CHAPTER 9 – ELECTRIC SYSTEM
CHAPTER 9—ELECTRICAL SYSTEMS

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Section 9.1 General Requirements

9.1.1 When installing or changing equipment, the designer shall evaluate available fault currents and size the ampere interruption capacity accordingly.

9.1.2 Electrical Systems shall be designed to meet the most recent NEC codes.

9.1.3 Lamp Disposal

9.1.3.1 As of January 6, 2000 the Environmental Protection Agency (EPA) requires that all fluorescent, mercury vapor, and high intensity discharge (HID) lamps be disposed of properly (recycled). Lamps can no longer be disposed of as trash. The Department of Environmental Health & Safety will be responsible for accumulating and recycling all lamps on campus. For large quantities, arrangements can be made for delivery of lamps to the Hazardous Waste Facility on Kimball Ave. Pickups for smaller quantities will be made by EH&S.

9.1.3.2 Packing Tips: Lamps should be placed back into the original boxes, without the padding. Boxes of 4’ fluorescent lights should be able to hold 30-36 bulbs without padding. If you have 6’, 8’, or U-bent bulbs treat them the same as the 4’ bulbs. Please keep the boxes intact so they can be resealed. Do not wrap bare bulbs with tape. Please seal each box end with clear tape. If bulbs are broken please place them into a separate box.

Section 9.2 Distribution Systems

9.2.1 Duct bank systems (concrete encased)

9.2.1.1 It is preferred that all duct banks have a minimum of 3’ of earth cover. Instances that do not allow this amount of cover must be approved in advance and in writing by the owner.

9.2.1.2 Duct shall be type DB PVC. In runs over 100', the designer shall evaluate the need for galvanized rigid steel elbows to prevent damage during cable installation.

9.2.1.3 All duct shall be installed in such a manner to prevent accumulation of water that may be subject to freezing.

9.2.1.4 A warning tape that is a minimum of 6" wide shall be installed 18" above all duct banks.

9.2.1.5 Upon completion of the installation of the duct and prior to pulling any cable in the duct, a mandrel smaller than the normal size of duct shall be pulled through the duct.

9.2.1.6 Duct bank penetrations into manholes shall continue completely through the wall of the manhole and shall use one larger hole rather than several small holes. If the above method is not practical, the concrete may stop outside the manhole but must be pinned to the manhole with steel pins to prevent differential settlement.

9.2.1.7 Duct bank penetrations of foundation wall shall comply with Section 2.5.2, Electrical Duct Banks.

9.2.1.8 All unused duct shall have a nylon or polypropylene pull string installed for future use. The pull string shall be Greenlee or equal with a minimum of 240 lbs. tensile strength, and shall be rot and mildew resistant. Wire shall not be used.

9.2.1.9 Concrete

9.2.1.9.1 The concrete shall cover the duct a minimum of 3" in all directions, and a maximum of 6".

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9.2.1.9.2 The concrete shall be 4,000 psi and shall have the color additive Colorcron - Tile Red as manufactured by Masterbuilders; Solomon Grind Chemical Services #140 Red, or approved equal. The color additive shall have a minimum concentration of 9 lbs. per bag of cement and shall be mixed throughout all of the duct bank concrete.

9.2.1.9.3 The maximum aggregate size shall be 3/4”.

9.2.1.9.4 The concrete shall be placed with the aid of a mechanical vibrator.

9.2.1.9.5 If trench erosion occurs, the use of forms may be required to prevent overly large masses of concrete.

9.2.1.10 Minimum reinforcing of the concrete shall be as follows:

9.2.1.10.1 The minimum size is #4.

9.2.1.10.2 The reinforcing shall be installed longitudinally, at each corner of the duct (in cross section) and along the top, bottom, and sides at a maximum of 6” on center. All reinforcing steel shall have a minimum concrete cover of 1/2”.

9.2.1.10.3 Reinforcing shall be installed latitudinally, as needed to hold the above in place during placement of the concrete.

9.2.2 Direct burial systems

9.2.2.1 All directly buried cable shall have a minimum of 45” of earth cover with a minimum of 3” of sand placed both above and below the cable.

9.2.2.2 Two warning tapes, that are a minimum of 6” wide, shall be installed 18” and 36” above all directly buried cable.

9.2.2.3 Penetrations into manholes shall be run in Schedule 40 PVC conduit from the interior of the manhole to a point not less than 8’ outside the manhole. A bell end shall be installed on each end of the conduit. The conduit shall be graded to drain any moisture away from the manhole.

9.2.2.4 Entrance into transformer pads shall be run in Schedule 40 PVC conduit. The cable shall maintain the minimum 48” of depth, then turn up directly below the transformer pad. The conduit shall extend from the surface at the transformer pad to a point not less than 8’ outside of the perimeter of the transformer pad. A bell end shall be installed on each end of the conduit.

9.2.3 Medium voltage (600 volts - 35,000 volts)

9.2.3.1 Equipment

9.2.3.1.1 Transformers

9.2.3.1.1.1 The designer shall evaluate the anticipated building harmonics to determine the K rating for each transformer installation. The K factor shall be determined as follows:

Transformer K-Factor (Harmonic rating): The transformers shall be designed to operate at full kVA rating while carrying harmonic current contents as defined by the indicated K-Factor. Harmonic current content shall be defined as odd harmonics (3rd through 15th order) which are all equal in their percentage of the fundamental (60 Hertz) frequency. K-Factor shall be defined as follows:

\[
K = \sum_{i=1}^{15} \frac{h_i}{f_{hi}}
\]

where \(h_i\) = harmonic frequency, given as an integral multiple of the fundamental frequency, and \(f_{hi}\) = harmonic distortion, for the ith harmonic, as percent of the unit fundamental frequency.

Transformer nameplates shall be clearly marked with the transformer K-Factor rating.
9.2.3.1.2 Fusing of transformers shall coordinate with the owner’s first upstream device.

9.2.3.1.3 In all transformer installations, especially retrofit or replacement, the secondary system fault current shall be analyzed.

9.2.3.1.2 Switch Gear

9.2.3.1.2.1 All pad-mounted switch gear shall be type PMU or System 2, as manufactured by S&C.

9.2.3.1.2.2 All switch gear and switch gear components must be rated for 25 KA (symm) available fault current and be tested to 25 KA (symm) by an independent testing agency.

9.2.3.1.2.3 All switch gear shall be above ground type.

9.2.3.1.3 Circuit breakers shall be GE double high vacuum, rated to 1,000 MVA, and designed to be electrically, mechanically interchangeable with the owner’s existing GE vacuum circuit breakers and work with the owner and SCADA System.

9.2.3.2 Execution

9.2.3.2.1 All cable installations where the calculated pulling tension exceeds 67% of the manufacturer’s recommended maximum tension shall be installed using tension measuring equipment. The owner’s representative must be present to observe these installations. These cable runs shall be clearly marked on the plans.

9.2.3.2.2 All cable pulled through wet or damp conduit shall be sealed on the end to prevent any moisture from entering the insulation.

9.2.3.3 Testing

9.2.3.3.1 Medium Voltage Cable - Direct-current Voltage Test (D.C. HiPot): After installation and prior to being placed in service, all medium voltage cables shall be tested by use of a D.C. HiPot test. Test voltages and procedures shall be in accordance with ICEA standard S-68-516/NEMA standard WC-8 (latest edition). Cable test data shall be recorded on the Medium Voltage Cable Test Data form included in the appendix of this section.

9.2.3.3.2 Transformers: The following test shall be performed on each transformer prior to the unit being placed in service.

9.2.3.3.2.1 Insulation resistance tests (5000 volt MEGGER) shall be performed on high voltage and low voltage windings prior to placing the transformer in service. This test must be approved by the transformer manufacturer prior to testing.

9.2.3.3.2.2 Transformer turns ratio testing shall be done on all transformers prior to energizing. Testing should be done by Contractor on the construction project and Facilities' Shops.

9.2.3.3.2.3 Each transformer shall be energized from the low voltage bushings, and voltages measured (phase to phase) across the high voltage bushings. All primary and secondary voltages shall be recorded and forwarded to the owner.

9.2.3.3.3 All testing shall be witnessed by the Owner’s Representative.

Section 9.3 Secondary Circuits

9.3.1 General Requirements

9.3.1.1 All neutral conductors shall be a minimum of full size. The designer shall evaluate the need for oversized neutral conductors.
9.3.1.2 The preferred method for grounding is through the use of a buried loop or, in new construction, the use of the concrete reinforcing steel. Use of the building steel for grounding shall not be allowed unless the steel was designed for this use or the grounding capability of the steel was tested and found adequate.

9.3.1.3 The designer shall evaluate anticipated building loads for potential harmonic design requirements.

9.3.1.4 No aluminum conductors or busses shall be allowed. All conductors shall be copper. No stabiloy shall be allowed under any circumstances.

9.3.1.5 Load center shall not be allowed. The minimum level of quality is a panelboard or a switchboard.

9.3.1.6 When installing or changing equipment, the designer shall evaluate available fault currents and size the ampere interruption capacity accordingly.

9.3.1.7 Color code secondary service, feeder, and branch circuit conductors with factory applied color as follows:

<table>
<thead>
<tr>
<th>208/120 Volts Phase</th>
<th>480/277 Volts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black</td>
<td>Brown</td>
</tr>
<tr>
<td>Red</td>
<td>Orange</td>
</tr>
<tr>
<td>Blue</td>
<td>Yellow</td>
</tr>
<tr>
<td>White</td>
<td>Neutral White or Gray</td>
</tr>
<tr>
<td>Green</td>
<td>Ground Green</td>
</tr>
</tbody>
</table>

9.3.2 Service Entrance

9.3.2.1 In new installations, it is preferred that only one disconnect be installed per service entrance. However, if multiple disconnects are installed, no more than 4 disconnects shall be installed, with space allowed for a total of 6 disconnects.

9.3.2.2 At the points where conduit penetrates concrete that is in contact with soil, that conduit shall be Schedule 40 PVC conduit. If the PVC has a bend of greater than 45 degrees, the bend shall be completely encased in concrete. This is to prevent the rusting away of metal conduit at the place it exits the concrete. The concrete encasement is to prevent destroying the PVC bend during the wire installation.

9.3.3 Feeders

9.3.3.1 All feeders shall have a separate grounding conductor installed. In no case shall the conduit or raceway be used as the grounding conductor.

9.3.3.2 All conduit sizes and conductor numbers and sizes shall be shown on the drawings.

9.3.3.3 All panelboards shall have separate grounding and neutral busses. All grounding and neutral wiring shall be terminated on the proper buss.

9.3.3.4 The preferred breaker is the snap-in type.

9.3.3.5 All panelboards shall be sized to allow a minimum of 20% of space for additional breakers, by count of breakers.

9.3.3.6 No piggyback breakers shall be allowed.

9.3.3.7 Breakers on all new or renovation projects will be re-labeled to actual room number before the contractor is out of the building and University takes over.

9.3.4 Branch Circuits

9.3.4.1 All wiring systems shall be installed using conduit. Flexible wiring systems shall not be used. With the exception of using flexible wiring systems to lights and sealite flex
conduit, limited to a 6 ft max run. Over that run length use conduit.

9.3.4.2 The minimum conduit size shall be 3/4", except conduit enclosed in a wall, conduit used for switch legs, and conduit used for control wiring. These exceptions shall have a minimum of 1/2" conduit. The project shall pay for the extra size.

9.3.4.3 A separate grounding conductor shall be installed. Use of the conduit or raceway is not an acceptable grounding method.

9.3.4.4 All general purpose power circuits shall be a minimum of 20 amps.

9.3.4.5 General purpose power circuits in office areas shall not have shared neutrals.

9.3.4.6 Conduit shall be supported from the building structure. Attachment to other pipes, conduits, ductwork, etc. shall not be allowed.

9.3.4.7 Non-metallic conduit or boxes shall not be used except in wet locations. In cases where it is used, conduit 2" and smaller shall be a minimum of Schedule 80.

9.3.4.8 All exposed conduit installed in a finished space shall be painted to match the background.

9.3.4.9 All lighting switching layouts shall be shown on the drawings. The drawings shall show the circuit numbers for each receptacle, and shall show the wire counts for all circuitry.

9.3.4.10 Panelboards shall be supplied with lighting sufficient for working at the panelboard. In some cases this may require the installation of additional lighting.

9.3.4.11 Conductors carrying more than 150v to ground shall not be installed in conduits with conductors carrying less than 150v to ground.

Section 9.4 Devices and Motors

9.4.1 Devices

9.4.1.1 All receptacles and switches shall meet the requirements of ADA. The preferred mounting heights, above finished floor, are 48" for switches and 18" for receptacles.

9.4.1.2 All receptacles and switches shall have a minimum rating of 20 amps and shall be heavy duty specification grade. A standard of quality for switches is Leviton #1221 and for receptacles is Hubbell #5362-1. Preferred cover is metal.

9.4.1.3 The preferred color for receptacles and switches is brown. Receptacles in hallways shall have stainless steel covers. Other colors may be used to match existing devices or for special uses.

9.4.1.4 Each restroom must have at least one receptacle and it must be a GFI receptacle. The project will pay for this.

9.4.1.5 In areas that are required to have ground fault interrupting capability, it is preferred that GFI receptacles be used rather than GFI breakers.

9.4.1.6 The designer shall use brushed stainless steel covers appropriate for the usage of the area.

9.4.2 Fuses

9.4.2.1 Renewable fuses shall not be used.

9.4.2.2 As much as possible, equipment should be specified with fuse holders that will accept fuses that are dimensionally the same as Class H fuses.

9.4.2.3 Each project shall supply one set of three spare fuses for each type and size fuse installed.

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9.4.2.4 The designer shall evaluate the need for a box for storage of the spare fuses. If a box is installed, it shall be a metal box designed to store fuses and mounted in a highly visible, but Facilities' controlled, location and labeled appropriately.

9.4.3 Safety Switches

9.4.3.1 All safety switches shall be heavy-duty grade, within reach of devices and controls.

9.4.3.2 All safety switches shall have a durable label permanently attached to the inside cover that describes the fuse size, type, current-limiting ability and devices controlled. (Device-controlled only).

9.4.3.3 All safety switches intended for use on circuits where current-limiting fuses are required shall be specified with rejection clips designed to permit installation of Class R fuses only.

9.4.3.4 The covers on safety switches shall be provided with a method of opening the cover without opening the switch. If the switch doesn't allow for this, change the switch.

9.4.3.5 Safety switches in mechanical rooms shall have NEMA 3R enclosures unless the environment or usage requires a different enclosure.

9.4.3.6 All safety switches shall have a grounding bar.

9.4.4 Motors

9.4.4.1 All motors shall meet ASHRAE 90.1 and EMO Energy Conservation Policy #060 (Appendix 2), and shall have a minimum service factor of 1.15.

9.4.4.2 The designer shall evaluate the possibility of using 480v whenever practical. It should be noted, however, that 90% of buildings at KSU don't have 480v at present.

9.4.4.3 No motors shall be designed to operate in the service factor.

9.4.4.4 The designer shall evaluate the use of soft starting whenever appropriate.

Section 9.5 Communications and Alarm Systems

9.5.1 Telephone and Data Systems

9.5.1.1 General Guidelines

9.5.1.1.1 In general, the contractor will install the wall boxes and any required conduit, with pull strings. In general the project will provide funding for all wiring and termination devices. KSU Telecommunications will install all wiring and termination devices. If the contractor will be installing any wiring on a particular project, the full cable specification shall be obtained from KSU Telecommunications.

9.5.1.1.2 A minimum of one voice and one data cable shall be installed for every 100 sf. of office area.

9.5.1.1.3 The design of all communications systems shall be coordinated with KSU Telecommunications and Facilities Planning.

9.5.1.2 Telecommunications Closets

9.5.1.2.1 All telecommunications closets should be considered as potential locations for ancillary electrical equipment as well as the basic termination of Cable/Wire/Fiber. As such, the following are EIA basic standards for such spaces:

Size: Minimum size requirements – 5’ by 6’ with door opening out or 5’ by 8’ with door opening into the room.
Ceiling Height: 8’ minimum ceiling height.

Doorways: Minimum measurement of 3’ wide by 6’-8” high. These measurements do not include a door sill or center post.

9.5.1.2.2 Location: A minimum of one telecommunications closet shall be located on each floor. Distance limitations or other considerations may require more than one closet on each floor. Closets should be located as close to the core of the structure as possible and should be stacked one above the other in multiple floor buildings. One closet should be allocated for every 10,000 sq. ft. Average cable runs should be 150 horizontal feet with no single cable run exceeding 295 feet.

Dust and Static: Install tile and/or seal concrete.

9.5.1.2.3 Power: Each closet must have a minimum of two 120V AC duplex outlets. Outlets must be separately fused, 20 amp, 3-wire grounding and on a non-switched circuit. The outlets should be located below the termination board location, if known.

Lighting: Minimum equivalent of 538 lux measured at 4’ above finished floor.

9.5.1.2.4 Conduit/Cores: Each closet must be constructed with a minimum of 2-4 inch cores equipped with sleeves extending a minimum of 1 inch above finished floor. Two additional 4” cores are required for each additional 10,000 square feet per floor.

9.5.1.2.5 Environment: Temperature ranges 65° F to 95° F; humidity ranges 20% to 60% relative; heat dissipation 750 to 5,000 BTU’s per hour per cabinet.

9.5.1.2.6 Electrical: Each manufacturer’s equipment is different. The following are requirements generic to all systems requirements:

- 2-4 inch conduits per 200,000 square feet of usable office space.
- One spare conduit for each 2 conduits to be used.
- No more than 2 - 90° bends between pulling points.
- All ends of metallic conduit must be reamed and brushed.
- All conduits shall have a pull string installed.
- Metal sleeves through foundation walls must extend a minimum 20’ beyond the wall.

9.5.1.3 Pathways (interior)

9.5.1.3.1 Pathways must support cables and provide protection. Pathways should be planned to facilitate original installation of voice/data cabling as well as ongoing maintenance, additions, and relocations. For new construction and in renovations where possible, cable trays or conduit for horizontal distribution shall be installed in corridors. In renovations of existing facilities, existing conduits or other pathways may be used.

9.5.1.3.2 Sections of conduit shall be no longer than 100’ and must not have more than 2 bends between pull points or pull boxes with individual bends not to exceed 90°. Inside bending radius must be at least six (6) times the inside conduit diameter for conduit 2" or less and at least 10 times the conduit diameter for conduit greater than 2”. Pull boxes should be placed directly after a bend or sized accordingly if the pull box is located at the bend. Designer is to verify types of cable used with KSU Telecommunications and make sure conduit bending radius conforms to type of cable used.

9.5.1.3.3 The conduit shall be sized to avoid exceeding the following cable fill maximums:

- 3” conduit - 50 cables maximum
- 2” conduit - 22 maximum
- 1” conduit - 7 cables maximum
- 3/4” conduit - 4 cables maximum
Terminal boxes shall be standard electrical boxes; 2" x 4" x 2" mounted flush with the wall surface in new construction. In existing buildings the terminal boxes may be surface-mounted where necessary. Surface-mounted boxes shall be single gang deep switch and receptacle boxes, 4 5/8" x 2 7/8" x 2 1/4"; wiremold 5744S or approved equal.

9.5.2 Fire Alarm Systems

9.5.2.1 All new buildings and major renovations shall include a central, addressable system.

9.5.2.2 All fire alarm systems shall comply with ADA.

9.5.2.3 Drawings for fire alarm systems shall include zoning and locations for each device on the plan view and a riser diagram. The use of addressable systems with LED reader of each device's location is preferred.

9.5.2.4 Acceptable brands for fire alarms systems are Faraday, Honeywell, Notifier, Simplex, FCI, and Powertronics. Simplex is the preferred system to match current University systems.

9.5.2.5 The vendor for fire alarms systems must show the ability to respond to requests for service within 24 hours and the ability to supply replacement parts for the system within 48 hours.

9.5.2.6 All new fire alarm panels must be expandable. The future ability to provide fire alarm service for the entire building is desired.

9.5.2.7 All fire alarm panels shall be equipped with a “walk test” feature. This allows each activating device to be tested without the need to reset the panel after each device is activated.

9.5.2.8 All fire alarm panels shall be equipped with a “building evacuate” switch.

9.5.2.9 All fire alarm panels shall be located at the main entrance of the building or shall have a remote annunciator located at the main entrance. A diagram of the building showing the various zones shall also be located at the main entrance.

9.5.2.10 Pull stations shall be located at all building and floor entrances.

9.5.2.11 If a security system is available in the building where a new fire alarm panel is being installed, the fire alarm panel shall be connected to the security system to allow reporting of a fire alarm to the Campus Police through the security system. All fire alarm panels shall be capable of reporting through the security system or other external system.

9.5.2.12 If an Energy Management Controls System (EMS) is available in the building where a new fire alarm panel is being installed, the fire alarm panel shall be connected to the EMS.

9.5.2.13 If door hold-opens are used, they shall be a wall-mounted, magnetic type with proper mounting blocking in the wall. Combination door closer/hold-opens shall not be used.

9.5.2.14 All pull stations shall be key operated, keyed the same as the building fire alarm panel. All keying shall be coordinated with the KSU Public Safety.

9.5.2.15 Ionization type smoke detectors shall not be installed in mechanical rooms.

9.5.2.16 All smoke detectors or other activating devices shall be installed in locations that are readily accessible for maintenance. Beam detectors shall be used in atriums or other high ceiling areas.

9.5.2.17 When fire alarm systems are installed in buildings with elevators, provisions shall be included for alternate floor controls.

9.5.2.18 All wiring for fire alarm systems shall be either Type FPLM, plenum rated cable or an acceptable cabling in conduit.

9.5.3 Security Systems
9.5.3.1 For all new buildings and major renovations, the designer shall evaluate the need for a security system.

9.5.3.2 All security systems must be compatible with the existing campus wide annunciator system in use by the University Police.

9.5.3.3 Security systems may be a part of the construction contract, not a separate project. Typically, security is sold to departments for a monthly charge.
Project Title and Location_________________________________________ Project #_________________
Circuit Designation______________________________________________ Date_____________________
Name of Person Performing Test________________________________________________________________
Name of Contractor__________________________________________________________________________

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Test Conditions:
DC Test Voltage
Temperature_______________ Humidity_______________

Cable Data:
Installation: New_____ Used_______
Size_________ Length________ (feet)
Rated Voltage__________________________
Manufacturer__________________________
Insulation wall (type and thickness)
Conductor jacket wall (type and thickness)
Shield type__________________________
Type terminations_____________________
Type & location of splices__________________________

Test Equipment:
Manufacturer__________________________
Model__________________________
APPLICATION OF TEST VOLTAGE

The initially applied direct-current voltage shall not be greater than 3.0 times the rated alternating-current voltage. The rate of increase from the initially applied voltage to the specified test voltage shall be uniform and shall not be over 100% in 10 seconds nor less than 100% in 60 seconds. The duration of the direct-current voltage test shall be 15 minutes for shielded cables and 5 minutes for nonshielded cables. Test voltage for newly installed 15 KV cable with 220 MIL (133%) insulation shall be 65 KVDC in accordance with ICEA/NEMA standards.
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