

M. Electrical Systems

1. Introduction

The following Electrical Systems Standards provide requirements and guidelines for use by the Consultant in the design and construction of electrical systems at the University of Chicago. The Standards are not intended to be used as a specification or in place of a specification. These standards exist as a program document and are not intended to be a contract document. The information in the Standards is not meant to replace professional design analyses and does not relieve the Consultant of any professional or contractual responsibility. Consultants are expected to conduct independent evaluations and to discuss recommendations with the project manager and associated professional staff. Refer questions and comments regarding the content and use of this document to the University FS Project Manager.

General Design Requirements

1. In general, Consultant is to design systems considering sustainable items such as regional manufacturers, recycled / American steel and copper and manufacturer's use of low VOC coatings.
2. All electrical systems shall be designed and specified as "Fully-rated" systems. "Series-rated" systems are **not** acceptable.
3. It is expected that the project design follow all applicable FM Global Property Loss Prevention Data Sheets (Engineering Guidelines). The FS Project Manager will coordinate the review of system designs with FM Global.
4. On completion of installation, including outlets, fittings and devices, inspect exposed finish. Remove burrs, dirt, paint spots and construction debris.
5. Protect equipment and installations and maintain condition to ensure that coatings, finishes and cabinets are without damage or deterioration at time of Substantial Completion.
6. All VFD driven motors shall employ sustainable motor design to prevent bearing failure. All VFD driven motors will be designed to employ induced voltage bearing current mitigation strategies using shaft ground ring technology, isolated bearing, insulated coupling, etc.

University Adopted Naming Convention for Panelboards, Switchboards and Equipment.

1. The panel designation can be up to five (5) characters, last character separated by a hyphen.
2. Position One – Source
 - a. N – Normal

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- b. C – Critical Branch
- c. S – Life Safety Branch
- d. E – Equipment Branch
- e. R – Legally Required
- f. O – Optional Standby
- 3. Position Two – Voltage
 - a. G – 2400/4160 Volt
 - b. H – 480/277 Volt
 - c. J – 240/120 Volt
 - d. L – 208/120 Volt
- 4. Position Three – Distribution/Equipment
 - a. DP – Distribution Panel
 - b. PP - Power Panel
 - c. LP – Lighting Panel
 - d. ATS – Automatic Transfer Switch
 - e. BD – Bus Duct
 - f. MC – Motor Control Center
 - g. MS – Motor Starter
 - h. VFD – Variable Frequency Drive
- 5. Position Four - Building Level
 - a. SB2 – Sub-Sub-Basement
 - b. SB - Sub-Basement
 - c. 0 – Lower Level
 - d. 1 - First
 - e. 2 – Second
 - f. 3 - Third
- 6. Position Five - Sequential Panels/Equipment
 - a. -1 - First Panel
 - b. -2 - Second Panel
 - c. -3 - Third Panel

Electrical Testing

- 1. Independent testing agencies: Independent of manufacturers, suppliers and installers of components to be tested or inspected.
 - a. Testing Agency's Field Supervisor for Power Component Testing: Person currently certified by the International Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing.
- 2. Contractor shall coordinate with testing agency and any additional requirements.

2. System Guidelines

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a) New Construction - Temporary Power and Building Service Considerations

1. Summary
 - a. This section contains design criteria for Site Temporary power and Building Service requirements and options.
2. New Construction – Site Temporary Power Requirements
 - a. 208/120V Trailer Power (lighting, receptacles, etc) and 480/277V Site Power (Equipment, Cranes, Elevators, etc) to be provided by ComEd.
 - b. Site Temporary power to be metered and billed to General Contractor.
 - c. ComEd Load letters, meters and engineering deposit shall be provided to ComEd by Electrical Contractor. Coordinate information with Project Electrical Engineer.
 - d. Site Construction Power shall NOT be supplied from University of Chicago buildings or existing switchgear.
3. New Construction – Building Service
 - a. Primary Service to new buildings shall be minimum (2) 12.47kV Primary Utility Lines with Bus Tie and interlock system.
 - b. Service Transformers shall be owned by Local Utility (12.47kV) and are sized based on Load letters submitted to ComEd.
 - c. Secondary Voltage for new buildings shall be 480/277V, 3-phase, 4 wire and for plants 4160V, 3-phase, 3 wire.
4. Building Service - Network Options
 - a. Primary Selective, Dual Source, Auto Transfer.
 - b. Secondary Selective, Dual Source, Auto Transfer.
 - c. Simple Radial, Dual Source, Manual Transfer.
5. Building Service – Distribution Options
 - a. 4160 Volt distribution
 - b. 480/277 Volt distribution
 - c. 208/120 Volt distribution.
6. Building Service – Emergency Options
 - a. Code minimum plus all optional standby loads.
 - b. Code minimum plus predetermined kW of optional standby loads.
 - c. Code minimum only.
7. Building Service – Critical Equipment
 - a. In Buildings with Critical Equipment (Lab Instruction, Computer, Hot/Cold rooms, etc) a second 208/120V K-rated transformer and distribution panel shall be installed to “Isolate” critical loads.

b) Low-Voltage Electrical Power Conductors and Cables

1. Summary

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- a. This section contains design criteria for building wire and cable, flexible cords, connecting devices and related material for wiring systems 600 Volts and below.
2. Sustainability
 - a. General applicable items include regional manufacturers, recycled / American steel and copper and manufacturers use of low VOC coatings.
3. Quality Assurance
 - a. Electrical components, devices and accessories shall be listed and labeled as defined in NFPA 70, Article 100, by Underwriters Laboratories and marked for intended use.
4. Conductors:
 - a. All conductors shall be Copper. **Aluminum is not acceptable.**
 - b. Conductors #12 AWG and larger shall be stranded.
 - c. No conductors smaller than #12, except #14 for motor control, #16 stranded for annunciator wiring and #18 TFFN solid for fixture wiring (ballast to socket).
5. Insulation Types
 - a. Service Entrance wiring in a raceway to be THHN-THWN, THWN-2.
 - b. Exposed Feeder wiring in a raceway to be THHN-THWN, THWN-2.
 - c. Concealed Feeder wiring in a raceway to be THHN-THWN, THWN-2.
 - d. Branch Circuit wiring in a raceway to be THHN-THWN, THWN-2.

c) Grounding and Bonding for Electrical Systems

1. Summary
 - a. This section contains design criteria for Electrical System Grounding and Bonding.
2. Sustainability
 - a. There are not any specific sustainability requirements associated with this section.
3. Design Intent
 - a. It is the intent of the University of Chicago to utilize a **single grounding electrode** system in all buildings. The incoming water main pipe, and a supplemental electrode in accordance with Article 250 of the Chicago Electrical Code shall be bonded to create the electrode system. Building steel shall be bonded to the system as well, where applicable. **A separate equipment grounding conductor** shall be included in all feeders and branch circuits. Conduit or raceway shall not be utilized for equipment grounding.
4. Quality Assurance
 - a. Electrical components, devices and accessories shall be listed and labeled as defined in City of Chicago Electrical Code, Article 100, by Underwriters Laboratories and marked for intended use. Electrical components, devices and accessories must comply with UL 467.
 - b. Comply with City of Chicago Electrical Code for overhead –line construction and medium-voltage underground construction, comply with IEEE C2.

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5. Grounding Conductors
 - a. Ground Conductor for Wood Poles shall be #4 AWG minimum soft-drawn copper conductor. Conductor Protector for Wood Poles shall be half-round PVC or wood molding. If wood, use pressure-treated fir, cypress or cedar.
6. Equipment Grounding Conductors
 - a. Comply with City of Chicago Electrical Code, Article 250, for types, sizes, and quantities of equipment grounding conductors, unless specific types, larger sizes, or more conductors than required by City of Chicago Electrical Code are indicated.
 - b. Busway Supply Circuits: Install insulated equipment grounding conductor from the grounding bus in the switchgear, switchboard, or distribution panel to equipment grounding bar terminal on busway.
 - c. Computer Outlet Circuits: Install insulated equipment grounding conductor in branch-circuit runs from computer-area power panels or power-distribution units.
 - d. X-Ray Equipment Circuits: Install insulated equipment grounding conductor in circuits supplying x-ray equipment.
 - e. Air-Duct Equipment Circuits: Install an equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners and heaters. Bond conductor to each unit and to air duct.
 - f. Water Heater, Heat-Tracing, and Anti-frost Heating Cables: Install a separate equipment grounding conductor to each electric water heater, heat-tracing, and anti-frost heating cable. Bond conductor to heater units, piping, connected equipment, and components.
 - g. Bond all panelboard enclosures to its respective grounding bus. Bond all metal boxes to the grounding conductor.
7. Installation
 - a. UFER Ground (Concrete-Encased Grounding Electrode): Fabricate according to NFPA 70, using a minimum of 20 feet of bare copper conductor not smaller than No. 4 AWG. If concrete foundation is less than 20 feet long, coil excess conductor within the base of the foundation. Bond grounding conductor to reinforcing steel in at least four locations and to anchor bolts. Extend grounding conductor below grade and connect to building grounding grid or to a grounding electrode external to concrete.
8. Overhead-Line Grounding
 - a. Comply with IEEE C2 requirements. Use 2 or more parallel ground rods if a single ground rod electrode resistance to ground exceeds 25 ohms.
 - b. Drive ground rods to a depth of 12 inches below finished grade in undisturbed earth.
 - c. Ground Rod Connections: Use clamp-type connectors listed for the purpose for underground connections and connections to rods.
 - d. Lightning Arresters: Separate arrester grounds from other grounding conductors.
 - e. Secondary Neutral and Tank of Transformer: Interconnect and connect to grounding conductor.
 - f. Protect grounding conductors running on surface of wood poles with molding extended from grade level up to and through communication service and transformer spaces.

9. Field Quality Control

- a. Owner will engage a qualified testing agency to perform field quality-control testing as required by specifications.

d) Raceway and Boxes for Electrical Systems

1. Summary

- a. This section contains design criteria for raceways, fittings, boxes, enclosures and cabinets for electrical wiring.

2. Sustainability

- a. There are not any specific sustainability requirements associated with this section.

3. Metal Conduit and Tubing

- a. Rigid Steel Conduit shall comply with ANSI C80.1 standards.
- b. Aluminum Rigid Conduit shall comply with ANSI C80.5 standards.
- c. Intermediate Metal Conduit (IMC) shall comply with ANSI C80.6 standards.
- d. Electrical Metal Tubing (EMT) shall comply with ANSI C80.3 standards.
 - i. Fittings shall be Compression Type with insulated throat.
- e. Flexible Metal Conduit (FMC) to be zinc coated steel.
- f. Liquidtight Flexible Metal Conduit (LFMC) to be flexible steel conduit with PVC jacket.

4. Nonmetallic Conduit and Tubing

- a. Rigid Nonmetallic Conduit (RNC) shall be NEMA TC 2, type EPC-40 PVC unless otherwise indicated.

5. Design and Performance Requirements

- a. Outdoors/Above Grade:
 - i. Exposed conduit shall be Rigid Aluminum.
 - ii. Concealed conduit shall be Rigid Aluminum.
 - iii. Boxes and Enclosures shall be NEMA 250, Type 3R or 4.
- b. Outdoors/Below Grade:
 - i. Beneath paved areas shall be Rigid Metal Conduit (RMC) with concrete encasement.
 - ii. Grouped or single runs shall be RNC for 3" trade size or smaller and RMC for trade size greater than 3".
 - iii. Handholes and Pull Boxes shall be as follows Polymer concrete or Fiberglass-reinforced polyester resin based on individual application's load rating requirements.
 - iv. Below Slab-on-Grade feeder conduits shall be concrete encased.
- c. Indoors:
 - i. RMC shall be used in exterior walls, slab penetrations, corrosive or hazardous locations and for exposed work at heights less than 8 feet.
 - ii. EMT, 2" maximum trade size, shall be used in interior partitions, above ceilings and for exposed work at heights eight feet above finished floor.
 - iii. RNC shall be used only for circuits below basement floors.

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- iv. Rigid steel conduit shall be used for damp or wet locations.
- v. Boxes and Enclosures shall be NEMA 250, Type 1 or Type 4(damp or wet location).
- d. Minimum Raceway Size shall be 3/4-inch trade size. However, 1/2" trade size acceptable for flexible conduit in lengths not exceeding six feet and for hard conduit used for switch legs.
- e. Install raceway sealing fittings where required by City of Chicago Electrical Code.

e) Identification for Electrical Systems

1. Summary
 - a. This section contains design criteria for Electrical System Identification.
2. Sustainability
 - a. There are not any specific sustainability requirements associated with this section.
3. Design Intent
 - a. The intent of this section is to provide a means of identification that will help the University Operations and Maintenance personnel trouble shoot, repair, and maintain the electrical systems in each building. It is also the intent of the University to standardize the electrical identification for all electrical systems owned by the University.
4. Submittals
 - a. Schedule of Nomenclature: Provide an index of electrical equipment and system components labeled during execution of contract scope of work.
 - b. Samples: For each type of label and sign to illustrate color, lettering style, and graphic features of identification products.
 - c. Name Plate Schedule: Prior to making name plates, submit a complete schedule to the University for approval indicating name plate size, lettering style, size, color, and actual name plate information.
5. Installation
 - a. Circuits with More Than 600 V: Identify raceway and cable with "DANGER--HIGH VOLTAGE" labels in black letters 2 inches high, at 10-foot intervals over a continuous orange background. Identify the following:
 - i. Entire floor area directly above conduits running beneath and within 12 inches of a basement or ground floor that is in contact with earth or is framed above unexcavated space.
 - ii. Wall surfaces directly external to conduits concealed within wall.
 - iii. All accessible surfaces of concrete envelope around conduits in vertical shafts, exposed in the building, or concealed above suspended ceilings.
 - iv. Entire surface of exposed conduits.
 - b. Raceway and Cable Labels

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- i. Adhesive Labels: Preprinted, flexible, self-adhesive vinyl with legend overlaminated with a clear, weather- and chemical-resistant coating.
 - ii. Colored Adhesive Tape: Self-adhesive vinyl tape not less than 3 mils thick by 1 to 2 inches wide.
- c. Circuit Identification Labels on Boxes
 - i. Exposed Boxes: Indicate panel name and circuit number with black indelible marker.
 - ii. Concealed Boxes: Indicate panel name and circuit number with black indelible marker.
- d. Color-Coding of Secondary Phase Conductors: Use the following colors for service, feeder and branch-circuit phase conductors:
 - i. 208/120V Conductors
 - Phase A: Black
 - Phase B: Red
 - Phase C: Blue
 - Grounded Conductor: White
 - Grounding Conductor: Green
 - ii. 480/277V Conductors
 - Phase A: Yellow
 - Phase B: Brown
 - Phase C: Orange
 - Grounded Conductor: Gray
 - Grounding Conductor: Green with Yellow Stripe
- e. Power receptacles and light switches shall have the associated circuit number and panelboard identified with black indelible marker on the interior of the cover plate.
- f. Conduits connected to Distribution or Branch Panels: Indicate on Raceway with black indelible marker the panel name and circuit number of the enclosed conductors.

ELECTRICAL SYSTEMS IDENTIFICATION

6. EQUIPMENT IDENTIFICATION NAMEPLATES

(a) Indoor (By Manufacturer/Factory Installed)

- (i) Engraved, Three-layer, Laminated Acrylic or Melamine Nameplate: Stainless steel screws mount nameplate to equipment. **White letters on a black background, except emergency power equipment nameplates are to have white letters on a red background.** Minimum letter height shall be 3/8" unless noted otherwise.

(b) Outdoor (By Manufacturer/Factory Installed)

- (i) Engraved, Three-layer, Laminated UV Resistant Acrylic or Melamine Nameplate: Attached with non-corrosive mechanical fastener or other permanent method to maintain compliance with NEMA rating of enclosure. **White letters on a black background, except emergency power equipment nameplates are to have white**

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letters on a red background. Minimum letter height shall be 1/2” unless noted otherwise.

- (c) Equipment Identification Nameplates (In Field): On each unit of equipment, install unique designation nameplate that is consistent with wiring diagrams, schedules, and Operation and Maintenance Manual. Apply nameplates to disconnect switches and protection equipment, central or master units, control panels, control stations, terminal cabinets, and racks of each system. Systems include power, lighting, control, communication, signal, monitoring, and alarm systems unless equipment is provided with its own identification.
 - (i) Nameplate Instructions:
 1. Indoor Equipment: Engraved, laminated acrylic self-adhesive backed. Unless otherwise indicated, provide a single line of text with 3/8” high letters on 1-1/2” high nameplate; where 2 lines of text are required, use nameplates sized 2” high.
 2. Outdoor Equipment: Engraved, laminated UV resistant acrylic nameplates with 1/2” high letters. Outdoor equipment labels are to be factory applied with non-corrosive mechanical fasteners or other permanent method to maintain compliance with NEMA rating of enclosure.
 3. Elevated Components: Increase sizes of labels and letters to those appropriate for viewing from the floor.
 - (ii) Install nameplates for equipment including, but not limited to, the following:
 1. Panelboards, electrical cabinets, and enclosures
 2. Access doors and panels for concealed electrical items
 3. Electrical switchgear and switchboards, including each device
 4. Transformers
 5. Electrical substations
 6. Emergency system boxes and enclosures
 7. Motor-control centers, including each device
 8. Disconnect switches
 9. Enclosed circuit breakers
 10. Motor controllers
 11. Pushbutton stations
 12. Automatic Transfer Switches
 13. Contactors
 14. Remote-controlled switches, dimmer modules, and control devices
 15. Battery inverter units
 16. Battery racks
 17. Power-generating units
 18. Voice and data cable terminal equipment
 19. Master clock and program equipment
 20. Intercommunication and call system master and staff stations
 21. Television/audio components, racks, and controls
 22. Fire alarm control panel and annunciators
 23. Security and intrusion-detection control stations, control panels, terminal cabinets, and racks

24. Monitoring and control equipment
25. Uninterruptible power supply equipment
26. Terminals, racks, and patch panels for voice and data communication and for signal and control functions
27. Non-concealed junction box covers of auxiliary electrical systems

(d) Nameplates shall indicate:

- (i) Unique Name
- (ii) Electrical Source
- (iii) Location of Source
- (iv) Voltage
- (v) Amperage Rating
- (vi) Equipment Being Served
- (vii) Location of Equipment Being Served

f) Overcurrent Protective Device Coordination

1. Summary
 - a. This section contains design criteria for Fault Current Studies, Protective Device Evaluation Studies, Protective Device Coordination Studies, Arc-Flash Hazard Analysis and Shock Hazard Analysis for the electrical distribution system from all power sources rated 50 volts or greater.
2. Sustainability
 - a. There are not any specific sustainability requirements associated with this section.
3. Quality Assurance
 - a. Studies shall use AutoCad 14 or higher and Version 3.8 Revision 1.6 of SKM Power Tools for Windows.
 - b. Software other than that indicated above may be recommended by the engineer to the University for consideration.
 - c. Studies shall be overseen by a Professional Engineer licensed in the State of Illinois.
4. Arc Flash Hazard Analysis: Provide a complete Arc Flash Hazard Analysis for the project indicated in the accompanying Request for Proposal (RFP).
 - a. When indicated by the RFP, the Arc Flash Hazard Analysis shall be performed independent of a construction project. The AFC is expected to survey the building, collect appropriate data and prepare reports as described in the RFP. Recommendations to reduce incident energy levels shall be included in the draft report for review by the University. Recommendations that are immediately implemented shall be reflected in the final report; outstanding recommendations will be addressed in future capital projects and the study updated at that time.

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- b. When indicated by the RFP, the Arc Flash Hazard Analysis shall be performed in concert with the A/E of record during the design and construction phases of the project. The AFC is expected to coordinate and correspond regularly with the A/E as required to review the electrical design as it progresses and provide input to the design to provide the lowest incident energy levels practical. This collaborative process is expected to occur throughout the entire design and construction phase of the project.
- c. When indicated by the RFP, the Arc Flash Hazard Analysis shall be performed by the A/E of record as an integral part of the design and construction phases of the project. The AFC is expected to review the electrical design as it progresses and ensure that arc flash hazards are reduced by design. The resulting electrical design shall have the lowest incident energy levels practical.

5. Applicable Codes and Standards

- a. ANSI Z535.4 (American National Standard for Product Safety Signs and Labels)
- b. CSA Z462 – Workplace Electrical Safety Standard
- c. IEEE-1584 – Latest Edition (Institute of Electrical & Electronic Engineers Guide for Performing Arc-Flash Calculations)
- d. IEEE-141 – Latest Edition (Institute of Electrical & Electronic Engineers Recommended Practice for Industrial Plants (IEEE Red Book))
- e. IEEE-241 – Latest Edition (Institute of Electrical & Electronic Engineers Recommended Practice for Electric Power Systems in Commercial Buildings (IEEE Gray Book))
- f. IEEE-242 – Latest Edition (Institute of Electrical & Electronic Engineers Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems – Buff Book)
- g. IEEE-399 – Latest Edition (Institute of Electrical & Electronic Engineers Recommended Practice for Power System Analysis – Brown Book)

6. Quality Assurance

- a. Studies shall be prepared using Power Tools software obtained from SKM Systems Analysis, Inc.
- b. Studies shall be signed and sealed by a Professional Engineer registered in the State of Illinois. All elements of the study shall be performed under the direct supervision and control of the Professional Engineer.
- c. Studies shall be prepared per current applicable codes and standards.
- d. Studies shall be based on systems designed and specified as “fully-rated” systems. “Series-rated” systems are not acceptable.

7. Safety and Security

- a. The AFC shall comply with all applicable OSHA regulations as well as the most current edition of NFPA-70E when doing on-site field investigation and data

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gathering. Determination of appropriate PPE during data gathering shall be the responsibility of the AFC.

- b. A minimum of two qualified persons as defined by NFPA-70E with appropriate PPE shall be on-site when field survey work of energized equipment is underway. The qualified personnel shall be employees of the AFC or employees of a University approved sub-contractor.
- c. All access to the project work site shall be coordinated through the University. The AFC shall submit a proposed schedule for site visits to the Arc Flash Coordinator. The proposed schedule shall identify the building requiring access, room numbers, proposed day and duration. The proposed schedule shall be submitted in writing two weeks prior to the proposed visit.
- d. There are not planned power outages for the purpose of conducting the Arc Flash Hazard Assessment. The AFC must submit a written request to the University's Arc Flash Coordinator assigned to the project if an outage is needed.

8. On-Site Data Gathering and Reporting

- a. The following data shall be gathered and summarized:
 - i. Locations (Room Numbers) of all equipment that will require Arc Flash Hazard labels. Note that this data is necessary to complete the labels and must be manually added to the MS Excel spreadsheet prior to importing into the label maker software.
 - ii. Fuses – manufacturer, type, Amp rating, Short circuit rating, etc.
 - iii. Circuit Breakers – manufacturer, type, Amp rating, Short circuit rating, settings, etc.
 - iv. Panels and Switchboards – manufacturer, type, Voltage rating, Amp rating, Short Circuit Rating, Ratings of circuit breakers / fuses, etc.
 - v. Primary Transformers – manufacturer, rating, impedance, fusing, short circuit available, etc.
 - vi. Secondary Transformers – manufacturer, type, Voltage rating, Amp rating, impedance, fusing, etc.
 - vii. Wire / Cable – size, insulation type, conductor type, length, etc.
 - viii. SCR and/or Isolation Transformers – size, impedance, fusing, etc.
 - ix. Disconnects / Combination Motor Starters – manufacturer, type, Voltage rating, Amp rating, Short Circuit Rating, OCPD Rating, etc.
 - x. Bus Duct – manufacturer, Voltage rating, Amp rating, conductor type, short circuit rating, impedance value (based upon model number), etc. (Obtain the following information regarding all Buckets and Disconnects on the duct – Amp rating, OCPD Rating, length, etc.)
 - xi. Equipment Panels – All end use equipment that is permanently connected to the building electrical system. Document all short circuit ratings, fusing / circuit breakers, etc.

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- xii. Motors and other equipment that will contribute to the available short circuit current. Collect motor data for all motors 50 Hp and above.
- xiii. VFD- manufacturer, Voltage rating, Amp rating, bypass, OCPD Rating, etc.
- xiv. Engine-Generator – manufacturer, type, Voltage rating, Amp rating, KVA rating, KW rating, impedance, etc.
- xv. Automatic Transfer Switch – manufacturer, Voltage rating, Amp rating.

b. Infrared Scan Requirements:

- i. At the time data is being gathered from existing equipment for the Arc Flash Hazard Analysis the AFC shall also utilize an Infrared Camera to scan the equipment being surveyed.
- ii. The Infrared Scan equipment shall be a Fluke TIR series or equal capable of recording a digital image.
- iii. The scope of the IR Scan is to identify items that require further investigation and preventive maintenance.
- iv. The use of current measurement devices is not anticipated or required.
- v. Calculations or detailed engineering analysis of IR images is not anticipated or required.
- vi. The scope of the Infrared Scan is to scan the equipment for connection issues.
- vii. Data gathering for the Arc Flash Hazard Analysis presents an opportunity to perform a basic Infrared Scan of the equipment being surveyed. It is not the intent of this project that the Infrared Scan be a complete and detailed IR analysis. Its purpose is to identify items of concern for further evaluation by the University.

9. System Short Circuit Analysis

- a. Calculate the maximum available short circuit current in amperes rms symmetrical at each point of the electrical power distribution system. The calculation shall be for a current immediately after initiation and for a three-phase bolted short circuit.
- b. Study electrical distribution system scenarios that result in maximum and minimum fault current. These scenarios shall include at a minimum the following:
 - i. Normal configuration.
 - ii. Emergency power system operation.
 - iii. Alternate sources when multiple sources and configurations are available.
 - iv. Feeder cable length variation from modeled value +/- 10%.

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- c. Scenarios evaluated shall also make use where available of the maximum and minimum fault current values available from Local Utilities.
10. Equipment Evaluation Analysis:
- a. Confirm that interrupting ratings are equal to or higher than calculated $\frac{1}{2}$ cycle symmetrical fault current for 600 Volt over current protective devices.
 - b. Interrupting Rating Analysis
 - i. Calculate momentary and interrupting duties on the basis of maximum available fault current.
 - ii. Calculations to verify interrupting ratings of overcurrent protective devices shall comply with IEEE 141, IEEE 241 and IEEE 242.
- 1. Transformers:
 - a. ANSI C57.12.10
 - b. ANSI C57.12.22
 - c. ANSI C57.12.40.
 - d. IEEE C57.12.00.
 - e. IEEE C57.96
 - 2. Medium Voltage Circuit Breakers: IEEE C37.010
 - 3. Low Voltage Circuit Breakers: IEEE 1015 and IEEE C37.20.01
 - 4. Low Voltage Fuses: IEEE C37.46.
- c. Apply multiplication factors listed in the standards to $\frac{1}{2}$ cycle symmetrical fault current for devices and equipment rated for asymmetrical fault current.
 - d. Verify adequacy of phase conductors at maximum three-phase bolted fault currents; verify adequacy of equipment grounding conductors and grounding electrode conductors at maximum ground fault currents. Ensure that short circuit withstand ratings are equal to or higher than calculated $\frac{1}{2}$ cycle symmetrical fault current.
11. Shock Hazard Analysis: Perform a Shock Hazard Analysis in accordance with NFPA 70E. The completed study shall determine:
- a. Voltage exposure at each location.
 - b. Shock Protection Boundaries.
 - i. Limited Approach.
 - ii. Restricted Approach.
 - c. Required PPE for shock hazard protection.
12. Overcurrent Protective Device Coordination Analysis:
- a. Protective Device Coordination Study for all system devices (adjustable and fixed).

- b. Provide TCC curves for each type of breaker down to and including the 20A and 30A breakers in branch circuit panelboards.
- c. The coordination study shall include TCC curves for all devices on the emergency system and verify proper coordination thereof per NEC.
- d. Perform coordination study in compliance with IEEE 399.
- e. Calculate the maximum and minimum ½ cycle short circuit currents.
- f. Calculate the maximum and minimum interrupting duty (5 cycles to 2 seconds) short circuit currents.
- g. Calculate the maximum and minimum ground fault currents.
- h. Comply with IEEE recommendations for fault currents and time intervals.
- i. Transformer Primary Overcurrent Protective Devices:
 - i. Device shall not operate in response to the following:
 - 1. Inrush current when first energized.
 - 2. Self cooled, full-load current or forced air cooled, full-load current, whichever is specified for that transformer.
 - 3. Permissible transformer overloads according to IEEE C57.96 if required by unusual loading or emergency conditions.
 - ii. Devices settings shall protect transformers according to IEEE C57.12.00, for fault currents.
- j. Motors served by voltages more than 600 volts shall be protected according to IEEE 620.
- k. Conductor Protection: Protect cables against damage from fault currents according to ICEA P-32-382, ICEA P-45-482, and conductor melting curves in IEEE 242. Demonstrate that equipment withstands the maximum short-circuit current for a time equivalent to the tripping time of the primary relay protection or total clearing time of the fuse. To determine temperatures that damage insulation, use curves from cable manufacturer or from listed standards indicating conductor size and short-circuit current.
- l. Tabular Format of Settings Selected for Overcurrent Protective Devices:
 - i. Device Tag
 - ii. Relay-current transformer ratios; and tap, time-dial, and instantaneous-pickup values.
 - iii. Circuit-breaker sensor rating; and long-time, short-time, and instantaneous settings.
 - iv. Fuse-current rating and type.
 - v. Ground-fault relay-pickup and time-delay settings.
- m. Coordination Curves:

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- i. Prepare to determine settings of overcurrent protective devices to achieve selective coordination. Graphically illustrate that adequate time separation exists between devices installed in series, including power utility company's upstream devices. Prepare separate set of curves for the switching schemes and for emergency periods where the power source is local generation. Show the following information:
 1. Device Tag
 2. Voltage and current ratio for curves
 3. Three-phase and single phase damage points for each transformer.
 4. No damage, melting, and clearing curves for fuses.
 5. Cable damage curves.
 6. Transformer inrush points.
 7. Maximum fault current cutoff point.
 8. Single-line diagram inset on the Time Current Curves.
- ii. Organize labeling on the Time Current Curves so that the labels appear on the left side and go from top to bottom to match the order of devices from left to right. Single line diagram shall be located in the upper right corner whenever possible.
- iii. Format report so that Time Current Curves always appear on the right side of the binder and the corresponding breaker settings appear on the left side of the binder. This is to facilitate viewing of settings and curves at the same time.
- iv. Report shall contain hardcopy and softcopy of:
 1. Coordination study input data, including completed computer program input data sheets.
 2. Coordination curves for each major electrical equipment / circuit breaker / fuse / cable, etc.
 3. Data sheets for setting of overcurrent protective devices.
- n. **Overcurrent Protection Devices and Fuse Recommendations: (Construction Related Projects)**
 - i. The AFC shall make recommendations during the design phase of the project to the A/E in regard to the specification of overcurrent protective devices and fuse ratings that provide for the lowest incident energy levels and greatest degree of coordination. The A/E shall include this information as "basis of design" on the contract documents. The AFC shall strive to avoid selection of proprietary equipment and devices and shall advise the University when such devices are necessary or warranted to achieve incident energy goals.

- ii. The AFC shall review and make recommendations during the construction phase of the project to the A/E in regard to the submitted overcurrent protective devices and fuse ratings to ensure the submitted equipment complies with the incident energy levels established during the design phase.

13. Arc Flash Hazard Analysis

a. Arc Flash Study Limits

- i. These study requirements exceed the requirements of the NFPA-70E standards and shall include all electrical equipment on the buildings power distribution system as described below:
 - 1. Buildings served by a public utility shall be studied from the primary side of the service entrance transformer using fault current and X/R ratio values that the AFC obtains from the public utility.
 - 2. All electrical panel boards and load centers including single phase panel boards and load centers. (Computer model single phase devices as three phase devices.)
 - 3. All electrical equipment disconnect switches.
 - 4. All bus ducts.
 - 5. All open transformers.
 - 6. All Variable Frequency Drives (VFD)
 - 7. DC systems where applicable.
 - 8. UPS Systems where applicable
 - 9. All disconnect switches that are integral to equipment that is hardwired to the building electrical system. (HVAC equipment, Kitchen equipment, etc.)
- ii. The intent is that all electrical equipment subject to access while energized or that is a point of a Lock out / Tag out operation is labeled. Notable exclusions from the study include 20 Amp lighting branch circuits, receptacle branch circuits and enclosed transformers.
- iii. The study requirements shall include all electrical distribution system components that are served by power source rated 50 Volts or greater.

b. Arc Flash Hazard Analysis:

- i. Analysis methods shall conform to NFPA 70E and IEEE 1584.
- ii. Analysis shall include all voltage classes of equipment from the service entrance down to 50 volts.
- iii. Analysis shall calculate and assign Arc Flash values based upon worst case operational configuration. Summaries shall indicate both conditions. Applied labels shall reflect the highest IE value. Examples include:

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1. UPS's shall be assumed to be in bypass mode.
2. VFD's shall be assumed to be in bypass mode.
3. ATS's and MTS's shall be assumed to be on standby power.
- iv. Calculate the Arc Flash Incident Energy (IE) for each point in the system(s). This includes values for the line side of each main overcurrent device in panel boards, switchboards, MCCs.
- v. Calculate the Arc Flash Boundary distances for each point in the system(s). This includes values for the line side of each main overcurrent device in panel boards, switchboards, MCCs.
- vi. Prepare recommendations based upon modeling OCPD device settings and ratings to lower IE to a hazard category of "1" when possible but no higher than "2". (Temporary maintenance settings can be used to accomplish this, if necessary with the University's approval.)
- vii. Report shall contain hardcopy and softcopy of the Arc Flash Evaluation showing the bus name, protective device name, bus (kV), bus bolted fault (kA), protective device arcing fault (kA), trip / delay time (sec.), arc type, arc flash boundary (in.), working distance (in.), incident energy (cal/cm²), and required protective FR clothing class.
- viii. The completed study shall include:
 1. Device Tag for each point assessed
 2. Voltage exposure at each location
 3. Available bolted fault current
 4. Hazard Risk Category
 5. Arc-Flash Protection Boundary
 6. Working Distance
 7. Incident Energy (in cal/cm²)
 8. Required PPE
 9. Components or equipment that have insufficient AIC for available fault current, or are over-dutied
 10. Assessment date
 11. Recommendation regarding results and how to lower hazards
 12. Data Tables: Report shall contain hardcopy and softcopy of Arc Flash Hazard Assessment data tables from SKM software.
14. Deliverables: Refer to Electrical Overcurrent Studies document as part of these standards for specific requirements on reports concerning electrical overcurrent protection.
15. Arc Flash Warning Labels

- a. The contractor of the Arc Flash Hazard Analysis shall provide a 4 in. x 6 in. thermal transfer type label of high adhesion polyester for each work location analyzed.
- b. All labels will be based on recommended overcurrent device settings and will be provided after the results of the analysis have been presented to the owner and after any system changes, upgrades or modifications have been incorporated in the system.
- c. The label shall include the following information, at a minimum:
 - i. Location designation
 - ii. Nominal voltage
 - iii. Flash protection boundary
 - iv. Hazard risk category
 - v. Incident energy or energy range corresponding to reported Hazard risk category.
 - vi. Working distance
 - vii. Engineering report number, revision number and issue date.
- d. Labels shall be machine printed, with no field markings.
- e. Arc flash labels shall be provided in the following manner and all labels shall be based on recommended overcurrent device settings.
 - i. For each 600, 480 and applicable 208 volt panelboard, one arc flash label shall be provided.
 - ii. For each motor control center, one arc flash label shall be provided.
 - iii. For each low voltage switchboard, one arc flash label shall be provided.
 - iv. For each switchgear, one flash label shall be provided.
 - v. For medium voltage switches one arc flash label shall be provided
 - vi. For each machine control panel, one arc flash label shall be provided.
 - vii. For each bus duct plug, one arc flash label shall be provided.
- f. Labels shall be field installed by the contractor performing the engineering analysis.

16. Arc Flash Training

- a. Training is optional. Contractor is to verify with the owner if training is required.

g) Electrical Power Monitoring and Control

1. Summary

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- a. This section contains design criteria for Electrical Power System Monitoring and Control.
2. Sustainability
 - a. There are not any specific sustainability requirements associated with this section.
3. Design and Performance Requirements
 - a. Power monitoring and control shall be provided for Substations, service entrances and as specifically directed by the University.
 - b. Refer to BAS Facility Standards section for networking and communications protocol requirements.
 - c. Power Monitors shall monitor the following RMS Real-Time values:
 - i. Current: Phases, Neutral, Average of three phases, unbalance percentage
 - ii. Voltage: Line-to-Line each phase, Line-to-Line average of phases, Line-to-Neutral percent unbalance.
 - iii. Power: Per phase and three phase total.
 - iv. Reactive Power: Per phase and three phase total.
 - v. Apparent Power: Per phase and three phase total.
 - vi. Power Factor: Per phase and three phase total.
 - vii. Displacement Power Factor: Per phase and three phase total.
 - viii. Frequency.
 - ix. Total Harmonic Distortion (THD): Current and Voltage.
 - x. Accumulated, Incremental and Conditional Energy: Real kWh, reactive kVARh, apparent kVAh (signed/absolute).
 - d. Power Monitors shall monitor and perform the following calculations:
 - i. Demand Current calculations, per Phase, Three phase average and neutral: Present, Running average, Last completed interval, Peak.
 - ii. Demand Real Power calculations, Three phase total: Present, Running average, Last completed interval, Predicted, Peak, coincident with peak kVA demand, coincident with kVAR demand.
 - iii. Demand Reactive Power calculations, Three phase total: Present, Running average, Last completed interval, Predicted, Peak, coincident with peak kVA demand, coincident with kVAR demand.
 - iv. Demand Apparent Power calculations, Three phase total: Present, Running average, Last completed interval, Predicted, Peak, coincident with peak kVA demand, coincident with kVAR demand.
 - v. Average Power Factor calculations, Demand Coincident, Three phase total: Last completed interval, Coincident with kW peak, Coincident with peak kVA demand, Coincident with kVAR demand.
 - a. Power Analysis Values: THD - Voltage and Current, per phase, three phase and neutral; Displacement Power Factor – per phase, three phase; Fundamental Voltage – Magnitude and angle per phase; Fundamental Currents – Magnitude and angle per phase; Fundamental Real Power – per phase, three phase; Fundamental Reactive

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Power – per phase; Harmonic Power – per phase, three phase; Phase Rotation;
 Unbalance – Current and Voltage; Harmonic Magnitudes and Angles for Current
 and Voltages – per phase, up to 31st harmonic.

4. Manufacturers
 - a. ABB Power T & D Company Inc.; Distribution Systems Division
 - b. Cutler-Hammer Product; Eaton Corporation
 - c. GE Electrical Distribution and Control
 - d. Siemens Energy & Automation, Inc.
 - e. Square D Co.; Power Management Organization. (ION Meters are University Standard)

h) Lighting Control Devices

1. Summary
 - a. This section contains design criteria for time switches, outdoor and indoor photoelectric switches, switch box occupancy sensor, indoor occupancy sensors, outdoor motion sensors and multi-pole contactors.
2. Sustainability
 - a. Applicable items include regional manufacturers, occupancy sensors and day lighting sensors.
3. Design and Performance Requirements
 - a. Occupancy sensors located in restrooms to be moisture resistant and dual technology.
 - b. Refer to BAS standards for additional information.
4. Manufacturers
 - a. Time Switches
 - i. Area Lighting Research, Inc.
 - ii. Intermatic, Inc.
 - iii. Paragon Electric Co.
 - iv. Leviton Mfg. Company Inc.
 - v. WattStopper
 - b. Outdoor Photoelectric Switches
 - i. Area Lighting Research, Inc.
 - ii. Leviton Mfg. Company Inc.
 - iii. Intermatic, Inc.
 - iv. Paragon Electric Co.
 - c. Indoor Photoelectric Switches
 - i. Area Lighting Research, Inc.
 - ii. Leviton Mfg. Company Inc.
 - iii. Novitas, Inc.
 - iv. Paragon Electric Co.
 - v. WattStopper
 - d. Indoor Occupancy Sensors
 - i. Hubbell

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- ii. Leviton Mfg. Company Inc.
 - iii. Sensor Switch, Inc.
 - iv. WattStopper
- e. Outdoor Occupancy Sensors
 - i. Paragon Electric Co.
 - ii. RAB Electric Manufacturing Inc.
 - iii. Leviton Mfg. Company Inc.
- f. Lighting Contactors
 - i. Allen-Bradley/Rockwell Automation
 - ii. ASCO Power Technologies, LP; a division of Emerson Electric Co.
 - iii. Eaton Electrical Inc.; Cutler-Hammer Products
 - iv. GE Industrial Systems; Total Lighting Control
 - v. Square D; Schneider Electric

i) Low-Voltage Transformers

1. Summary
 - a. This section contains design criteria for low-voltage, dry-type transformers rated 600V and less, with capacities up to 1000 KVA.
2. Sustainability
 - a. General applicable items include regional manufacturers, recycled / American steel and copper and manufacturers use of low VOC coatings.
3. Quality Assurance
 - a. Transformers shall be UL listed and comply with IEEE C57.12.91
 - b. Energy efficient transformers rated 15 KVA and larger to be certified as meeting NEMA TP-1, Class 1 efficiency levels when tested according to NEMA TP-2.
4. Design and Performance Requirements
 - a. Isolate core and coil from enclosure with suitable vibration absorbing mounts.
 - b. All transformers must be delta-wye configuration.
 - c. Transformer impedance levels must be minimum of three percent to limit short-circuit currents on secondary systems.
 - d. All transformers rated up to 225 KVA must be air cooled.
 - e. All transformers must have copper windings. **Aluminum windings are not acceptable.**
 - f. All transformers shall have insulation class of 220 deg C **with a maximum of 80 deg C rise** under full load above 40 deg C ambient temperature.
 - g. K-Rated transformers shall be used when serving loads with a high degree of harmonics.
 - h. Transformer 15 kVA or smaller shall have (2) 5% FCBN (full capacity below normal) primary taps and transformers larger than 15 kVA shall have (2) 2.5% FCAN (full capacity above normal) and (4) 2.5% FCBN primary taps.
5. Enclosures
 - a. Rated for environmental conditions as follows:

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- i. Indoor: Ventilated, NEMA 250, Type 2
 - ii. Outdoor: Ventilated, rain-tight, NEMA 250, Type 3R
 - iii. Other Wet or Damp Indoor: Ventilated, drip-proof, NEMA 250, Type 2
- b. Finish color shall be ANSI 61 gray.
- 6. Manufacturers
 - a. Eaton Corporation; Cutler-Hammer Products
 - b. GE Electrical Distribution & Control
 - c. Jefferson Electric, Inc.
 - d. Siemens Energy & Automation, Inc.
 - e. Sola/Hevi-Duty Electric
 - f. Square D; Schneider Electric
- 7. Installation
 - a. Transformers shall be floor mounted atop concrete bases of at least 4 inches larger than the foot print of the unit and 4 inches high.
 - b. **Suspended transformers are not acceptable.**
 - c. Mount transformers on neoprene pads.
- 8. Quality Control
 - a. Prior to energizing transformer, perform moisture insulation resistance tests.

j) **Switchgear**

- 1. Summary
 - a. This section contains design criteria for metal-enclosed, low-voltage, power circuit-breaker switchgear rated 1000 Volts and less.
- 2. Sustainability
 - a. General applicable items include regional manufacturers, recycled / American steel and copper and manufacturers use of low VOC coatings.
- 3. Design and Performance Requirements
 - a. Switchgear shall be located in electrical equipment rooms or other equipment rooms designed for such. Access to rooms shall be accessible to qualified personnel only.
 - b. Phase, Neutral and Ground Buses shall be hard-drawn copper 98% conductivity and silver plated. (Aluminum is not acceptable.)
 - c. Switchgear shall be mounted atop concrete bases of no more than 2 inches larger than the foot print of the unit and 4 inches high.
 - d. Draw-out circuit breakers shall be equipped with interlocks to prevent movement of circuit breaker when closed and to prevent closure when in test, connected or disconnected position.
 - e. Switchgear shall have utility metering in a separate utility metering compartment that complies with the utility company requirements.
- 4. Enclosures
 - a. Rated for environmental conditions as follows:

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- a. Indoor Locations: NEMA 250, Type 1
 - b. Outdoor Locations: NEMA 250, Type 3R Walk-in, Non Walk-in
- b. Switchgear enclosure shall be made of steel and painted with manufacturer's standard gray finish over a rust inhibiting primer on phosphatizing treated metal surfaces.
- c. Circuit breaker compartments shall be equipped to house draw-out type circuit breakers and fitted with hinged outer doors.
- d. Enclosures to be fabricated with removable, hinged, rear cover panels secured by captive thumbscrews to allow access to rear interior of switchgear.
5. Quality Assurance
 - a. Electrical components, devices and accessories shall be listed and labeled by a testing agency acceptable to the Authority Having Jurisdiction and marked for intended use.
 - b. Warranty shall be manufacturer's standard or 12 months; whichever is greater.
 - c. Obtain switchgear through on source from a single manufacturer.
6. Project Conditions
 - a. Provide minimum seven (7) days notice to Owner's Designated Representative of a proposed interruption of electrical service.
7. Manufacturers:
 - a. Eaton Corporation; Cutler-Hammer Products
 - b. General Electric Co.; Electrical Distribution & Protection Division
 - c. Siemens Energy & Automation, Inc.
 - d. Square D; Schneider Electric
8. Identification
 - b. Refer to Switchgear naming convention in Common Work Results for Electrical Design Standards.
9. Provide working space per City of Chicago Code.

k) Switchboards

1. Summary
 - a. This section contains design criteria for service and distribution switchboards rated 600V and less.
2. Sustainability
 - a. General applicable items include regional manufacturers, recycled / American steel and copper and manufacturers use of low VOC coatings.
3. Design and Performance Requirements
 - a. Each switchboard shall have its own main disconnecting means. Typically this will be a main breaker, molded case switch or fusible switch.
 - b. Each switchboard shall have fixed individually mounted main device, panel-mounted branches and sections rear aligned.
 - c. Switchboards shall have Transient Voltage Surge Suppressor (TVSS) device per TVSS device Facility standards.

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- d. Switchboards shall be located in electrical equipment rooms or other equipment rooms designed for such. Access to rooms shall be accessible to qualified personnel only.
- 4. Quality Assurance
 - a. Electrical components, devices and accessories shall be listed and labeled by a testing agency acceptable to the AHJ and marked for intended use.
 - b. Warranty shall be manufacturer's standard or 12 months; whichever is greater.
- 5. Project Conditions
 - a. Provide minimum seven (7) days notice to Owner's Designated Representative of a proposed interruption of electrical service.
- 6. Enclosures
 - a. Switchboards to be Front-connected, Front-accessible with sections front and rear aligned.
 - b. Rated for environmental conditions as follows:
 - i. Indoor Locations: NEMA 250, Type 1
 - ii. Outdoor Locations: NEMA 250, Type 3R
- 7. Manufacturers
 - a. Eaton Corporation; Cutler-Hammer Products.
 - b. General Electric Co, Electrical Distribution & Protection Div.
 - c. Siemens Energy & Automation, Inc.
 - d. Square D: Schneider Electric
- 8. Manufacturers for projects requiring custom built switchboards.
 - a. Peterson Electric Panel Mfg. Co.
 - b. Chicago Switchboard
 - c. Illinois Switchboard Corporation
 - d. Switchboard Apparatus Inc.
- 9. Construction
 - a. All bus bars to be tin or silver plated hard-drawn copper of 98 percent conductivity.
 - b. All bus bars shall be rated for maximum short circuit protection.
 - c. Horizontal bus shall be fully rated. No tapered bus allowed.
- 10. Installation
 - a. Floor mounted switchboards shall be mounted atop concrete bases of at least 4 inches larger than the foot print of the unit and 4 inches high.
- 11. Identification
 - a. Refer to naming convention in Common Work Results for Electrical Design Standards.
- 12. Provide working space per City of Chicago Code.

1) Panelboards

- 1. Summary
 - a. This section contains design criteria for panelboards and distribution panels.
- 2. Sustainability

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- a. General applicable items include regional manufacturers, recycled / American steel and copper and manufacturers use of low VOC coatings.
- 3. Design and Performance Requirements
 - a. Each panelboard shall have its own main disconnecting means. (Main breaker or molded case switch.)
 - b. Panelboards shall be located in electrical equipment rooms or other equipment rooms designed for such. Access to rooms shall be accessible to qualified personnel only. Panelboards shall not be located in corridors or other areas accessible to the public.
 - c. Load center construction is not acceptable.
 - d. Modular or integrated panel board assemblies are not acceptable.
 - e. Panelboards installed flush in masonry or framed walls shall have a minimum of four 1” empty conduits stubbed into accessible ceiling space, raised floor space or below slab (if not slab on grade).
- 4. Quality Assurance
 - a. Electrical components, devices and accessories shall be listed and labeled by a testing agency acceptable to the Authority Having Jurisdiction and marked for intended use.
 - b. Warranty shall be manufacturer’s standard or 12 months; whichever is greater.
- 5. Project Conditions
 - a. Provide minimum seven (7) days notice to Owner’s Designated Representative of a proposed interruption of electrical service.
- 6. Enclosures
 - a. Rated for environmental conditions as follows:
 - i. Indoor Locations: NEMA 250, Type 1
 - ii. Outdoor Locations: NEMA 250, Type 3R
 - iii. Kitchen and Lab Areas: NEMA 250, Type 4X, Stainless Steel.
 - iv. Other Wet or Damp Indoor Locations: NEMA 250, Type 4
 - v. Hazardous Areas Indicated on Plans: NEMA 250, Type 7C
- 7. Branch Circuit Panelboards (225 Amps and under):
 - a. Manufacturers shall be limited to the following:
 - i. Panelboards, Overcurrent Protective Devices, Controllers, Contactors and Accessories:
 - Eaton Corporation; Cutler-Hammer Products
 - General Electric Co.; Electrical Distribution & Protection Division
 - Siemens Energy & Automation, Inc.
 - Square D; Schneider Electric
 - ii. Manufacturers for projects requiring custom built panelboards.
 - Peterson Electric Panel Mfg. Co.
 - Chicago Switchboard.
 - Illinois Switchboard Corporation.
 - Switchboard Apparatus Inc.

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- b. Minimum enclosure width of 20” or as approved for renovations.
 - c. All circuit breakers shall be bolt on type.
 - d. All circuit breakers shall be fully rated for available interrupting current. (Series rated is not acceptable.)
 - e. Phase, Neutral and Ground Buses shall be hard-drawn copper 98% conductivity. (Aluminum is not acceptable.)
 - f. Breakers shall indicate tripped condition by a means other than the off position.
 - g. Hinged-to-box (tub), front door construction.
 - h. Panelboards with 30 or more branch circuits shall have a minimum of two door latches for each door.
 - i. Panelboards shall be equipped with 20% spare breakers. A/E shall note that it is not the intention of this guideline to provide an extra panelboard just to meet this requirement.
 - j. Panelboards shall be fully bussed with mounting brackets for all positions including spaces.
8. Power Panelboards (1,200 Amps and under to 225 Amps)
- a. Manufacturers shall be limited to the following:
 - i. Panelboards, Overcurrent Protective Devices, Controllers, Contactors and Accessories:
 - Eaton Corporation; Cutler-Hammer Products
 - General Electric Co.; Electrical Distribution & Protection Division
 - Siemens Energy & Automation, Inc.
 - Square D; Schneider Electric
 - i. Manufacturers for projects requiring custom built panelboards.
 - Peterson Electric Panel Mfg. Co.
 - Chicago Switchboard
 - Illinois Switchboard Corporation
 - Switchboard Apparatus Inc.
 - b. All circuit breakers shall be bolt on type.
 - c. All circuit breakers shall be fully rated for available interrupting current. (Series rated is not acceptable.)
 - d. Phase, Neutral and Ground Buses shall be hard-drawn copper 98% conductivity. (Aluminum is not acceptable.)
 - e. Breakers shall indicate tripped condition by a means other than the off position.
 - f. Hinged-to-box (tub), front door construction.
 - g. Panelboards shall be equipped with 20% spare breakers. A/E shall note that it is not the intention of this guideline to provide an extra panelboard just to meet this requirement.
 - h. Panelboards shall be fully bussed with mounting brackets for all positions including spaces.
9. Identification
- a. Refer to Panelboard naming convention in Common Work Results for Electrical Design Standards.

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10. Provide working space per City of Chicago Code.

m) Motor Control Centers

1. Summary
 - a. This section contains design criteria for Motor Control Centers for use on ac circuits rated 600V and less.
2. Sustainability
 - a. General applicable items include regional manufacturers, recycled / American steel and copper and manufacturers use of low VOC coatings.
3. Design and Performance Requirements
 - a. Motor Control Centers shall be located in electrical equipment rooms or other equipment rooms designed for such. Access to rooms shall be accessible to qualified personnel only.
 - b. Phase, Ground and Ground Buses shall be hard-drawn copper 98% conductivity. (Aluminum is not acceptable.)
 - c. Design motor control centers and their components with short circuit rating of not less than 42,000AIC.
 - d. Units that are size 3 and above shall have draw-out mountings.
 - e. Individual feeder-tap units through 225A shall have draw-out mountings.
4. Enclosures
 - a. Rated for environmental conditions as follows:
 - a. Indoor Locations: NEMA 250, Type 1
 - b. Wet or Damp Indoor Locations: NEMA 250, Type 4
 - c. Enclosure shall be painted with manufacturer's standard grey finish.
5. Quality Assurance
 - a. Electrical components, devices and accessories shall be listed and labeled by a testing agency acceptable to the Authority Having Jurisdiction and marked for intended use.
 - b. Warranty shall be manufacturer's standard or 12 months; whichever is greater.
6. Project Conditions
 - a. Provide minimum seven (7) days notice to Owner's Designated Representative of a proposed interruption of electrical service.
7. Manufacturers:
 - a. ABB Power Distribution, Inc.; ABB Control, Inc. Subsidiary
 - b. Eaton Corporation; Cutler-Hammer Products
 - c. General Electric Co.; GE Industrial Systems
 - d. Rockwell Automation Allen-Bradley Co.; Industrial Control Group

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- e. Siemens/Furnas Controls.
- f. Square D; Schneider Electric
- 8. Identification
 - a. Refer to Equipment naming convention in Common Work Results for Electrical Design Standards.

n) Enclosed Bus Assemblies

- 1. Summary
 - a. This section contains design criteria for Feeder-bus assemblies, Plug-in bus assemblies and Bus plug-in devices.
- 2. Sustainability
 - a. General applicable items include regional manufacturers, recycled / American steel and copper and manufacturers use of low VOC coatings.
- 3. Quality Assurance
 - a. Electrical components, devices and accessories shall be listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, UL listed and marked for intended use.
 - b. Comply with NEMA BU 1, “Busways”.
- 4. Extra Materials
 - a. Provide additional plug-in units equal to 10 percent of amount installed but no fewer than 2 units.
 - b. Provide hookstick operator for plug-in units.
- 5. Manufacturers
 - a. Eaton Corp.; Cutler Hammer Products
 - b. General Electric Company; Electrical Distribution & Control Division
 - c. Siemens Energy & Automation, Inc.
 - d. Square D; Schneider Electric
- 6. Bus Assemblies
 - a. Weather proof steel enclosure with manufacturer’s standard enamel finish, sealed seams and drains with removable closures.
 - b. Phase, Neutral and Ground Buses shall be copper. (Aluminum is not acceptable.)
- 7. Plug-in Devices
 - a. Plug-in units shall be hookstick handle operated, circuit breaker type with common trip for all poles.

o) Wiring Devices

- 1. Summary
 - a. This section contains design criteria for receptacles, ground-fault circuit interrupters, integral surge suppression units and isolated-ground receptacles in addition to snap

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- switches, dimmer switches, device wall plates, floor service outlets, poke-through assemblies, service poles and multi-outlet assemblies.
2. Sustainability
 - a. There are not any specific sustainability requirements associated with this section.
 3. Quality Assurance
 - a. Electrical components, device and accessories shall be listed and labeled as defined in NFPA, Article 100, by Underwriters Laboratories and marked for intended use.
 4. Receptacles
 - a. Isolated-ground Receptacles shall be listed and labeled as isolated-ground receptacles.
 - b. Isolation method shall be integral to receptacle construction and not dependent on removable parts.
 - c. Use of an isolated equipment grounding conductor does not relieve the requirement for grounding the raceway system and outlet box.
 - d. For healthcare facilities (i.e., hospitals, outpatient clinics, healthcare centers, etc.), if a receptacle is supplied from the emergency system, it or its cover plate shall have a distinctive color or marking to be readily identifiable. If color is used to identify these receptacles, use the same one throughout the facility. **Red** is commonly used for this application. However, **orange** has been used in some facilities where red was selected for use on the fire alarm circuits. In general, the components of the essential electrical system, with the exception of the alternate source of supply and transfer switches, are the same as those in the normal distribution system.
 5. Finishes
 - a. Wiring devices connected to normal power systems shall be as selected by owner unless otherwise indicated or required by City of Chicago Electrical Code.
 6. Manufacturers
 - a. Cooper Wiring Devices; a division of Cooper Industries, Inc.
 - b. Hubbell Incorporated; Wiring Device-Kellems
 - c. Leviton Mfg. Company Inc.
 - d. Pass & Seymour/Legrand; Wiring Devices & Accessories
 7. Provide basis of design device listed below or equal by approved manufacturers.
 - a. Receptacles (125V, 20A unless otherwise noted)
 - i. Straight Blade Convenience Receptacle – Hubbell HBL5362
 - ii. Straight Blade Hospital-Grade Receptacle – Hubbell HBL8300H
 - iii. Straight Blade Isolated-Ground Receptacle – Hubbell CR5352IG
 - iv. Straight Blade Tamper-Resistant Receptacle – Hubbell HBL8300SG
 - v. GFCI Convenience Receptacle – Hubbell GFR5352L
 - vi. GFCI Hospital-Grade Receptacle – Hubbell HGF8300
 - vii. TVSS Convenience Receptacle – Hubbell HBL5362SA
 - viii. Twist-Locking Receptacle – Hubbell HBL2310
 - b. Snap Switches (120/277 V, 20A)
 - i. Single Pole Switch – Hubbell HBL1221

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- ii. Pilot Light Switch – Hubbell HPL1221PL
 - iii. Key-Operated Switch – Hubbell HBL1221L
- c. Double-Throw, Momentary Contact, Center-Off Switches
 - i. Single-Pole – Hubbell HBL1557
 - ii. Key-Operated, Single-Pole – Hubbell HBL1557L

p) Enclosed Switches and Circuit Breakers

1. Summary
 - a. This section contains design criteria for individually mounted, safety disconnect switches, molded-case circuit breakers rated at 600 Volts or less, low-voltage power circuit breakers.
2. Sustainability
 - a. There are not any specific sustainability requirements associated with this section.
3. Submittals
 - a. For each type of enclosed switch, circuit breaker, accessory and component indicated. Include dimensioned elevations, sections, weights, shipping configuration and manufacturers' technical data on features, performance, electrical characteristics, ratings and finishes.
4. Quality Assurance
 - a. Electrical components, devices and accessories shall be listed and labeled as defined in NFPA 70, Article 100, by Underwriters Laboratories and marked for intended use.
5. Cleaning
 - a. Inspect exposed surfaces and repair damaged finishes.

q) Variable-Frequency Motor Controllers

1. Summary
 - a. This section contains design criteria for separately enclosed, pre-assembled, combination VFCs, rated 600 V and less, for speed control of three-phase, squirrel-cage induction motors.
2. Sustainability
 - a. There are not any specific sustainability requirements associated with this section.
3. Enclosures:
 - a. Shall be NEMA 250, Type 1, unless otherwise indicated to comply with environmental conditions at the installed location.
 - b. Provide (2) normally open and (2) normally closed auxiliary control relay contacts.
 - c. Provide Integral cooling fans and filters within enclosure.
4. Integral Disconnect, Isolating Switch and Isolated Bypass

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- a. All VFDs shall be equipped with an integral disconnect switch.
- b. All VFDs shall be equipped with an isolated service bypass.
- c. All VFDs shall be equipped with an isolating switch to permit safe troubleshooting and testing while energized and de-energized while motor is operating in bypass mode.
5. Power and Control Wiring
 - a. All power and control wiring shall be routed in separate metallic conduits.
6. Factory Startup Service
 - a. Provide VFD system startup and training to be performed by factory-authorized service representative.
7. Manufacturers
 - a. ABB Power Distribution, Inc.; ABB Control, Inc. Subsidiary
 - b. Square D; Schneider Electric

r) Variable Frequency Driven Motors – Induced Voltage Bearing Current Mitigation Strategies

1. All motors operated on variable frequency drives (VFD) shall be equipped with a maintenance free, conductive micro fiber, shaft grounding ring (SGR) with a minimum of two (2) rows of circumferential micro fibers to discharge electrical shaft currents within the motor and/or bearings.
2. All motors up to 200HP shall be provided with a minimum of 1 shaft grounding ring (SGR) installed on the drive/shaft end (preferably) or non-drive end.
3. All motors 250HP and above shall be provided with an insulated bearing on the non-drive end and a shaft grounding ring (SGR) on the drive/shaft end of the motor.
4. All shaft grounding rings (SGR) shall be provided and installed by the motor manufacturer or contractor and shall be installed in accordance with manufacturer's recommendations,
5. Approved Manufacturer (SGR):
 - a. AEGIS—SGR Bearing Protection Ring

s) Engine Generators

1. Summary
 - a. This section contains design criteria for Natural Gas and Diesel Engine Generators.
2. Sustainability
 - a. There are not any specific sustainability requirements associated with this section.
3. Design Intent
 - a. Code required generators: Locate indoor generators within separate 3 hour fire rated room.
 - b. Load bank testing: Provide exterior connection for outdoor portable load bank testing to indoor generators.

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- c. Provide monitoring connection to the University B.A.S. Refer to B.A.S design standards section.
- d. Provide convenient and accessible means of refueling generator day tanks and sub-base mounted tanks.
- e. Natural Gas Generators are preferred for University projects.
 - i. Main gas line service from Peoples Gas shall be a “dedicated” service, supplying only the life safety/optional standby generator.
- 4. Quality Assurance
 - a. Installer Qualifications
 - i. Maintenance Proximity: Not more than two (2) hours normal travel time from Installer’s place of business to project site.
 - b. Manufacturer Qualifications
 - i. A qualified manufacturer shall maintain, within 100 miles of project site, a service center capable of providing training, parts and emergency maintenance repairs.
 - ii. Provide 1 year full maintenance by skilled employees of manufacturer’s designated service organization and coordinate rollover to University’s maintenance contractor at end of term.
 - c. Comply with NFPA 110 and City of Chicago requirements for Level 1 and/or 2 emergency power supply systems.
- 5. Manufacturers
 - a. Caterpillar Engine Division
 - b. Onan Corp./Cummins Power Generation; Industrial Business Group
 - c. Kohler Co.; Generator Division
 - d. MTU Onsite Energy
 - e. Inland Detroit Diesel
- 6. Fuel Supply System
 - a. Natural Gas
 - i. Provide “dedicated” service from Peoples Gas
 - b. Diesel
 - i. Comply with NFPA 30, NFPA 54 and City of Chicago Code.
 - ii. Day Tank shall comply with UL 142, freestanding, factory-fabricated fuel tank assembly, with integral, float-controlled transfer pump and the following features:
 - Containment: Integral rupture basin with a capacity of 150 percent of nominal capacity of day tank.
 - Tank Capacity: As recommended by engine manufacturer for an uninterrupted period of 4 hours operation at 100 percent of rated power output of engine generator system without being refilled.
 - Pump capacity: Exceeds maximum flow of fuel drawn by engine-mounted fuel supply pump at 110 percent of rated capacity, including fuel returned from engine.

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- High-level alarm sensor: Liquid-level device operates alarm and redundant fuel shut off contacts at midpoint between overflow level and 100 percent of normal fuel level.
 - Redundant High-Level Fuel Shutoff: Actuated by high-level alarm sensor in day tank to operate a separate motor device that disconnects day-tank pump motor. Sensor shall signal solenoid valve, located in fuel suction line between fuel storage tank and day tank, to close. Both actions shall remain in shutoff state until manually reset. Shutoff action shall initiate an alarm signal to control panel but shall not shut down engine-generator set.
 - Provide leak detection in interstitial space and connect to provide audible and visual alarms in the event of a leak.
- c. Base-Mounted Fuel Oil Tank shall be factory installed and piped, complying with UL 142 fuel oil tank. Features include the following:
 - i. Tank level indicator.
 - ii. Fuel capacity for four (4) hours' continuous operation at 100 percent rated power output.
 - iii. Vandal-resistant fill cap.
 - iv. Containment Provision shall comply with requirements of authorities having jurisdiction.
- 7. Field Quality Control
 - a. Owner will engage a qualified testing and inspecting agency to perform field tests and inspections and prepare test reports.

t) Static Uninterruptible Power Supply

1. Summary
 - a. This section contains design criteria for three phase, on-line, double conversion, static type UPS units.
2. Sustainability
 - a. There are not any specific sustainability requirements associated with this section.
3. Design Intent
 - a. Include proper ventilation in battery rooms.
 - b. Provide connection to University B.A.S. for monitoring. Refer to B.A.S. facility standards for additional information.
4. Modes of Operation
 - a. The UPS shall be designed to operate as an on-line reverse transfer system in the following modes:
 - i. Normal: The UPS inverter continuously supplies the critical AC load. The rectifier/charger derives power from a utility AC source and supplied DC power to the inverter while float-charging a power reserve battery.

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- a. Emergency: Upon failure of utility AC power, the critical AC load is supplied by the inverter, which without any switching, obtains power from the battery. There shall be no interruption in power to the critical load upon failure or restoration of the utility AC source.
- b. Recharge: Upon restoration of utility AC power the rectifier/charger shall automatically restart, walk-in and gradually assume the inverter and battery recharge loads.
- c. Bypass: If the UPS must be taken out of service for maintenance or repair or should the inverter overload capacity be exceeded, the static transfer switch shall perform a reverse transfer of the load from the inverter to the bypass source with no interruption in power to the critical AC load.
- b. Manufacturers
 - a. Liebert Corporation; a division of Emerson
 - b. MGE UPS Systems
 - c. Exide Electronics; Powerware
 - d. Mitsubishi Electric Automation Div.
 - e. Eaton Corp.; Cutler-Hammer Products

u) Transfer Switches

1. Summary
 - a. This section contains design criteria for transfer switches, manual bypass or isolation switches rated 600V and less.
2. Sustainability
 - a. There are not any specific sustainability requirements associated with this section.
3. Design Intent
 - a. Code required emergency systems: Locate transfer switches and associated distribution equipment within a separate 2 hour fire rated room from Utility Power.
 - b. Provide switched neutral for 3 phase, 4 wire, automatic transfer switches.
 - c. Provide In-Phase Monitor for transfer of power between normal and emergency sources only when both sources are synchronized in-phase within 15 electrical degrees and only if transfer can be completed within 60 electrical degrees.
4. Quality Assurance
 - a. Electrical components, device and accessories shall be listed and labeled as defined in NFPA 70, Article 100, for emergency service under UL 1008, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
5. Submittals
 - a. Submit shop drawings with wiring diagrams, product data and parts list.
 - b. Submit qualification data for manufacturer and testing agency.

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- c. Submit operations and maintenance instructions.
- 6. Manufacturers
 - a. Caterpillar, Engine Division
 - b. Emerson, ASCO Power Technologies, LP
 - c. GE Zenith Controls
 - d. Onan Corp/Cummins Power Generation, Industrial Business Group
 - e. Russelectric, Inc.

v) Transient-Voltage Suppression for Low-Voltage Electrical Power

- 1. Summary
 - a. This section contains design criteria for Surge Protection Devices (SPDs) for low-voltage (120 to 600 V) power distribution and control equipment.
- 2. Sustainability
 - a. There are not any specific sustainability requirements associated with this section.
- 3. Provide only UL Listed Surge Protection Devices.
- 4. Service Entrance Suppressors – Type 1
 - a. The following construction features are not acceptable
 - i. Plug-in component modules in the primary transient path will not be accepted.
 - ii. Equipment that creates hazard upon failure will not be accepted.
 - iii. Suppressors that rely on other external or upstream units to achieve the required performance and UL 1449 listing will not be accepted.
 - iv. Suppressors that employ cartridge fuses will not be accepted.
- 5. Panelboard Suppressors – Type 2
 - a. The following construction features are not acceptable
 - i. Plug-in component modules in the primary transient path will not be accepted.
 - ii. Equipment that creates hazard upon failure will not be accepted.
 - iii. Suppressors that rely on other external or upstream units to achieve the required performance and UL 1449 listing will not be accepted.
 - iv. Suppressors that employ cartridge fuses will not be accepted.
- 6. Installation of surge protection devices
 - a. Install Type 1 devices at switchboard on load side, with ground lead bonded to service entrance ground.
 - b. Install Type 2 devices for panelboard with conductors or buses between suppressor and points of attachment as short and straight as possible. Do not exceed manufacturer's recommended lead length. Do not bond neutral and ground.
 - c. Provide multi-pole circuit breaker as shown on the One Line Diagram as a dedicated disconnect for suppressor, unless otherwise indicated

w) Interior Lighting

- 1. Summary

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- a. This section contains design criteria for interior lighting fixtures with lamps and ballasts. It also includes preferred practices for lighting retrofits within campus buildings. The University recognizes the significant impact on both energy consumption and costs that lighting represents in buildings. Therefore, the University is interested in progressive technology, such as LED lighting, to reduce these impacts. Any such technology will be readily considered for projects as long as quality and costs are acceptable. All applicable building codes shall be referenced during the lighting design process. If there are any disparities between the requirements in this document and the buildings code, then the building code shall take precedence.
2. Sustainability
 - a. Applicable items include regional manufacturers, energy efficient fluorescent lamp technology and the use of natural day lighting in design methods.
3. Design and Performance Requirements
 - a. Lighting technology and especially LED lighting technology is a developing industry. Lighting designs must incorporate the latest proven technologies in an effort to increase energy savings and decrease early obsolescence of the lamps and fixtures.
 - b. Design interior lighting levels in the following spaces to the IES footcandle values as listed below. Deviations are allowed from these levels as long as there is a justifiable reason.

Room Type	Illuminance (Foot Candles)
Classrooms	35
Lecture Halls	35
Offices and Conference Rooms	30
Reception, General Use Areas	10
Restrooms	30
Kitchens	50
Cafeterias	30
Corridors, Utility rooms (i.e. A/V closets)	10
Mechanical Rooms (i.e. electrical/HVAC equipment)	25
Laboratory and Research	50 or per dept.

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- c. Utilize natural day lighting in design wherever possible to supplement artificial lighting.
- d. Utilize occupancy sensors, dimming controls, multi-level switching, photo sensors, programmable dimming panels and programmable relay panels where possible and appropriate.
 - i. Ceiling-mounted occupancy sensors are preferred to minimize abuse.
 - ii. Specify open protocol lighting control systems compatible with University BAS system (i.e. BACNET)..
- e. Ballasts must be energy-efficient, high power factor and multi-voltage.
 - i. Rapid programmed start.
 - ii. Independent lamp operation allowing remaining lamps to maintain full light output when one or more lamps fail Independent lamp operation with instant start allowing remaining lamps to maintain full light output when one or more lamps fail.
 - iii. Low ballast factor is required unless lighting levels require higher ballast factor.
 - iv. Auto restart.
 - v. Low voltage ballasts should be quick-connect type with parallel operation.
- f. Ballasts of all fixtures shall be accessible without opening the ceiling.
- g. In lighting calculations, maintenance factors must not exceed 0.65.
- h. Lighting designs must use common lamp types. Avoid unusual lamp types.
- i. Stair lighting shall use fixtures with T-8 lamps or better and provide occupied illuminance of 10 footcandles and unoccupied illuminance of 1 foot candle. The preferred method of control is through an occupancy sensor that is not integrated into the fixture.
- j. Fluorescent lamps
 - a. Fluorescent T8 lamps shall have minimum CRI 75 and color temperature of 3500K and a lifetime of at least 45,000 hours.
 - T8 lamps shall be the standard and preferred lamp on all projects. Higher wattage lamps will be considered on specific cases (i.e. if one 32 W T8 can be used to meet lighting levels instead of two 25 W T-8 lamps).
 - b. Fluorescent T5 and T5HO lamps shall have minimum CRI 85 and color temperature of 3500K.
 - T5 lamps will be considered by application and must be approved by the University.
 - U-lamps are **not** acceptable.
 - c. Compact Fluorescent lamps shall have minimum CRI 80 and color temperature of 3500K.
 - Hard wired recessed Compact Fluorescent lamps with remote ballasts are **not** acceptable.
- k. High Intensity discharge lamps

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- a. High pressure sodium lamps shall have minimum CRI 21 and color temperature of 1900K.
 - (i) High pressure sodium lamps are not acceptable for indoor applications.
- b. Metal halide lamps, including pulse-start, shall have minimum CRI 65 and color temperature of 4000K.
- c. Ceramic pulse start Metal halide lamps shall have minimum CRI 80 and color temperature of 4000K. Other types of metal halide lamps are not acceptable.
- l. LED lamps
 - a. LED lamps shall have minimum CRI 80 and color temperature between 2700k to 3500k and have a lifetime of at least 25,000 hours at 70% lumen maintenance. The efficacy of the lamp should be at least 40 lumens/watt. For lamps greater than 5 watts, the power factor must be 0.70 or better.
 - b. Linear LED products that are to replace traditional tubular fluorescents (i.e. T8) are acceptable at color temperatures higher than 3500K if the LED product is approved by the University
 - c. LED lamps shall be the standard preferred lamp in all Exit signage.
 - d. LED fixtures will be considered by application and must be approved by the University.
 - e. LEDs in lamps and luminaires shall be Cree or equivalent and documentation showing the LED manufacturer and model number shall be provided to the University and have at least a 5 year warranty.
 - f. LED lamps or LED fixtures should be DLC listed or have a “Lighting Labels” designation. If none of these exist, then LM-79, LM-80, and TM-21 (if TM-21 is available) testing results shall be presented to the University for review.
 - g. Interior lighting design shall comply with IECC wherever applicable.
- 4. Manufacturers
 - a. Cooper Lighting
 - b. H.E. Williams
 - c. Infinity
 - d. Hubbell
 - e. Lightolier
 - f. Lithonia
 - g. Cree LED Lighting
 - h. OSRAM/Sylvania LED Trim/Lamp Products
 - i. JLG Schneider Electric traditional and LED fixtures
- 5. Installation
 - a. Set fixtures level, plumb and square with ceilings and walls.
 - b. Adjust directional fixtures to provide required light levels.
 - c. Fixtures in stairwells shall be mounted less than eight feet above platform level.
 - d. Clean and adjust fixtures upon substantial completion of project.

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6. Lighting Retrofits

- a. The following list details retrofit options that the University of Chicago has found to provide energy savings and reasonable financial payback. The list should be used to guide future lighting retrofits, so detailed energy and financial analysis is not required for standard lamp retrofits.
 - i. Replace any existing screw-in (E26 base) incandescent bulbs with LED lamps in areas with high lighting use (i.e. hallways, classrooms, offices, conference rooms, etc.) or fixtures where dimming is desired as long as there are no concerns about LED failures due to heat issues.
 - ii. Replace existing screw-in (E26 base) incandescent bulbs with CFL lamps in areas with low lighting use (i.e. janitor closets, mechanical rooms, utility closets, etc.).
 - iii. Replace T-12 fluorescent lamps with T8 25 watt lamps. If delamping during retrofit, then T8 32 watt lamps may be used if needed to maintain lighting levels.
 - iv. Retrofit incandescent or fluorescent exit sign fixtures with LEDs
 - v. Replace stair lights with bilevel fixtures if illuminance levels in stairwells are below 10 foot candles. The bilevel fixtures shall use T-8 lamps or better and provide occupied illuminance of 10 footcandles and unoccupied illuminance of 1 foot candle. The preferred method of control is through an occupancy sensor that is not integrated into the fixture.
- b. Occupancy sensors provide additional savings for lighting retrofits projects and shall comply with the following:
 - i. Ceiling- mounted occupancy sensors are preferred to minimize abuse. If dual technology is used then the technology shall consist of infrared and ultrasonic.
 - ii. No occupancy sensors will be considered for mechanical/electrical rooms.
 - iii. Occupancy sensors for office spaces will be considered if light logger data shows potential savings or other justifications are given.
 - iv. Occupancy sensors are preferred for classrooms, common rooms, conference rooms, restrooms, etc.
 - v. Spacing between occupancy sensors shall be 4 ft. closer than manufacturer recommendations to make sure there are no areas that are not sensed in a space.

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- c. Propose daylight harvesting scenarios where daylighting seems like a viable option
- d. Delamping options for linear fluorescent fixtures shall be proposed for rooms that are overlit 50% above lighting levels specified in this standard if financially viable.
- e. Delamping options for linear fluorescent fixtures shall be proposed for fixtures with 3 or more lamps if financially viable
- f. LED technology is rapidly advancing each year, which brings new retrofit opportunities. When selecting specific LED lamps, it is important to select lamps that carry an Energy Star rating, “Lighting Facts” label, or has gone through LM-79 and LM-80 testing. This provides 3rd party verification to manufacturer performance claims. If LED lamps are to be placed on a circuit with a dimmer, then the dimmer may need to be replaced to maintain compatibility. Check with dimmer manufacturer to confirm compatibility. Purchasing decisions should also take into consideration reliability factors such as warranty information, manufacturer track record, and field testing. The University will approve LED fixtures based on life cycle cost analysis submitted by the designer. The following incandescent and fluorescent lamp types have LED equivalents that have been proven by the Department of Energy to perform equal or better.
 - i. 65 W or 75 W incandescent BR30/R30 lamps
 - ii. HID, CFL, incandescent, halogen floodlights (can work in some cases although LED floodlamps have lower lumen output and have difficulty with narrow spot distributions if that is required)
 - iii. 60 W to 100 W incandescent (13 W to 32 W CFL) downlights using LED retrofit units
 - iv. Metal halide, HPS, and fluorescent high-bay luminaries
 - v. 2 X 2 fluorescent troffers (LED may have less lumen output)
 - vi. 40 W to 60 W A-lamp (Edison base) incandescent bulbs and CFL equivalents. However, there are limited LED products that can work in sconces or enclosed fixtures
 - vii. 20 W halogen MR16s
 - viii. 45 to 75 W halogen PAR20,30,38 lamps

x) Exterior Lighting

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1. Summary
 - a. This section contains design criteria for exterior luminaries with lamps and ballasts.
2. Sustainability
 - a. Applicable items include regional manufacturers, energy efficient fluorescent lamp technology and reduction of night sky light pollution and light trespass in design practices.
3. Design and Performance Requirements
 - a. Lighting technology and especially LED lighting technology is a fast, aggressively developing industry. Lighting designs must incorporate the latest proven technologies in an effort to increase energy savings and decrease early obsolescence of the lamps and fixtures.
 - b. Design exterior lighting levels in the following areas to the IES footcandle values as listed below:

Outdoor Area Description	
Building Entrances	5
Prominent Structures	5
Pedestrian Malls	5
Gardens - Focal Points	5
Gardens - General Lighting	3
Retail Areas	10

- c. High Intensity Discharge lamp ballasts shall be pulse start where available and probe start otherwise.
 - d. Minimum starting temperature shall be minus 22 degrees F for single lamp ballasts.
 - e. Fluorescent lamps shall have minimum CRI 80 and color temperature of 3500K.
 - f. High pressure sodium lamps shall have minimum CRI 21 and color temperature of 1900K.
 - g. Metal halide lamps shall have minimum CRI 65 and color temperature of 4000K.
 - h. Mount fixtures so hinged panels swing to allow access by maintenance personnel.
 - i. Exterior lighting design shall comply with IECC wherever applicable.
 - j. Refer to Site Lighting standards for additional information.
4. Manufacturers
 - a. Cooper Lighting: Lumark or McGraw Edison
 - b. Hubbell
 - c. Lithonia
 - d. Spero

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y) Emergency Lighting

1. Summary
 - a. This section contains design criteria for Emergency Lighting, Exit Signs and Battery Inverter Ballasts.
2. Sustainability
 - a. Applicable items include regional manufacturers and energy efficient fluorescent lamp technology.
3. Design and Performance Requirements
 - a. Emergency Lighting
 - i. Emergency lighting shall be powered by generator when available. If generator power is not an option then integral emergency inverter ballast with sufficient capacity to provide 90 minutes of emergency power will be provided.
 - ii. Emergency lighting to be configured such that 1 lamp operates continuously and the unswitched circuit is connected to battery inverter and switched circuit is connected to the fixture ballast.
 - iii. Emergency lighting shall be equipped with Push to test button to simulate loss of normal power and integral self-diagnostics which automatically initiates code required test of unit at required intervals. Test failure is indicated by audible alarm and flashing red LED.
 - b. Exit Signage
 - i. LED lamps shall be the standard preferred lamp in all Exit signage.
 - ii. The University standard color for all Exit Signage lettering shall be Red.
 - iii. Exit signage shall be powered by generator when available. If generator power is not an option then integral emergency inverter ballast with sufficient capacity to provide 90 minutes of emergency power will be provided.
 - iv. Exit sign shall be equipped with Push to test button to simulate loss of normal power and integral self-diagnostics which automatically initiates code required test of unit at required intervals. Test failure is indicated by audible alarm and flashing red LED.
 - c. Battery Inverter Ballast
 - i. Emergency lighting battery shall be sealed, maintenance-free and nickel cadmium type.
 - ii. Exit Signage battery shall be sealed, maintenance-free and nickel-cadmium type.
4. Manufacturers
 - a. Emergency Lighting - Battery Inverters
 - a. Bodine
 - b. Iota Engineering
 - c. Lithonia Power Sentry
 - b. Exit Signage

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- a. Chloride Systems
- b. Cooper Industries, Inc.; Sure-Lites Division
- c. Hubbell, Inc.; Dual-Lite
- d. Lithonia Lighting, Emergency Lighting Systems
- e. Thomas & Betts Corporation; Emergi-Lite Corporation Division

3. References

All electrical components, devices and accessories installed shall be listed and labeled as defined in NFPA 70, Article 100, by Underwriters Laboratories and marked for intended use. Always comply with City of Chicago Electrical Code, NFPA, NEC and all other applicable building codes.

The latest edition of the following codes and standards shall apply:

- National Fire Protection Association (NFPA)
- National Electrical Code (NEC)
- The City of Chicago Electrical Code
- Occupational Safety and Health Act (OSHA)
- Underwriters Laboratory (UL)
- Institute of Electrical and Electronics Engineers (IEEE)
- Illuminating Engineering Society of North America (IESNA)
- National Electrical Manufacturers Association (NEMA)
- American National Standards Institute (ANSI)
- FM Global

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