conduits wide, use two marking tapes, one at each edge of the trench.

Underground pullboxes shall be installed minimum 6' behind back of curb or sidewalk.

26 05 53	Identification for Electrical Systems
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Part 1 – General

Arc flash labeling is required.

Part 2 – Products

Provide plastic laminate labels (black with white letters for normal power; red with white letters for generator-backed power) switchgear, switchboards, main and feeder breakers in switchboards and switchgear, panelboards, motor controllers, variable frequency drives, disconnect switches, etc. Mount with self-tapping screws; adhesive type is not approved. Panelboard doors shall be labeled with panel designation and voltage. Lettering to be minimum 3/8" high with inscription centered on label. For switchboards and switchgear with spare breakers or spaces the labels shall be left blank for future engraving by others. In addition, CT cabinets shall be marked with the CT ratio.

Part 3 – Execution

Pullboxes and junction boxes shall be identified with permanent marker as to which circuit(s) and panel the box contains, e.g. "Panel E - Cir. 16-18-20."

Branch circuits shall be tagged in panelboards and pullboxes, using as-installed circuit numbers. Tags to be plainly marked with indelible ink, and securely attached to the wires.

All power outlet faceplates shall be labeled to indicate source circuit and panel.

Transformers, switches, equipment, pullboxes, cabinets, junction boxes and gutters having voltages of more than 600 volts shall be identified as to the voltage of the

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system within. Letters and numbers shall be a minimum of 2" and are to be highly visible contrasting colors. "DANGER - HIGH VOLTAGE - KEEP OUT" signs shall be permanently attached to the primary section door on transformers and on doors of sectionalizing switches of 600 volts or more. Signs shall be bilingual Spanish/English, and sized according to OSHA codes.

Service entrance main circuit breaker shunt trip panic buttons shall be marked "EMERGENCY-POWER OFF SWITCH" with a red and white laminate label.

Fire alarm system conduit shall be field-painted red, or shall be factory red topcoat colored conduit, or shall be labeled with 2" wide, red, heavy duty, indoor/outdoor rated, pressure-sensitive adhesive-backed flexible high-gloss vinyl tape, similar to Brady #55261 pipebanding tape. For tape-labeled conduit, clean surface with isopropyl alcohol and completely encircle the conduit in half-lapped turns of tape with the last two turns applied with no tension to prevent possible unwinding. Tape shall be installed maximum of 10' on center and within 3' of all changes of direction.

Fire alarm system boxes shall be red and shall be labeled "F/A" in 1" indelible black lettering.

All Fire Alarm Signaling Line Circuit/Initiating Device Circuit (SLC/IDC) devices shall have labels physically applied, noting both the Signaling Line Circuit/Loop number and the sequential device number; i.e., "S209" for a Signaling Line Device, sequential number nine (9), located on Signaling Line Circuit/Loop number two (2).

All Fire Alarm Notification Appliance Circuit (NAC) devices shall have labels physically applied, noting whether the Notification Appliance is fed from the fire alarm control panel (FACP) or a Remote Power Supply, the Notification Appliance Circuit/Loop number and the sequential device number; i.e., "N209" for a Notification Appliance Circuit Device sequential number nine (9), located on Notification Appliance Circuit/Loop number two (2), fed from the FACP, or "NP209" for a Notification Appliance Circuit Device sequential number nine (9), located on Notification Appliance Circuit/Loop number two (2), fed from a Notification Remote Power Supply.

Labels for both SLC/IDC and NAC devices shall be ½", clear flexible vinyl pressure-sensitive adhesive-backed, thermal transfer printed labels with ¼" high, black lettering, similar to Brady #M71C-500-580-CL. Label shall be mounted on flat plane of the metal ceiling tile support grid, directly adjacent to device, or on a non-curved surface of the actual device. Label shall be installed plumb. Installers hands shall be clean and shall clean the surface with isopropyl alcohol prior to installation of label t , such that label properly adheres and does not show installer fingerprints.

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All fire alarm head-end equipment shall have large red micarta label with two lines of ½” high, white, engraved lettering, physically adhered to the cover, plumb, and attached with minimum of (2) 3/16” diameter rivets and a flat washer. The first line shall indicate the type of head-end equipment, and the second line shall indicate the equipment’s physical location, including building number, floor level, and nearest column intersection; i.e., “FACP B24-1-K/2” for a Fire Alarm Control Panel located in Building 24, level one, near column K/2. Labels shall use the following acronyms:

- FACP – Fire Alarm Control Panel
- FAAP – Fire Alarm Annunciator Panel (Text)
- NP – Fire Alarm Notification Remote Power Supply
- FGAP – Fire Alarm System Graphic Annunciator Panel

**26 09 00 Instrumentation and Control for Electrical Systems**

26 09 13 Electrical Power Monitoring and Control

Part 1 – General

Provide data connection for metering. Coordinate requirements with NAU IT.

Part 2 – Products

Service entrance switchboards or panelboards shall be provided with an electronic meter with the following functions (per phase as applicable): ammeter, voltmeter, kilowatt demand, kilowatt-hour, harmonic distortion. Meter shall be capable of communication by non-proprietary protocol. Owner has pre-approved the following product to be in compliance with these standards: Veris E50H5, Enhanced Power and Energy Meter.

New medium voltage box pad mounted switchgear shall be provided with integral bus voltage and current metering and switch position monitors that shall report to the central metering system at the North Plant via fiber optic pathway.

Determine requirements for submetering of systems necessary to comply with measurement and verification of HVAC and other building systems.

Part 3 – Execution

Metering must be energized and programmed when the electrical system is energized. The electrical contractor and commissioning agent is to verify readings at that time. Communication with EMS can be setup at a later date but trending must be setup prior to substantial completion. Refer to Division 23 for EMS requirements.

26 09 43 Network Lighting Controls



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Part 1 – General

The system shall be digital.

Lighting Control Panel (LCP) shall fail in the last switched state in the event of a power failure. LCP to have individual nonproprietary relays capable of being removed and replaced individually without interruption of any other relays. LCP shall have one relay per load in its own separate package (not two or more relays built together as a unit). Relays shall be mechanically locking with the capability to manually switch each relay individually for maintenance, troubleshooting, and in the event of LCP or relay failure (relays to have a manual actuator).

Relays shall be UL20 listed, plug load rated, with heavy duty contacts.

Relays shall be 30 amp rated for ballast lighting loads.

Relays shall have a pluggable connector on external low voltage control wires with which to tie the relay to the LCP.

Means of connecting switching devices to the LCP shall be Cat5 minimum, not hard wired, with multiple switching devices being series connected capable.

The lighting control system shall have a hand held configuration tool for remote configuring of devices without the use of a ladder or tools.

Two configuration tools shall be provided to Owner.

Part 2 – Products

Owner has pre-approved the following manufacturer to be in compliance with these standards: Watt Stopper.

Part 3 – Execution

N/A

**\*\*END OF SECTION\*\***

Section Title  
Number

**26 10 00 MEDIUM VOLTAGE ELECTRICAL DISTRIBUTION**

See Division 33 for all components over 600 volts.

**\*\*END OF SECTION\*\***

Section Title  
Number

**26 20 00 LOW VOLTAGE ELECTRICAL TRANSMISSION**

**26 22 00 Low Voltage Transformers**

Part 1 – General

N/A

Part 2 – Products

Transformer windings shall be copper.

Part 3 – Execution

Dry transformers shall not be suspended or wall-mounted unless specifically approved by Owner (Electrical Department).

**26 24 00 Switchboards and Panels**

**26 24 13 Switchboards**

Part 1 – General

Refer to Division 33, for metering requirements for service entrance switchboards.

Part 2 – Products

Switchboards and switchgear

Owner has pre-approved the following manufacturer to be in compliance with these standards: Square D.

All bussing shall be copper.

Panic buttons

Mushroom head push buttons are not acceptable.

Owner has pre-approved the following products to be in compliance with these standards: Allen Bradley #800T-BGA extended head red push button unit with Allen Bradley #800-N13 extra long guard ring.

Overcurrent devices with adjustable trip characteristics shall be set in the field by the installing contractor, per the settings of the coordination study performed by the Design Professional.

Part 3 – Execution

Section Title  
Number

Panic buttons shall be installed in the electrical service entrance room at the exit(s). These panic buttons shall be wired to a shunt trip main breaker and in parallel with the ground fault trip (where applicable).

26 24 16 Panelboards

Part 1 – General

N/A

Part 2 – Products

Panelboards shall be as commercial grade, copper bus, circuit breaker type, hinged door in hinged door, painted gray with manufacturer's standard finish, keyed alike, without pre-punched knockouts. Main breaker shall be provided, center mounted in line with bus. Owner has pre-approved the following manufacturers to be in compliance with these standards: Square D, General Electric (bolt-on type), Siemens, Eaton, or approved equal.

Panelboards shall be circuit breaker type. Circuit breakers in 120/208 volt and 277/480 volt panelboards shall be bolt-on breakers. Breaker numbers shall be stamped on the deadfront; decal numbering is not allowed.

Load centers are not allowed.

Panic buttons

Mushroom head push buttons are not acceptable.

Owner has pre-approved the following products to be in compliance with these standards: Allen Bradley #800T-BGA extended head red push button unit with Allen Bradley #800-N13 extra long guard ring.

Submit sample directory with material submittals.

Part 3 – Execution

If the building is served by a service entrance panelboard, panic buttons shall be installed in the electrical service entrance room at the exit(s). These panic buttons shall be wired to a shunt trip main breaker.

When more than one panelboard is installed at the same location, the tops of the panelboards shall be mounted at the same height.

Furnish and install a neat, plastic-covered typed and printed circuit directory inside of each panelboard door. Directory shall indicate equipment or area(s) of building or equipment supplied by each circuit. Use as-built room numbers affixed on doors or

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as designated by Owner (Project Manager). Minimum size shall be 5" x 8" for panels up to 20 circuits; two for panels above 20 circuits, or 6" x 11".

Overcurrent devices with adjustable trip characteristics shall be set in the field by the installing contractor, per the settings of the coordination study performed by the Design Professional.

## **26 25 00 Enclosed Bus Assemblies**

### Part 1 – General

N/A

### Part 2 – Products

N/A

### Part 3 – Execution

Busways shall be installed with wall flanges at all wall penetrations. Floor penetrations shall have a sealed 1" minimum lip above finished floor.

## **26 27 00 Low Voltage Distribution Equipment**

### **26 27 26 Wiring Devices**

#### Part 1 – General

Receptacle outlets in office areas and classrooms, designated for instruction in the use of office or lab equipment, shall be laid out at a maximum of 6' on center.

Lighted toggle switches shall be used in all tunnels and equipment rooms.

Dual technology motion sensing switches shall be specified for all office, restroom, classroom, and storeroom areas, and other areas with more than six two-lamp fixtures. All motion sensors shall be equipped with a manual switch.

Toilet rooms shall be equipped with motion sensing switches for both lights and fans. Motion sensors shall be equipped with a toggle sensor.

All exterior receptacles, and interior receptacles within 6' of a water source (such as a sink, eye wash, drinking fountains, emergency showers, hose bibbs, etc.), shall be GFCI protected.

#### Part 2 – Products

Section  
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Wiring devices shall be 20A, specification grade, back or side wired standard National Electrical Manufacturers Association (NEMA) configuration. 15A devices and push-on devices are not allowed.

Cover plates shall be specification grade, nylon. Plate color shall match devices. Plates in exposed wiring shall be steel, rounded to box edge. Oversized plates are not allowed. Type 302 stainless steel shall be installed in all equipment and mechanical spaces.

Owner has pre-approved the following products to be in compliance with these standards:

- Receptacles & GFCI receptacles: heavy-duty specification grade, Hubbell 5362.
- Surge-suppression isolated-ground receptacles: Hubbell IG5362S.
- Isolated Ground: Hubbell IB5362BR.
- Toggle switches: Hubbell 1221.
- Lighted toggle switches: white or clear only, Hubbell 1221LC.
- Pilot light toggle switches: Hubbell 1221PLC.
- Momentary-contact switches: 3-position, single-pole double-throw, Hubbell 1557.

Devices and cover plates on emergency power shall be red. Cover plates shall be engraved "Emergency Power."

### Part 3 – Execution

All device wiring shall be pigtailed.

Horizontal receptacles shall be installed so that the neutral is to the top. Vertical receptacles shall be installed so that the ground is to the top.

All devices shall be grounded to the conduit system, the box ground screw, and the circuit equipment grounding conductor.

Receptacles shall be 18" AFF to center of receptacle, or 48" or 40" where table, work benches and counters occur, or as noted.

Mount wall switches on the latch side of doors. All switches shall be 48" AFF to the center of the switch, except where located in cabinets.

## **26 29 00 Low Voltage Controllers**

26 29 13 Enclosed Controllers

### Part 1 – General

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Number Title

Provide combination fused-switch magnetic motor starters or variable frequency drives on all motors 1 hp or larger.

Provide loss-of-phase protection on all 3-phase motors.

Provide motor-rated switches with overloads on small single-phase motors.

Part 2 – Products

Controllers shall be heavy-duty (HD), with green and red pilot lights, and operate on 120V control circuits. Owner has pre-approved the following manufacturers of enclosed controllers to be in compliance with these standards: Square D, General Electric, Siemens, Eaton, Crouse-Hinds.

Small single-phase motors shall be protected by a motor-rated switch at the motor location, or shall be provided with integral overload protection and a fuse stat at the motor location. Owner has pre-approved the following product to be in compliance with these standards: Allen-Bradley Bulletin 600 motor-rated switch.

Part 3 – Execution

N/A

26 29 23 Variable Frequency Motor Controllers

Part 1 – General

Do not locate drive inside of air handling units.

On equipment with Variable Frequency Drives, (VFD) provide a separate disconnect and contractor to start and operate equipment when the VFD fails.

Control wiring shall be in separate steel conduit from the motor feeder.

De-rate VFDs for installed altitude.

Part 2 – Products

VFDs shall be pulse-width modulated. All VFDs shall be the product of the same manufacturer. Owner has pre-approved the following manufacturer to be in compliance with these standards: ABB (ACH Series).

Indoor enclosures shall be NEMA 12. Outdoor enclosures shall be NEMA 4.

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Number      Title

Match type of drive to actual load driven (i.e. variable torque or constant torque).  
Coordinate use of VFD rated motors with Owner (HVAC department).

Provide 5% line reactors, electromagnetic interference filter/radio frequency interference filter (EMI/RFI) filtering, door-interlocked input circuit breaker or fused switch, and contactor bypass.

Coordinate communications protocol and control signal type with other Divisions of these Technical Standards.

Part 3 – Execution

Complete operation and maintenance manuals shall be provided to Owner prior to conducting the onsite training. The operation and maintenance manual shall contain a complete copy of the submittal documents. Training shall at a minimum consist of four hours of onsite training by a certified factory representative. The training shall be scheduled after the VFDs are in service and fully operational.

Install a fused bypass disconnect externally piped around the VFD.

**\*\*END OF SECTION\*\***



Section Title  
Number

**26 30 00 FACILITY ELECTRICAL POWER GENERATING AND STORING EQUIPMENT**

**26 32 00 Packaged Generator Assemblies**

26 32 13 Engine Generators

Part 1 – General

Generators shall be diesel-fueled. Access for fuel trucks must be provided.

Means shall be provided for shutting down the engine at the entrance to the generator room or enclosure. This shall be labeled "Generator Emergency Stop."

Outdoor generators shall be provided with skid-mounted double-wall steel fuel tank. Indoor generators shall be provided with an outdoor double-wall steel fuel tank.

Derate generators for installed altitude.

Part 2 – Products

Generator Emergency Stop

Mushroom head push buttons are not acceptable.

Owner has pre-approved the following products to be in compliance with these standards: Allen Bradley #800T-BGA extended head red push button unit with Allen Bradley #800-N13 extra long guard ring.

Part 3 – Execution

Generators which are installed in structures, or at outside locations, shall have adequate emergency lighting equivalent to normal lighting.

A complete test of the entire emergency electrical system, including load banking of generator and testing of each automatic transfer switch with the generator shall be performed on or before substantial completion of project.

Overcurrent devices with adjustable trip characteristics shall be set in the field by the installing contractor, per the settings of the coordination study performed by the Design Professional.

**26 36 00 Transfer Switches**

Part 1 – General

Transfer switches shall be 4-pole (switched neutral), except when adding a transfer switch to an existing emergency electrical system which is based on 3-pole topology.

Section  
Number      Title

Part 2 – Products

N/A

Part 3 – Execution

N/A

**\*\*END OF SECTION\*\***

Section Title  
Number

**26 40 00 ELECTRICAL AND CATHODIC PROTECTION**

**26 41 00 Facility Lightning Protection**

26 41 13 Lightning Protection for Structures

Part 1 – General

Lightning Protection Risk Analysis: Prepare and submit calculations as described in Annex L of NFPA 780. Use this analysis to make recommendation to Owner on the provision of a lightning protection system.

Part 2 – Products

N/A

Part 3 – Execution

N/A

**26 43 00 Transient Voltage Suppression**

26 43 13 Transient Voltage Suppression for Low Voltage Electrical Power Circuits

Part 1 – General

Two levels of transient voltage surge suppression (TVSS) or surge protective device (SPD) are required to protect electrical distribution equipment serving computer-intensive and/or critical information dependent areas and offices. These levels do not include receptacle-level TVSS.

Part 2 – Products

Surge protection devices shall have a 10 year warranty, all modes of protection, and active phase indicator lights.

Part 3 – Execution

N/A

**\*\*END OF SECTION\*\***

Section Title  
Number

**26 50 00 LIGHTING**

**26 51 00 Interior Lighting**

Part 1 – General

Lighting concepts and recommended illuminance levels per the Illuminating Engineering Society of North America (IESNA) Lighting Handbook and Recommended Practices (latest editions) shall govern the lighting design.

The lighting shall be designed for maximum efficiency, incorporating energy saving fixtures and daylighting when possible. Allowed Lighting Power Density (LPD) figures shall follow ASHRE 90.1.

Lighting fixtures shall utilize lamps that match the campus standards. Select fixtures and light sources with long operating lives; which utilize controlling elements (lenses, louvers, reflectors, etc.) designed to provide the best utilization of emitted light at the task location; that are appropriate for the ambient temperature; and that are not prone to dirt accumulation.

Fluorescent lighting for athletic or machinery spaces shall be circuited to minimize "strobe" effect.

LED shall be used for parking garages and under covered outdoor locations.

In high ceiling areas, locate fixtures for maintenance access or provide access for maintenance equipment.

Task lighting shall be used in order to reduce the general lighting load.

Suitable listed fixtures shall be specified and installed in fire-rated ceilings.

Wall-grazing lighting (fixtures mounted where the wall and ceiling intersect) will highlight irregularities in tile walls, gypboard walls, or wall coverings. Wall grazing lighting should only be used when the wall is highly textured by design. Wall washing lighting (fixtures at least 24" off the wall to the closest edge of fixture) is preferred.

The preferred method of powering egress and exit lighting is (in order of most preferred to least preferred) engine-generator (if present), and integral battery packs. Battery packs shall be approved by Owner via a submittal.

In renovation projects where existing fixtures are to be re-used, they shall be retrofitted with new ballasts and lamps as specified herein.

Section Title  
Number

In existing buildings, emergency battery ballasts in unswitched normal power fixtures shall be used. An acceptable alternate is sealed beam emergency lights with individual power packs, circuited to a normal power panel.

Projects requiring emergency power shall have a feasibility study, examining central inverter or generator vs. individual battery packs. Short battery life and inverters and high maintenance costs of battery packs should be considered in the study.

The following design parameters are provided as guides only for conceptual calculation for electrical and lighting loads.

<u>AREA</u>	<u>FOOTCANDLES</u>
Computer Labs	20-30
Library Reading Rooms	50
Calculating Rooms	50
Drafting Rooms	75
Accounting Rooms	50
Proofreading Rooms	75
Classrooms	50
Laboratories	75
Seminar Rooms	50
Offices	30-50
Toilet Rooms	10
Kitchens	30
Locker Rooms	10
Store Rooms	20
Corridors & Stairs (academic and offices)	25
Corridors & Stairs (dormitories)	10
Machine Rooms	20
Building Entrances (interior)	Same as corridors

Supplemental local illumination shall be provided wherever required to give the following local intensities:

Shop work at machines or benches	75
Displays	75
Demonstration Tables or Areas	60

Part 2 – Products

Lamps

Owner has pre-approved the following manufacturers to be in compliance with these standards: General Electric, Voss, Westinghouse, Sylvania, Phillips.

Section Title  
Number

Linear 4 ft fluorescent lamps shall be LED, 4100K, 20,000 hr life rated, CRI > 75. Four foot lamps are the standard. 8 ft and U-bend lamps shall not be used.

Linear 4 ft replacements or retrofits will be line voltage LED.

Exit lights shall be red LED type.

All fixtures operating in low temperatures shall be supplied with low temperature ballasts.

Ballast wiring shall be connected in accordance with 2011 NEC Article 410.130 (G). Owner has pre-approved the following product to be in compliance with these standards: WAGO LUMI-NUTS disconnect.

Fluorescent ballasts shall be high efficiency T5 instant start universal voltage electronic type with total harmonic distortion less than 20%, power factor 95% minimum, lamp current crest factor 1.6 or less, sound rating "A," and minimum five year material and labor replacement warrantee. Ballast preference is Sylvania Quicktronic T5 with normal and low ballast factor. High ballast factor must be approved by the Owner (Electrical Department's Supervisor). Owner has pre-approved the following manufacturers to be in compliance with these standards: Ballast, Valmont (Ultramizer), Advance, Motorola, EBT, Magnetek (Triad).

### Part 3 – Execution

In 277V lighting systems where inside tubes and outside tubes are switched separately, the same phase shall be used for each fixture so that 480V will not be accessible in the fixture.

Wiring for fixtures in accessible ceilings shall be accessible after fixture installation, without requiring removal of the fixture from the ceiling.

Fixtures mounted in plaster or drywall ceilings shall be rigidly supported with channel supports across plaster framing. Mount all fixtures with a minimum of three 1/4" bolts for 1' x 8' fixtures, two 1/4" bolts for 1' x 4' fixtures, and four 1/4" bolts for 2' x 4' fixtures.

Recessed fixtures shall be supported to the building structure (not the roof deck). All fixtures shall be supported on at least two points (opposite corners each individual fixture) with #12 gauge ceiling wire with a minimum of 3 twists of wire at each point of attachment. Two or more wires shall not be supported by a single anchor. Two or more fixtures shall not be supported by a single wire. Points of attachment and anchoring shall be approved by the Design Professional. Install strut channel as necessary to provide support between building structural points.

Section Title  
Number

Lighting within mechanical rooms, electrical rooms or above ceilings shall not be connected by electrical cord.

See Division 23 on light and HVAC diffuser requirements.

## **26 56 00 Exterior Lighting**

### Part 1 – General

See Design Guidelines,

### Part 2 – Products

Utilize narrow-spectrum amber LED with peak emission at 590 nm +/- 2 nm, spectral full width at half maximum intensity shall be less than 20 nm. Acceptable product numbers include Phillips LXML-PL01 or LXM5-PL01, Cree XBDAMB, or approved equal.

“Phosphor-converted” or “PC” amber LEDs are not acceptable in any applications requiring low-pressure sodium or amber LED.

### Part 3 – Execution

A 20' coil of #4 bare copper wire in contact with earth at the bottom of a pole base excavation will be installed.

All building entrances shall be illuminated with photocell-controlled luminaires.

Control components to have 3 phase contactors, a photocell with a hand off auto switch and contain an electrical meter.

When adding a new transformer for a lighting control box, a T-tap can be used with approval on an existing Pad Mounted Switch connection.

Street lighting circuits shall be 2" PVC conduits from box to box.

**\*\*END OF SECTION\*\***