

## DIVISION 16 - ELECTRICAL

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**16000**      **GENERAL**

All work shall comply with the exterior lighting ordinances of the City of Flagstaff, with all requirements of the National Electrical Code (latest edition adopted by The City of Flagstaff), and requirements of Arizona Public Service.

All materials shall be new, Underwriter listed, and standard first line products of their respective kinds.

All electrical work shall be inspected and approved by the Owner, it's designee, and/or the NAU Electrical Department before being covered. All tests are to be observed by the Owner or it's designee.

Any electrical work that will interfere with or interrupt the operation of any existing building services, must be coordinated with NAU Project Manager at least one (1) week in advance for proper scheduling. This activity may be required to be done during non-working hours at no increase in contract price. Outages shall be for minimum time periods. All preparation work shall be planned and executed prior to the actual outage. Emergency generators will be required in critical situations.

### **Documentation Requirements from Contractor**

Contractor will completely annotate wiring prints monthly showing actual configuration of connections and wire runs.

Contractor shall be required to provide complete, down to the component level, submittals of all Electronic / Electro-Mechanical devices.

Prints and schematics will supplied whether a service contract has been approved or not "Block Diagrams" do not constitute a schematic. Actual components used shall be shown on drawings.

Any substitutions or 'equivalent product' changes shall require prior approval by Facility Services Electric Shop.

If a computer program is used, a complete printout of the program shall be supplied by the contractor. All access codes and passwords will be furnished. Estimated cost of annual routine maintenance shall be required.

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### DESIGN STANDARD

The following design parameters are provided as guides only for conceptual calculation for electrical and lighting loads: (NOTE: Task Lighting shall be utilized in all possible areas to reduce general lighting load.)

<u>AREA</u>	<u>Foot-candles</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
Shops	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
Parking Structures & Lots	To meet City of Flagstaff Lighting Ordinance req's.
General Site Lighting	To meet City of Flagstaff Lighting Ordinance req's.

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

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

All building entrances shall be provided with illumination. Lights shall be connected to photocells. Fixtures shall comply with restrictions of City of Flagstaff Lighting Ordinances.

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16050	BASIC ELECTRICAL MATERIALS AND METHODS

### General

In general, no more than six circuits shall be run in a single ¾" homerun, if conductors are #12's or smaller. Size of all homerun conduits shall be ¾" minimum. Do not combine homeruns when shown separate. If conduit is greater than ¾", fill shall be no more than 50% allowed by NEC.

Neutral conductors shall be #10 AWG minimum, where 2 or more 15 or 20 amp circuits share a common neutral.

Metallic tags or labels shall not be used inside switchboards, panels and/or MCC's.

Telephone plates and devices or jacks (modular) shall match electrical device plates and devices, in color and material.

Panelboards, gutters, junction boxes and other electrical equipment with removable covers shall not be painted other than original factory paint and necessary touch up paint.

Different systems shall be run in separate conduits as complete systems with conduit, wireways, boxes, etc. Examples of separate systems are as follows: 120/208 volts, 277/480 volts, fire alarm, emergency lighting and power, computer, telephone, intrusion alarms, building automation, and energy management

All wiring shall be in conduits or raceways regardless of voltage. All main service, main feeder, and general circuitry wiring shall be specified as copper. Telephone cable and power limiter cable for fire alarm systems shall be in conduit unless they are plenum rated. All shall be properly installed and supported.

Panelboards, gutters, junction boxes and other electrical equipment with removable covers shall not be painted other than original factory paint and necessary touch up paint.

Sleeves shall be specified for penetration through floor and shall extend a minimum of 1 inch AFF (above finished floor). Fireproofing shall be provided for all penetrations.

The electrical contractor shall furnish copies of State of Arizona high voltage license to owner before proceeding with any work of over 600 volts. This includes raceway installations, cable pulling or terminations.

All electrical equipment, disconnects, starters, panels, devices and plates shall be installed plumb and true. All adjacent boxes shall be aligned and level. Devices will be installed with enough clearance and access to allow maintenance, repair, or calibration. (N.E.C. 110-6a)

All Panelboards, disconnects and starters shall be mounted at a height to make testing and maintenance as easy as possible. In no case shall panelboards be mounted so that the maximum height of any circuit breaker exceeds 78 inches to top of breaker. For panelboards with excessive height, mount panelboard so that the bottom of the cabinet will not be less than twelve inches above the finished floor.

Electrical wires, electronic wires and air lines shall not be run in the same conduit. Control wiring of different voltages for the wiring of electrical equipment shall not be run in the same conduit as power feeders.

Conductor splices shall only be allowed in outlet boxes, gutters, junction boxes or pull boxes.

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16110	RACEWAYS

### General

Raceway systems shall be installed as complete systems. Support shall be every 10 feet and within 3 feet of boxes, cabinets, or fittings and within 18" of each change in direction. (Per NEC)

Wiremold or similar, and equal, wireways shall be installed as complete systems using accessory fittings (elbows, end plates, tees, etc.) according to the manufacturer's recommendations assuring a rigid mechanical and electrical connection between parts. Removable wireway covers shall be accessible except as in N.E.C. 362-8. Wiremold is acceptable only in exposed locations. If a box is located behind the raceway, the opening in the raceway shall be of the same dimension as the box opening. The opening shall be provided with a bushing.

Raceway installations shall be made in such a way that no wrench or tool teeth marks are evident

### Conduits

Wiring of every description shall be in an approved raceway. **All conduit shall be a minimum of 3/4".**

**Exception: 1/2" conduit may be used in walls for dead end runs only.**

Flexible Steel Conduits shall be used only where approved by the Owner for connection to equipment which is moveable for adjustment, mounted on isolation units for elimination of vibration and sound or for connection from a close by junction box to lay-in type light fixtures in a "T" grid ceiling. Run green ground wire in all flexible conduits. Seal tight flex shall be spirally wound steel.

Connectors for flexible steel conduit shall be of steel type. Twist on type connectors shall also be made of steel type. Under no circumstances shall runs of flexible conduit exceed six feet. Junction boxes shall be as close as possible to fixtures. Junction boxes shall be fully accessible without removing the fixture.

Type "MC" cable shall be the exception and not the norm. It shall only be used by special permission from the authority having jurisdiction. Type "MC" cable shall be of the **steel** type, color coded along its entire external length. Minimum size wire shall be #12. Light fixtures with factory "MC" whips are acceptable when approved per the Engineer / Architect.

Use of Flexible Metallic Tubing or non-metallic flexible conduit is **prohibited**.

Rigid Heavy Wall Steel conduit shall be installed with double locknuts and an insulated metallic bushing (150 degree C rated). All surface conduits exposed to weather or subject to mechanical damage shall be Rigid Heavy Wall Steel Conduit or I.M.C. unless other wise stated. Where conduits enter from below, install a threaded rigid conduit coupling flush with the concrete to permit removal of the conduit above the floor. When conduit is removed a threaded conduit plug can be installed flush with the floor for abandonment. Changing from one raceway to another shall be accomplished at an approved box only. Rigid Heavy Wall Steel Conduit shall be half lap wrapped with Scotch Wrap #50 or an approved equal when installed in concrete or in earth. Rigid heavy wall steel conduit shall be hot-dipped galvanized mild steel, full weight, with clean cut sharp threads. Only approved full radius benders shall be used. Rigid conduit shall be used in all tunnels, in concrete pours (high voltage only), wherever subjected to physical damage and shall be used in mechanical rooms 10' and below. Feeders of more than 100 amps rigid or I.M.C. is acceptable. EMT is allowable except where physical damage might occur. High voltage (12,470 volts) shall be installed in rigid or IMC. Only **steel** compression or set screw fittings are acceptable. Malleable or cast construction is not acceptable.

Electrical metallic tubing shall be hot-dipped galvanized and shall conform to the NEC requirements. Only UL approved steel fittings shall be used with all EMT. Fittings may be compression type or steel set screws. Only

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approved full radius benders shall be used. Minimum size EMT shall be 3/4". 1/2" EMT may be used for dead-end runs. EMT may be used in furred spaces, in either metal or wood stud walls, and either exposed or concealed. EMT is not approved for use in masonry walls. EMT shall not be installed so as to come into contact with the earth. EMT shall not be installed so as to come into contact with the earth.

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 rigid heavy wall steel conduit elbows. Normal radius bends may be used with runs of 600 volts or less, but long radius bends shall be used with systems over 600 volts and data systems, communication or phone systems. PVC may only be used in concrete or underground, except for runs over 600 volts, which must be run in rigid heavy wall steel. PVC shall convert to Rigid Heavy Wall Steel before stubbing out of earth or concrete, with a minimum of 18" of Ridged Heavy Wall Steel in the slab or earth. This also applies to runs of PVC, stubbing out of slabs into the earth. Rigid heavy wall steel shall extend 3' beyond the building when penetrating exterior walls.

Minimum burial depth shall be 18" for runs 600 volts or less and 36" for runs over 600 volts. Electrical power ducts, and phone communications or data ducts, shall be separated by 12" minimum. A minimum of 12" separation shall additionally be maintained between electrical and water & sewer lines.

PVC shall be totally encased over 600 volts with a minimum of 3" of 3000 pound (RED) concrete on all sides of each conduit. For two or more conduits, use approved plastic base and intermediate spacers placed no further apart than 18" from termination's and every five (5) feet thereafter. Tie conduits down securely before concrete pour. For duct bank runs, concrete shall be with aggregate small enough to work around conduits and provide the strength and durability required. Concrete around duct banks shall be carefully vibrated to prevent voids around and under conduits.

PVC shall not be used to penetrate outside walls or floors. Rigid heavy wall steel conduit shall be used and extended a minimum of 3' beyond the building exterior. High contrast underground hazard 3" wide marking tape with metal locating strip and proper legend shall be placed in the ditch with all buried electrical conduits. If duct bank is more than two conduits wide use two marking tapes, one at each edge of the trench or ditch. Locating tape shall be placed within twelve inches of finish grade.

All EMT Fittings shall be of steel type, not potmetal. Connectors shall have insulated throat (105 degree C rated) similar to T & B #5223 series. Couplings shall be extra long, similar to T & B #5220 series.

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 trays. Fasten conduits to cable trays with GEDNEY CTC or approved equal clamp. Cables are to be run in a raceway. FD or FS cast boxes with cast lugs shall be used for exposed wiring in buildings or where subject to weather. Covers to be FD/FS type. USE WLRD/WLRS by Crouse-Hinds or Arrow-Hart covers for outlets subject to weather.

Where wires or cables enter or exit a conduit which is used to provide support or protection from physical damage, a fitting such as a connector and ground bushing shall be provided on the end(s) of the conduit or tubing to protect the wires or cables from abrasion and to ground the conduit. All bushings to be insulated metallic bushings rated at 150° C.

Spare conduits shall be extended up from flush mounted panels to the space above false ceilings and capped. If there is no false ceiling, these 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 at least 3 spare conduits provided.

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Surface conduits shall be painted same color as surface it is attached to. Panels, gutters and other electrical equipment with removable covers shall not be painted. Conduits concealed, run in tunnels or equipment rooms shall not be painted.

**Installation of Conduit**

Conduit shall be run concealed except in certain approved locations. Conduit shall be secured both horizontally and vertically against movement. Listed mechanical fasteners shall be used. Tie wire may only be used for securing horizontal conduit runs within stud walls. Outlet boxes, junction and pull boxes, etc., shall be installed so as not to interfere with any piping, fixtures or equipment. All boxes shall be fully accessible. Exposed conduits shall be grouped in neat parallel lines, properly supported, following the lines of the building structure as closely as possible and as directed. All phone conduits that are buried and contain fiber optics shall have marking tape with metal locating strip 6" above

Conduit shall not run through any structural member of the building except as specifically directed by the Architect. Conduit run through ribbed slabs shall run at 45 degree angles to joints or parallel and in the joints.

No running threads will be permitted. Union fittings may be used as necessary. Rigid conduit threadless connectors or couplings, split couplings that bolt together, self-threading fittings or couplings permanently attached to conduit shall not be used unless approved by the NAU Electrical Inspector.

Ninety degree bends in conduit 1-1/2" and larger shall be made with factory bent standard conduit elbows or by hydraulic type benders. No more than four 90 degree bends (360 degrees) shall be used between pull, or junction, boxes. No more than three 90 degree bends (270 degrees) shall be used between pull, or junction, boxes on data, communications or phone conduits.

The ends of all conduits shall be cut square, carefully reamed to full size and shouldered in fittings. Conduit shall be fully seated in connector and couplings. Drip pans shall be used under threading equipment. Roller type tubing cutters shall not be used.

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.

Perforated strap iron or plumbers tape shall not be used for hanging conduit or boxes. Use standard pipe hangers with rings and rods for all conduits suspended from ceilings. Standard 16.5 gauge Ty Wire is acceptable with prior approval but only when tied per ironworkers tie.

Runs of one conduit suspended shall be on rings with rod hangers with self-drilling anchors or other approved methods. Runs of more than one conduit suspended, shall be on a strut trapeze support with clamps. Trapeze supports shall be 1-5/8" x 1-5/8" strut channel supported by minimum 3/8" rods.

Strut clamps shall be of the nut and bolt type, minimum 300 lb. static load limit.

Drive-it straps are not acceptable. Plastic sleeve, lead anchor, rawl plugs or power driven anchors are not acceptable.

When using all thread or bolts they must be backed on both sides with washers, lock-washers and nuts. (Floating unistrut/conduit straps etc. are not acceptable)

Electrical metallic conduits shall not touch any plumbing pipe. Where unavoidable, approved insulation shall be used.



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Upon completion of all runs, all conduits shall be properly sealed until ready to pull wires.

Install pull cord in all empty conduits and install plates on all communication boxes. All boxes shall have covers or plates.

Provide moisture tight hubs for entrance from above or sides of exterior boxes, gutter, panelboards, switchboards, etc.

Short pulling elbows and 90 degree connectors shall not be used on conduit sized greater than 1".

All feeder conduits for panels, switchgear, gutters, SES, and pull boxes shall have grounding bushings.

Bushings shall be insulated throat metallic bushings with a 150 degree C rating. Bushings shall be similar to T & B #BIM 75 series. Grounding bushings shall be similar to T & B #3871 series.

All conduit shall be terminated with a box, cabinet, panel, gutter, or a piece of electrical equipment. In fixtures, surface metal raceways and boxes where conductors pass through either factory or field punched, cut or drilled slots or holes in metal members, the conductors shall be protected by bushing material or grommets securely fastened in the opening prior to installation of the unit. Units shall have mechanical and electrical continuity. When conduits for communications, telephone or data are to be terminated by being clamped to cable tray, a threaded bushing and connector may be used in lieu of other terminal fittings at the cable tray. A Gedney CTC clamp or approved equal shall be used to clamp conduit to cable tray.

Conduit containing cables rated over 600 volts shall be identified at least every 20 feet with high visibility labeling. Transformers, switches, equipment, pull boxes, cabinets, junction boxes and gutters having voltages of more than 600 volts shall be identified as to the voltage of the cables 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 are to be bilingual Spanish/English sized according to OSHA codes.

**The Firewall integrity shall not be compromised.**

### **Cable Trays**

All buildings, except dorms, shall have cable tray facilities for computer and/or communication type wiring. These cable trays to terminate in designated communication room w/air conditioning. There must be adequate raceways from the communications room to the tunnel for necessary access, and adequate raceways from floor to floor. Fire stop material must be used for penetration of fire rated walls and all floors. Communication conduits shall be attached to cable trays with listed type clamps, such as Gedney CTC or approved equal, and terminated with threaded insulated metallic bushing on conduit. All cable trays are to be grounded (NEC 318-7).

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

### **Busways**

Busways shall be installed as a system with wall flanges at all wall penetrations. Floor penetrations shall have a 1" minimum lip to prevent water from dripping through. Fire walls shall not be compromised.

16120

**WIRE AND CABLE**

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Wire shall be 600v insulated NEC standard of the type specified below for different applications, shall bear the Underwriter's label, and shall be brought to the job in unbroken packages, showing the date of manufacture and the maximum allowable voltages. Manufacture date to be within the past year. Approved wire is Calec, Hi-Tec, Capitol, Rome, Essex, or General. All wire shall be copper soft-drawn, annealed, having conductivity of not less than 98% pure copper.

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

Minimum wire size shall be #12 except for controls wiring. Wire of size #10 and larger shall be stranded, all motor related wiring and controls shall be stranded.

Wire shall be color coded throughout its entire length, except feeders shall be identified with multiple rings or spirals of color coding tape at terminal points and any other accessible points. Grounded and grounding conductors shall be identified continuously at all visible points.

Circuits and feeder wires shall be continuous from switch to terminal or most distant outlet.

Continuity of all conductors shall not be dependent upon device connections, where the removal of such devices would interrupt the continuity of other conductors in the circuit.

Only approved wire lubricant may be used. Any conduit run that does not allow conductors to be pulled readily, will be condemned and the run must be replaced by other conduit satisfactory to the NAU Electrical Inspector.

Joints in wiring #8 B & S gauge, and larger, shall be made with compression only connectors.

Branch circuits shall be tagged in the load centers, with circuit numbers to correspond to the plans.

Joints shall be covered with a layer of rubber tape, then thermoplastic tape. Plastic electrical insulating tape shall be flame retardant and weather resistant, of premium grade vinyl plastic, resistant to hot and cold weather, 7 mil tape that applies well at 0 degree F, has an operating range up to 220 degrees F, and shall meet the requirements of ASTM D-3005-72, Type 1, UL 510 and HHI-595C. CAS Bulletin No. 561A (105 degrees C.).

When using twist on wire connectors, wires shall be twisted together, with pliers, before applying connector.

Carefully cable all wires, in panelboards, gutters, and wireways, in a neat arrangement, with termination located directly opposite terminals. Leave wire loops not less than 6" long, in each outlet box, even if wires do not stop in the box.

Color code wire throughout including feeders, branch circuits and equipment ground conductors, as specified and as indicated:

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PHASE	120/208 VOLTS	277/480 VOLTS
A	BLACK	BROWN
B	RED	ORANGE
C	BLUE	YELLOW
NEUTRAL	WHITE	GRAY
GROUND	GREEN	GREEN
Isolated Grnd	GREEN/Orange Stripe	GREEN/Orange Str.

Note: All 12470 systems shall be phased for convenience only.

Wiring for switches shall be the same color as phase wire. Colored insulation shall be used up through No. 6 conductors. Conductors No. 4 and larger may be phase coded with multiple bands of 1/2" wide color coding tape at all accessible locations. Grounded wires (neutral) and ground wires shall have a continuous color coding at all accessible locations. Maintain the same conductor color coding from incoming line to last device.

### 16130      **BOXES**

#### General

Boxes shall be 4" square as a minimum. For convenience outlets, switch, data, telephone, fire alarm system or intercom outlets use a 4" square or larger box with plaster ring.

Outlet boxes, junction boxes and switch boxes shall be galvanized code-gauge steel. Conduit body type case FD/FS boxes with cast lugs shall be used where exposed to the weather and where subject to moisture or mechanical damage. FD/FS covers shall be used with these boxes. Do not compromise integrity of FD/FS boxes by drilling holes in box for fastening.

For outlets in unplastered masonry walls use masonry boxes of the proper depth. 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. Handy boxes or handy box extension rings shall not be used.

Boxes shall be no less than 4" square. Use of more than one extension ring is not acceptable.

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

For convenience outlets, switch, data, telephone, fire alarm system, or inter-communication outlets, use 4" square, or larger, pressed steel boxes with plaster rings.

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

Receptacles installed in a horizontal manner shall be installed so that the neutral is to the top.

All boxes shall be grounded to conduit system, and bonded to the equipment ground, which shall be bonded to the equipment ground screw, on all devices.

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

All surface mounted fire alarm break stations shall be mounted on back-boxes specifically made for the purpose and red in color.

Pendant outlet boxes shall be highly visible Woodhead #3000 series boxes (or approved equal) with appropriate strain reliefs for the cord. Plates shall match box and outlet used.

### **Pull and Junction Boxes**

**Pull boxes and junction boxes shall be identified as to which circuit and panel the run feeds from, i.e., Panel E - Cir. 16-18-20.**

Boxes shall be galvanized or metal with baked enamel. Boxes shall be constructed with suitable barriers separating the different systems. Boxes shall be provided with removable covers, secured with machine screws. Gangable boxes shall be used for remodel fish jobs only.

Conduit shall enter boxes through tight fitting bored or punched clearance holes and be secured to boxes. Provide inserts, or expansion anchors, rods and angle iron members to support pull boxes independently of the conduit runs. Conduit shall enter boxes at right angle with no binding. Offsets shall be used as necessary for proper fit. Offset connectors are not acceptable.

Install junction boxes or pull boxes in order to facilitate the pulling in of wires or cables. Runs shall not exceed 90 feet between boxes.

Branch circuits shall be left tagged in the panel boards and pull boxes for the purpose of distinguishing the various circuits. Tags to be plainly marked with indelible ink, and attached to the wires.

Conduit bodies larger than 1-1/4" shall not be used. SLB fittings are not approved.

Conduit connections shall not be made to box covers.

Pull and junction boxes shall be grounded to conduit system, and bonded to the equipment ground, which shall be bonded to the equipment ground screw, on all devices.

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### Support of Boxes

Boxes shall be accurately placed, rigidly and securely supported from the structure. Boxes for concealed work shall be set flush with the finished surfaces of the walls or ceilings. Boxes may be supported by rods from the ceilings, only when fitted with approved support devices.

Approved bar hangers, fitted with fixture studs, shall be used to support boxes in ceilings.

Data and telephone outlet boxes shall be located at heights to match adjoining receptacles unless noted differently for wall mount phone. In remodeled locations box heights shall match existing.

### **16140 WIRE CONNECTIONS AND CONNECTING DEVICES**

Push on devices are not acceptable. Back and side-wired outlets with a tightening screw shall be used. Devices may not be used as a terminal jumper, all wires are to be pig-tailed.

Wiring devices shall be 20 amp brown or ivory specification grade. Fifteen amp devices are not acceptable. All power outlets shall be according to the NEMA configuration charts.

Cover plates shall be stainless steel type 302, nylon, or endura lexan. All plates shall be commercial spec grade. Plates shall be specified for all openings, with devices or blank. All plates shall match devices.

### Receptacles

Duplex - extra hard use specification grade, back and side wired; 2 pole, 3 wire, grounding type, 20 amp, 125 volt, Brown (NEMA 5-20 r) Hubbel #5362, or approved equal. Back wire through a hole with clamp type wiring assembly suitable for stranded wire.

Ground Fault Circuit Interrupter - 2 pole, 3 wire, grounding type, 20 amp, 125 volt, brown (NEMA 5 - 20 R) Hubbell #GF5362, or approved equal. Surge suppression with Isolated Ground, 20 amp, 125 volt, blue, UL listed to Standards 498 and 1449, Hubbell IG 5352 S.

Isolated Ground - 20 amp, 125 volt, brown, Hubbell IB 5362 BR. Use green wire with orange stripe for tracer for isolated ground wire. In addition to isolated grounds, an equipment ground shall also be provided. The equipment ground shall be pulled and bonded to the box.

All plugs and receptacles shall have the configuration specified by NEMA charts for circuit characteristics where they are being used. Hubbell numbers are used to establish a standard.

Receptacles shall be 18" to bottom in stud walls (per the requirements of the Americans With Disabilities Act of 1990), or 48" or 40" where table, work benches and counters occur, or as noted. In remodeled locations box heights shall match existing. Receptacle outlets in office areas and classrooms, designated for instruction in the use of office or lab equipment, shall be located at a maximum of 6' on center.

### **16195 ELECTRICAL IDENTIFICATION**

Provide plastic laminate (black with white letters) labels mounted on switches, magnetic, etc., designating unit controlled. Mount with self-tapping screws; stick-on tape of metal or plastic are not approved. Red with white letters shall be furnished for emergency equipment. Panelboard cabinet doors shall be labeled with panel

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designation and voltages. Letters to be a minimum 3/8" with inscription centered on plate. For equipment with spare breakers or spaces the labels shall be left blank for future engraving. See #16130 Pull and Junction Boxes

KWH meters to have multiplier marked on meter. CT cabinets shall have ratio labeling, on the outside of the cabinet.

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

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**HIGH VOLTAGE DISTRIBUTION (Above 600-Volt)**

The primary electrical distribution system throughout campus is an underground system in the tunnel network and is distributed at 12470 volts. Each new building shall provide the necessary switches and transformers for it's connected load.

High voltage cable shall be ethylene-propylene-rubber, 133% insulation, shielded cable with a 40 year warranty: Okonite manufacturer.

High voltage switchgear shall be pad mounted, low profile, dead front type, S&C Manufacturer.

**16320 TRANSFORMERS**

Service transformers shall be liquid cooled non-PCB type. Locate at exterior service side of building for accessibility. A concrete lip of 36" shall extend on the door side of the padmount transformers and padmount sectionalizing switches, 6 on other sides. Penta head bolt shall be used on transformer door. (Penta head socket to be turned over to NAU when job is complete.)

Transformers shall not be located in basements or other areas subject to contaminant by flood waters.

Provisions for extensions shall be specified for 12470 volt switch cabinets by adding incoming line primary loop feed configurations.

**16340 INSULATORS AND LIGHTNING ARRESTORS**

**16390 PRIMARY GROUNDING**

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

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**Title**  
**SERVICE AND DISTRIBUTION (600-Volt and Below)**

All switchboard, distribution panel, MCC and branch circuit panelboard buses shall be copper. All cans shall be field punched. **Pre-punched knockouts are not approved.** All switchgear shall be specified as Square "D" or equal.

Panic buttons shall be installed in each electrical service entrance switchboard room at the exits. These panic buttons shall be wired to a shunt trip main breaker in parallel with the ground fault trip. The buttons shall be Allen Bradley #800T-BGA (or approved equal) extended head red push button unit with Allen Bradley #800-N13 (or approved equal) extra long guard ring. These panic buttons are to be marked "EMERGENCY-POWER OFF SWITCH" by a red and white laminate label. Mushroom head push buttons are not acceptable.

**16420 SERVICE ENTRANCE**

Service Entrance Switchboards shall be provided with ammeter, voltmeter (both with phase switching positions and off positions). Provide kilowatt-hour meter with demand register. Multiplier shall be marked on meter. Label switchboards with CT ratios. KWH meters shall be adaptable to supply a pulse train output for future EMCS system.

**16425 SWITCH BOARDS**

**16440 DISCONNECT SWITCHES**

**16450 GROUNDING**

Provide an equipment ground, sized per NEC, shall be pulled and connected to all devices.

All conductors used for grounding will be color coded green continuously in all visible places, cabinets, equipment, pull boxes, junction boxes, switchboards, etc., or shall be bare copper continuously. Conductors used for isolated grounds shall be green with orange stripe or tracer.

**16460 BONDING**

The non-current-carrying metal parts of all outlet, device, pull, and junction boxes, gutters, motors, cabinets, switchgear, and panels shall be bonded to an equipment ground.

**16470 PANELBOARDS**

Panelboards shall be hinged door. The exterior surfaces of all cabinet fronts shall be painted with two coats of gray lacquer over a filler coat. Panelboards and cabinets shall be of a sufficient height and width to allow a minimum of 4" of wiring gutters around all sides. Minimum size shall be 20" wide, 5-3/4" deep, maximum width shall be 22". The doors shall be keyed alike. Busses shall be copper. Main breakers shall be provided, center mounted in line with bus. Acceptable manufacturers are GE, Square D, Cutler Hammer, with square D being the preferred manufacturer. Cover fastening bolts shall be accessible only when cabinet door is open. Cans shall be galvanized steel with blank end walls. Knockouts to be field punched. When more than one panelboard is used at the same location they shall be mounted the same height.

Panelboards shall be circuit-breaker type. Circuit breakers in 120/208 volt panels may be plug-in style. **Commercial Grade Only.** Circuit breakers in 277/480 volt panels shall be bolt-in type. All circuit breakers shall be specified as Square "D" or equal. Breakers shall be numbered between the breakers. Decal numbering is not satisfactory. Panels shall be sequence phased. Two pole or three pole breakers shall be "AB" common



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trip. Breaker handles shall not be tied together to make a multi-pole breaker. All circuit breakers shall be of the same manufacturer as the panelboards.

Furnish and install neat directory form with cover of thick plastic on inside of each panel cabinet door. Provide typewritten list of complete circuits in directory frame, showing portions of building or equipment supplied by each circuit. Use room numbers painted on doors or as designated by the Owner. Minimum size shall be 5" x 8" for panels up to 20 circuits; two for panels above 20 circuits, or 6" x 11". Numbering to be odd on the left and even on the right. Submit sample directory with submittals.

<b>16475</b>	<b>OVERCURRENT PROTECTIVE DEVICES</b>
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Surge Suppression Units:

Independent surge suppression shall be considered for computer intensive and/or critical information dependent offices.

Surge suppression shall:

- Use indicator light.
- Lifetime warranty
- All modes of protection
- Active phase indicator lights
- Parallel connection
- Surge current 100 amps minimum

<b>16480</b>	<b>MOTOR CONTROL</b>
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Motors shall have disconnecting means furnished by the Contractor. Westinghouse, General Electric, Square D or Crouse-Hinds are approved manufacturers. Magnetic switches shall be installed on motors 1 hp or larger (controls to be 120 volt). Magnetic switches shall have green and red pilot lights, in covers. All switches to be HD(Heavy Duty).

Single phase motors are to be protected with Allen-Bradley Bulletin 600 or Fusetrans. All magnetic switches to have one overload relay per phase. Westinghouse, General Electric or Allen-Bradley are acceptable manufacturers. Magnetic switches shall be installed on motors 1 hp or larger (controls to be 120 volt).

<b>16490</b>	<b>SWITCHES</b>
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Motion sensing switches shall be specified for all office, restroom, classroom and storeroom areas and other areas with more than six (6) two-lamp fixtures. Motion sensors shall be of the infra-red or ultra-sonic type.

Toggle - extra hard use specification grade, back and side wired, 20 amps, 120/277 volts, Brown, Hubbell #1221.

Momentary Contact - 3 position single pole double throw, Brown, Hubbell #1557.

Lighted Toggle - Clear - Hubbell #1221 - ILC.

Pilot Toggle - Clear Hubbell #1221 - PLC.

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All switches to have body securely locked to bridge by staked screw assembly. Back wire through a hole with clamp type wiring assembly suitable for stranded wire.

Lighted toggle switches shall be used in all tunnels and equipment rooms, so switch locations will glow in the dark. Lighted toggle switches shall be white or clear, not red or ivory.

Toilet rooms shall be equipped with motion sensing switches for both lights and fans.

Switch plate covers: White nylon in low impact areas or stainless steel, if requested by electric shop. Plates in exposed wiring to be steel rounded to box edge. Oversized plates are not acceptable.

Wall switches shall be on the latching side of doors according to the architectural plans. All switches shall be 48" high to the bottom of the switch, except where located in cabinets, see details.

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

## DIVISION 16 - ELECTRICAL

Section Number	Title
16500	LIGHTING

Interior lighting shall be designed to the maximum efficiency incorporating energy saving fixtures and daylighting when possible. Target range for lighting electrical consumption should be no more than 1.5 watts/s.f. (Reference: lighting levels table in 16010)

In 277 volt lighting systems where inside tubes and outside tubes are switched separately, the same phase shall be used so that 480 volts will not be accessible in the fixture. Barriers are to be used in any switch boxes where 480 volts would be accessible.

Fluorescent and "HID" lights specified in sports or machinery spaces shall be circuited to minimize "strobe" effect. Before specifying any fixtures utilizing HID lamps verify lamp replacement cost. Any fixtures requiring lamps costing more than \$15.00 shall require prior approval by the NAU electric shop.

16501	LAMPS
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Specification of incandescent fixtures shall only be allowed when specifically authorized in writing by the NAU Project Manager.

Lamps shall be General Electric, Voss, Westinghouse, Sylvania, or equal.

Fluorescent lamps shall be energy saving T-8 type, 4100K, 20,000 life rated, CRI > 75. Tubes shall be compatible with the ballasts. Four foot lamps are the standard, and preferred. Eight foot and U-tube lamps shall be specified only with written approval from the project manager.

Compact fluorescent lamps and fixtures, for food service areas and other special locations, shall be rated for such installations. (coated bulbs or lenses)

16502	BALLASTS AND ACCESSORIES
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All fixtures operating in low temperatures shall be supplied with low temperature ballasts.

Fluorescent fixtures shall be provided with fully electronic ballasts. All ballasts shall be rapid start with total harmonic distortion less than 20%. Power factor - 95% minimum, lamp current crest factor - 1.6 or less, sound rating "A", parallel operation required, minimum five year material and labor replacement warrantee. Specify: Valmont Ultramizer, Advance, Motorola, EBT, Magnitek Triad, or approved equal.

Dimmers shall not be SCR type unless noise suppressors are used. Dimmers shall be connected to fixed loads only. Not to be specified in conjunction with fluorescent lights unless compatible dimming ballasts are specified.

16510	LIGHTING FIXTURES
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In all cases where it is possible to maintain or re-use existing 2' x 4' four bulb fixtures the A/E shall specify retrofit of such fixtures with; (2) T-8 lamps and "zero watt" electronic ballasts.

Fixtures mounted in plaster or drywall ceiling shall be rigidly supported in approved manner with channel supported across plaster framing. Provide proper plaster frames for all fixtures requiring them. Wiring for

## DIVISION 16 - ELECTRICAL

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fluorescent fixtures is to be accessible after fixture installation, without requiring removal of the fixture from the ceiling. 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. Only approved anchors shall be used (Toggle bolt may not be used in damp location).

Recessed fixtures shall be supported to the supporting building structure above (not the roof deck). All fixtures shall be supported on at least two points (opposite corners each individual fixture). Support shall be with #12 gauge 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 Engineer. Install strut channel as necessary to provide support between building structure.

Contractor shall note that if certain areas in the building contain fire rated ceilings which require fire rated enclosures, the fixtures supplied for use in these areas shall be approved and suitable for the purpose.

**16530 SITE LIGHTING**

All exterior lighting shall meet the requirements of the City of Flagstaff Lighting Ordinance, Chapter 17 of the zoning code.

Minimum wire size shall be #10. All wire to be stranded.

Low pressure sodium fixtures are the University standard. Fixtures shall employ a standard 135 watt L.P.S. bulb.

Label circuit #, panel, and building # on the inside of the lightpole hand hole cover plate, w/ permanent marker.

**16535 EMERGENCY LIGHTING**

The preferred concept for emergency lighting is the use of a centrally located low voltage emergency lighting system. These systems will have a power source consisting of a power supply to operate lighting and a battery system to run the lights when normal power is lost. To maintain an already existing system, fluorescent emergency power packs which utilize individual T-8 lamps in a selected, unswitched, night light fixtures shall be used. An acceptable alternate is specification of sealed beam emergency lights with individual powerpacks.

Such powerpacks shall be run on individual circuits directly to a normal, non-emergency power panel. All other power for emergency lighting systems, without exception, shall be run from "E" panels.

**Exit Lights**

When renovating exit light fixtures shall be fitted with LED type. LED Exit lights shall be specified for all new applications.

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

## DIVISION 16 - ELECTRICAL

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Number**

**Title**

**16600 SPECIAL SYSTEMS**

**16610 UNINTERRUPTIBLE POWER SUPPLY SYSTEMS**

Projects requiring emergency power shall have a feasibility study; inverter/generator vs. individual battery packs. Short battery life due to temperature extremes, vandalism, unreliability and high maintenance costs of battery packs should be considered in the study.

Switch and outlet plates for devices on emergency power shall be red and engraved "Emergency Power".

**16620 EMERGENCY GENERATOR SYSTEMS**

Transfer switches on emergency generators shall have a switched pole for the neutral to eliminate two return paths for neutral current.

Generator and automatic transfer switch installation shall be in compliance with manufacturer's installation instructions.

Access for fuel trucks must be provided to fill generator fuel tank.

Domestic water outlet shall be within 20 feet of generator.

Compressed air (for power tool usage) shall be within 20 feet of generator. This requirement may be waived if there is no air compressor in building.

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."

Generators with skid mounted fuel tank shall have a concrete lined catchment basin or floor trench of sufficient size to contain the full volume of fuel tank.

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

Complete test of all emergency systems, including load banking of generator, shall be performed on or before substantial completion of project.

**16660 GROUND FAULT PROTECTION SYSTEMS**

Ground fault protection systems for personnel shall meet or exceed NEC standards, 1999 edition. All exterior receptacles, or receptacles within 6' of a water source (such as a sink, eye wash, drinking fountains, emergency showers, hose bibs, etc.), shall be GFI.

Ground fault protection systems for equipment shall meet or exceed NEC standards, 1999 edition.

Ground fault protection for personnel shall be provided and used by personnel during construction, remodeling, maintenance, repair, or demolition of buildings, structures, equipment or similar activities, per NEC 305-6 (a) and (b).

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<b>16670</b>	<b>LIGHTING PROTECTION SYSTEMS</b>
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Lighting protection systems shall be per NEC, 1999 edition, and/or the Engineer/Architect specifications, whichever is more stringent.

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

## DIVISION 16 - ELECTRICAL

Section Number	Title
16700	COMMUNICATIONS
16710	TELEPHONE INSTALLATION

### General

Cost for materials and installation of Telecomm related items shall be part of the Project Budget where indicated "by Contractor".

Items indicated by "NAU" shall be funded by Telecomm-NAU and not included in Project Budget.

Coordination with Telecomm-NAU will be required prior to actual construction and wiring placement.

### Site Development

The A/E shall specify the following site development requirements:

A minimum of two (2), four-inch conduits, shall be provided for building entrance cable. Larger complexes may need more. One (1) complete spare must be available after cable is installed. (Pull string must be in the spare conduit).

A minimum of two (2), two-inch conduits, shall be provided for other university requirements, such as coaxial cable, fiber optics.

All inter-building conduit/cable should be buried at a depth of 24" minimum.

All phone conduits that are buried, and contain fiber optics, shall have marking tape that contains a metal locating strip, 6" above.

Entrance cable shall be in conduit and meet the following requirements:

- o Conductor insulation - solid polyolefin color coded.
- o Core - gel filled.
- o Shield - aluminum, single jacket.
- o Sheath - alpeh, polyethylene. (size and gauge to be determined by Telecomm-NAU).

Riser Cable shall meet the following requirements:

- o Conductor insulation - solid polyolefin color coded.
- o Core - air.
- o Sheath - polyethylene.(size and gauge to be determined by Telecomm-NAU).

Grounding requirements - all entrance cable terminals grounded with no. 6 AWG - copper to earth ground or building ground.

Contractor is to be responsible for providing all associated structures, pull boxes, splice cases and all materials for industry standard cable systems. Size & type require pre-approval by NAU Telecomm.

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**Material: Building Interior (by Contractor)**

A minimum of one (1), one inch, home-run conduit shall be provided throughout the building, to feed all areas. Provide an additional spare conduit with a pull string.

Specify a minimum of two (2), one (1) inch, conduit to each room, on opposite walls. (More conduit may be required in some buildings). Conduit to terminate into a minimum of a 4"x4" double gang-box. Size appropriately for the number of cables provided.

Inside wiring should be two (2,) category 3, and two (2), category 4, pair wire to each jack location. Wire should be 24 gauge (minimum). 22 gauge spec - applications. Conductor insulation - standard color code. Conductors in air plenums shall be specified as teflon coated.

Duplex telephone jacks shall be specified at all locations. The preferred type is a modular duplex (RJ11/RJ45) jack plate. Hubbell Faceplate FPL 26I and 2 each Hubbell HD5819 & HD26U9 jacks.

**Installation: Site Development (by Contractor)**

Trenching for conduit - 24" minimum cover above conduit.

Joint-Trench Required Separation: When a joint-trench method is used, the following vertical or horizontal separations between telecommunications facilities and other facilities must be maintained:

ADJACENT STRUCTURE	MINIMUM SEPARATION
Power or other foreign conduit	* 3 inches of concrete OR * 4 inches of masonry OR * 12 inches of earth.
Pipes (gas, oil, water, etc.)	* 6 inches when crossing. * 12 inches when parallel.
Railroad crossings (except street railways)	* 5 feet below top of rail. * 12 feet from the nearest rail if terminating on a pole. * 7 feet from the nearest rail if terminating on a pole at a siding.
Street railways	3 feet below top of rail.

Cable pulled to building terminal room from splice point specified by Telecomm-NAU.



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Splicing - all splices encapsulated with gel. All setup time and testing (end-to-end) to be included in labor time.

### **Installation: Building Interior (by Contractor)**

Entrance cable is to be terminated on 3M brand 4188 protector units and 66M blocks on 183 type backboards.

Plywood shall be sealed, three-quarter (3/4) inch, 4' x 8' sheet as needed per terminal location.

Connector blocks - 66M type, mounted on 183 type backboards.

Protection blocks shall be carbon and shall be mounted.

Category 3 riser cable shall be pulled to designated point on other floors and terminated on 66M connector blocks, mounted on 183 type backboards. Category 5 riser cable shall be terminated on Hubbell 5811089I connecting block.

Category 3 four-pair wire pulled to each specified location and terminated on HD26U9 connector blocks. Category 5 four-pair wire pulled to each specified location & terminated on Hubbell 5819 connector blocks and Category 5 certified patch panel.

Termination is to be completed by Telecomm-NAU or by qualified contractor under supervision of Telecomm-NAU.

Communication, audio, coaxial and etc. cable or wire shall not be supported by piping systems other than those installed for communication type systems.

### **Building Distribution Frame: Space Design Requirements (by Architect)**

BDF and IDF (Building distribution frame and intermediate distribution frame require a submittal and written approval by NAU Telecomm.

Room space must be provided near the cable entrance to the building. Room located on side of building closest to node building. The largest room should be on the first floor. Recommend 10' x 10' area. If more than one floor, room space should be provided directly above the lower floor with risers in between. Suggest 6' x 10' space. Room space can be combined with other communication users.

20 amp dedicated circuit required.

Computer space can be normal environment; however, adequate ventilation should be provided and the area should be free from any hostile environment such as electro-mechanical devices or power transformers.

### **Main Distribution Frame: Installation**

MAIN NODE - Terminate cable on 3M brand 4188 protector units with gas modules and 66M connecting blocks mounted on 183 type backboards.

NORTH NODE - Terminate cable on Cook brand C-377 protector units with gas modules.

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SOUTH NODE - Terminate cable on 3M brand 4188 protector units with gas modules and 66M connecting blocks mounted on 183 type backboards.

### **Inside Telephone Equipment**

Telephone sets and handsets are to be provided by NAU.

Elevator and emergency telephones shall be provided and installed by the contractor.

NOTE: Telecomm-NAU will need rough estimates on the number of new telephones needed per each construction project. This estimate should be presented during the annual budgetary cycle.

**16715**

**COMPUTER CABLES AND JACKS**

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

## DIVISION 16 - ELECTRICAL

**Section  
Number**  
16780      **Title**  
TELEVISION SYSTEMS

### Cable Television Equipment and Signal

All distribution equipment shall be "Line Powered" with a 60 volt AC Quasi-square wave signal. The system shall meet or exceed all technical standards set forth in FCC Rules, Part 76. Band width of all passive and active devices in the forward feed shall be 54 MHz to 750 MHz and 5MHz to 30 MHz in the reverse feed. Amplifiers shall be "Push-Pull " design. The system shall be designed to -57dB or better cross modulation and a carrier-to-noise ratio shall be 46dB minimum. System radiation (CLI) shall meet all FCC requirements of Part 76: Rules and Regulations. Isolation between any two outlets in the system shall be a minimum of 28dB. All room outlets in the system shall provide a minimum level of +3dBmv and a maximum level of +12dBmv. The RF level deference between any two adjacent channels shall be no greater than 2dB.

### Drop Cable

RG59/u Type, 95% braid coverage 10 AWG:NOM 0.032" copper covered steel center conductor; gas expanded polyethelene dielectric; inner shield aluminum-polypropylene - aluminum laminated tape with overlap bonded to dielectric; outer shield of 34 AWG bare aluminum braid wire; jack of black polyvinylchloride or polyethelene. CROSS REFERENCE: Belden #9108 or comm/scope #F5995BVV

### Feeder Cable

500 P3 series copper clad aluminum center conductor: expanded polyethylene dielectric; solid aluminum sheath; outer jacketed of black high molecular weight polyethylene. CROSS REFERENCE: Comm/scope #P-3 Series.

### Trunk Cable

750 P3 series copper clad aluminum center conductor; expanded polyethylene dielectric; solid aluminum sheath; outer jacket of black high molecular weight polyethylene. CROSS: REFERENCE: comm/scope #P-3 75-750 JCA

### Connectors

RG59 F-Type Gilbert #GF/59-AHS, Feed .500 pintype Gilbert #GRS 500CH-DU-01 Trunk .750 pintype Gilbert #GRS 750CH-DU-01

### Distribution Amplifiers:

Trunk will be Scientific Alanta series 6500 750MHz sub-split truck station with reverse module. Feeder will be Scientific Alanta 6501/6502 distribution amplifier with reverse module. All 2-port, 4-port, 8-port taps and directional couplers will be Scientific Atlanta. All equipment shall be installed in equipment rooms on each floor of each wing all cable drops shall be home runs to the equipment room on that floor and labeled with its corresponding room number.

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

## **DIVISION 16 - ELECTRICAL**

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**Title**  
**ELECTRIC RESISTANCE HEATING**

Electric resistance heating shall not be specified for new buildings and shall be replaced wherever possible in renovations. Replace with other than electric resistance heating.

**16870**      **ELECTRIC UNIT HEATERS**

Electric unit heaters shall not be specified for new buildings and shall be replaced wherever possible in renovations. Replace with other than electric resistance heating.

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

## **DIVISION 16 - ELECTRICAL**

<b>Section Number</b>	<b>Title</b>
<b>16900</b>	<b>CONTROLS</b>

<b>16950</b>	<b>TESTING</b>
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High potential testing of medium voltage cable shall be by an independent tester (not the installing contractor). Reports to include time of day, humidity and temperature at time of tests. Tester shall furnish all necessary safety equipment and have at least two persons available during testing. Tests to be to National Electrical Testing Association standards (NETA).

<b>16960</b>	<b>EQUIPMENT TESTING</b>
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All generators and associated emergency equipment, including switching systems, shall be tested in accordance with section 16610 and completed on or before substantial completion.

Testing of load center GFI system shall be completed on or before substantial completion.

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