FACILITIES & OPERATIONS
ARCHITECTURE, ENGINEERING AND CONSTRUCTION
UNIVERSITY OF MICHIGAN

Design Guideline 260500
Common Work Results for Electrical

Scope

Prepare the project's electrical design and associated contract documents in accordance with these Design Guidelines, in accordance with the scope of work defined in the Program Documents, and within the construction budget.

Related Sections

U-M Design Guideline Sections:

DG 2.0 - Project Procedures
DG 4.0 - Special Instructions to Designers
DG 5.0 - Special Building Areas
DG 6.3 - Electrical Technical Sections
DG 8.4 - Electrical Trades Preferred Manufacturers List

U-M Master Specification Sections: (A digitally accessible version is pending; please email AEC-Digital Accessibility Support if assistance is needed)

Division 01 - General Requirements
Division 26 - Electrical Master Specifications
Division 27 - Communications
Division 28 - Electronic Safety and Security

U-M Standard Details:

9.3 - Electrical Standard Details

Reference Documents:

NFPA 70 - National Electrical Code (NEC)
NFPA 70E – Standard for Electrical Safety in the Workplace
IEEE Standard 141 - Recommended Practice for Electric Pwr. Dist. for Industrial Plants
IEEE Standard 1584 - IEEE Guide for Performing Arc-Flash Hazard Calculations

Design Requirements

Submit the documents specified in the Design Deliverables list for approval. Submit them at the end of the Schematic Design, Design Development and Construction Documents phases.

Provide flexibility for future changes in the use of the space, and provide spare capacity for future load growth. Provide 20 percent spare capacity for load growth unless 20 percent spare capacity would require a significant power distribution system upgrade. In those special cases, provide as much spare capacity as the existing system can supply.

Field verify the existing installation and/or site. Do not rely solely on the existing drawings and/or site surveys. As a minimum, field verify the quantities, sizes, ages, conditions and spare capacities of the following:

- Power ducts, manholes, services to the building and unit substations.
- Panels, circuit breakers, disconnect switches, motor controls, raceways and wiring.
- Interior and exterior lighting, switches and receptacles.
- Grounding.
- Telecommunications ducts, manholes, rooms and services to the building.
- Fire alarm, security, card access control, audio/visual and other special systems.

Coordinate with the Design Manager to obtain recent historical information from the following U-M departments:

- Key plans and electrical risers from AEC. UMHS projects to contact Facility Planning and Development (FPD) for risers and panel location drawings.
- Electrical usage, primary system and unit substation information from the Plant Utilities and Plant Engineering (UPE) Department.
- Existing condition information from the Facility Condition Assessment Program, the Facility's Manager and the Plant Region maintenance personnel.
- Card access control system information from the Plant Key Office.

Show all known below grade, below floor and in-floor utilities that will be impacted by the project's work.

Use existing spare circuit breakers or existing spaces whenever possible. If necessary, combine existing lightly loaded circuits to free existing circuit breakers for the new loads. Combining circuits requires matching phase conductor colors and relabeling references to circuits used in the field, including junction boxes and end of circuit labeling. Tap buses only with the approval of the Plant UPE Department. Coordinate with the Design Manager before adding a new unit substation.

Number electrical panels and devices in accordance with U-M Standard Detail 260500001. Match the existing installation whenever possible and practical.

Locate equipment requiring routine maintenance so it is easily accessible.

- Installations shall not require the use of a lift or scaffolding, or the removal of other infrastructure, for routine maintenance.
- For rooftop equipment with control panels, motor starters, disconnects or motors mounted over 6 feet above roof level and requiring routine maintenance, arrange for the Architect to provide a permanent galvanized steel work platform and ladder.

Provide access panels (24 inches square minimum to access equipment out of arm's reach) for maintaining electrical equipment located behind walls or above permanent ceilings.

Ensure that no piping or ductwork is routed in the NEC-required dedicated spaces above or working spaces around electrical equipment. Provide drip pans for existing piping routed over electrical equipment.

Correct code violations and safety hazards to the greatest extent possible within the project boundary. If existing code violations or safety hazards are discovered that are not addressed in the Program Documents, notify the Project Manager.

Short Circuit, Protective Device Coordination and Arc Flash Hazard (SPA) Studies

Short Circuit and Protective Coordination Device studies shall be prepared in accordance with IEEE Standard 141. Arc Flash Hazard studies shall be prepared in accordance with IEEE Standard 1584 and NFPA 70E.

SPA studies shall be signed and sealed by a Registered Professional Engineer, in the State of Michigan. Architect/Engineer shall be directly responsible for SPA's. If the SPA study is sub-contracted out, the Architect/Engineer shall review and approve the study. The Electrical Contractor shall not perform or arrange for these studies.

Perform SPA studies for projects that include new installations, total replacements or partial replacements of power distribution systems. Studies are required to establish proper electrical equipment ratings and settings of electrical distribution equipment and powered mechanical equipment including, but not limited to, unit substations, switchboards, panelboards, motor control centers, transformers, transfer switches, UPS's, generators, motor starters, disconnect switches, variable frequency drives and control panels. SPA studies shall also be performed for projects that include modifications to existing electrical utility service, major feeder conductors and motor quantities.

SPA studies shall begin at the point of utility service for the facility down through the 480V and 208V distribution systems. Include in the studies the project scope plus existing upstream electrical infrastructure and any other directly affected existing electrical distribution equipment. U-M standard practice is to de-energize electrical equipment prior to any work being performed. This standard practice should not be used as a basis for determining the scope for Arc-Flash Hazard analysis.

Complete a 'design basis' SPA study during the design phase of the project. For review the study shall be submitted to the Design Manager, Commissioning Authority and UPE Primary System Engineer.

Complete a 'final' SPA study during the construction phase of the project prior to energizing electrical equipment. Base calculations on actual field installation data. The final study shall incorporate shop drawing information, protective device coordination time-current curves from the electrical equipment manufacturers, and actual cable sizes and lengths from the Electrical Contractor. The final SPA study may be submitted in two parts to accommodate the construction schedule. The first part shall contain the short circuit and protective device coordination (completed shortly after shop drawing approvals) and the second part shall contain the arc flash hazard analysis (completed prior to equipment energization). For review the study shall be submitted to the Design Manager, Commissioning Authority and UPE Primary System Engineer.

Information on the primary distribution system and on the primary system fault capability is available from UPE Primary System Engineer.

Derive settings for new protective devices in consideration of existing upstream protective device settings, and optimize system coordination in light of this constraint. The utility upstream protective device feeding the facility shall be maintained as the upper limit for coordination. Where the upstream device characteristics do not allow reasonable coordination with new equipment, identify the problem and the recommended resolution in a letter to the Design Manager prior to submitting the coordination study

Design power distribution systems to limit the arc flash incident energy to a magnitude requiring Personal Protective Equipment (PPE) of Category 4 or less at unit substations and switchboards, and Category 2 or less at panelboards and similar equipment rated 600 amps or less.

All circuit breakers shall be fully rated for the available short circuit current, series ratings shall not be applied.

Do not rely upon AIC ratings of existing equipment. Do short circuit studies to affirm the proper AIC for each location.

When the power distribution system includes an interactive power source such as an engine-generator with closed transition automatic transfer switches, solar photovoltaic system, wind generator or fuel cells, only perform the short circuit study based on the combined fault contributions from the incoming utility power system and interactive source if the two power sources are paralleled for more than 100ms.

Verify electrical equipment supplied by others such as equipment control panels and variable speed drives are adequately rated for the available short circuit current.

The contractor shall furnish all field data as required by the SPA studies. Furnish the Contractor with a listing of required data.

SPA Study and Report Requirements

SPA studies shall be performed using computer software from SKM Power Tools.

SPA studies shall include an executive summary. Incorporate description, purpose, basis and scope of the study. Also include pertinent data and the rationale employed in developing the study calculations.

'Design Basis' SPA studies are not required to include all system components. The studies shall include sufficient detail to verify the following:

- Maximum available fault current at each level of the distribution system.
- Protective device coordination for the most restrictive scenarios.
- Arc-flash hazard levels at unit substations.

All other formatting and information requirements shall apply.

Short Circuit reports shall include, but not limited to, the following:

- Input data, case descriptions and definition of terms.
- One-line diagram showing calculated short circuit currents at each node, bus identification

numbers, voltages, protective devices with associated ampere ratings, cable sizes and lengths, transformer kVA sizes with voltage ratings and impedances, motor horse powers, generator kVA ratings with subtransient reactance, ATS's, switchboards and panelboards.

- Include fault contribution of motors, with motors < 50hp grouped together.
- Results of short-circuit calculations shall be presented in tabular form and include:
    - Bus identifications
    - Device identifications
    - Device ratings
    - Operating voltages
    - 3-phase short circuit currents (asymmetrical and symmetrical).
    - Phase-to-ground short circuit currents.

Protective Device Coordination reports shall include, but not limited to, the following:

- Tabulations of protective relay settings, adjustable circuit breaker trip unit settings, fixed circuit breaker ratings and fuse types/ratings.
- Automatic transfer switch voltage, current, time and control settings.
- Coordination curves prepared in log-log format to illustrate adequate clearing times between protective devices.
- Specific time-current characteristics of each protective device plotted in such a manner that all upstream devices will be clearly depicted on one sheet.
- Multi-color curve sheets for improved clarity.
- Curve sheets shall include the following:
    - Device identifications and associated settings/sizes/ratings
    - Voltage at which curves are plotted
    - Current multiplier
    - Curves labeled with applicable curve number
    - Relay CT ratios, tap, time dial, and instantaneous pickup
    - Circuit breaker sensor rating, long-time, short time, instantaneous and ground fault settings, time bands and delays
    - Melting and clearing fuse curves
    - Maximum short-circuit cutoff point
    - Cable ANSI insulation damage curves
    - Transformer ANSI damage curve and inrush point
    - Motor starting profiles (200hp and above)
    - Single-line for the portion of the system

Arc-Flash Hazard analysis reports shall include, but not limited to, the following:

- Arc-Flash Incident Energy (AFIE) levels and flash protection boundary distances at all locations in the electrical distribution system where work could be performed on energized parts.
- Analysis performed under worst-case Arc-Flash conditions.
- Results of arc-flash hazard analysis shall be presented in tabular form and include:

- Bus identifications
- 3-phase short circuit currents
- Arcing fault current levels
- Flash protection boundary distances
- AFIE levels
- Personal protective equipment (PPE) hazard risk category

SPA Study and Report Deliverables

Analyze the short circuit calculations, and highlight any equipment (new or existing) that is determined to be underrated as specified or that does not coordinate with upstream equipment. Propose approaches to effectively protect the underrated equipment.

Submit the report to the Electrical Contractor for their use in providing fuses and adjusting electrical equipment settings prior to equipment testing and energization. The independent electrical testing agency and Commissioning Authority will verify proper fuse sizes and protective device settings.

Submit the final SPA report (pdf format), including the associated SKM Power Tools data files, on a CD or DVD to UPE Primary System Engineer and to the contractor for inclusion in the O&M Manuals.

Arc Flash Hazard Warning Labels

The Electrical Contractor shall provide generic arc flash hazard warning labels on equipment. This equipment includes but is not limited to automatic transfer switches, switchboards, panelboards, meter socket enclosures, transformers, storage batteries, battery chargers, inverters, control panels, variable speed drives, motor controllers, circuit breakers and disconnect switches.

Although portions may be energized early to provide temporary power for construction, the power distribution system will not be declared Substantially Complete and will not be accepted by the University until the study and labeling tasks have been completed.

Design Drawings

Prepare the following electrical drawings and specifications in accordance with the Design Deliverables list and as applicable to the project, for use during construction:

- Demolition plans and details.
- Underground duct bank and manhole plans, elevations, profiles and details.
- Primary and secondary feeder conduit routing drawings.
- Normal and emergency power plans, one-lines, risers and details.
- Schematic and wiring diagrams.
- Lighting plans and details.
- Telecommunications, fire alarm, clock, card access control, security, CCTV, nurse call, audio/visual, sound reinforcement and other special systems plans, risers, schematics, and wiring diagrams.

- Grounding and lightning protection plans, risers and details.
- Substation, switchboard, panelboard, MCC and other applicable equipment schedules with connected load summaries.
- Systems and equipment sequences of operation.
- Indicate NEC required working clearances on plan views for electrical equipment and dedicated electrical space on equipment elevations. Space allotted for future equipment should be noted on plan view drawings including any associated working clearances.

For new electrical drawings, use the symbols and abbreviations established by the applicable nationally recognized trade association. When revising existing drawings, use the existing symbols and name equipment using the existing convention. Provide a complete symbols legend.

When revising existing drawings, identify revisions. Circle and label revisions, or draw the revisions using a heavier line weight than used for the existing and background.

When a building feature, cable tray, conduit, or circuit continues on to another drawing, reference the continuation drawing at the point of continuation. Show reference column and row numbers for clarity.

Indicate room names/numbers and include furniture layouts on all plan view drawings. Identify all offices intended to be occupied by more than one person.

Coordinate designs with reflected ceiling plans noting locations of soffits, beam pockets, skylights, etc.

On new buildings, building addition and total renovation projects, evaluate the use of aluminum cables in lieu of copper for feeder circuits No. 1 AWG and larger only. On partial renovation projects, match the existing cable type. Note that chiller manufacturers will not allow the use of aluminum cables to feed chiller VSDs or starters.

- Provide two cable and conduit sizing charts on the drawings, one for copper cables and one for aluminum cables.
- Include the aluminum cable technical and installation requirements contained in Master Specification 260513. Include Standard Detail 16120013 on the drawings.
- After completion of construction, verify the as-built drawings identify where aluminum conductor cables were installed.

Show the wire and conduit sizes for every feeder circuit on the riser and one-line diagrams.

Show wire and conduit sizes on the plan drawings for any circuit other than 20 amperes, single phase. Show multi-wire feeder and branch circuits requiring separate or oversized neutrals. A general note is adequate to define wire and conduit sizes for 20-ampere single phase circuits and to specify shared neutrals.

Show bus amperes, number of phases and wires, breaker/starter/fused switch/fuse sizes, and AIC ratings for all unit substations, switchboards, panels, MCC's, etc.

Specify the mounting heights of electrical devices. Indicate if the devices are flush or surface mounted. Indicate if raceways are exposed or concealed. Show 4" high minimum concrete housekeeping pads for

floor-mounted equipment.

Show Contractor furnished electrical equipment and control wiring on the plan drawings. Include equipment required by the NEC such as motor disconnect switches if not provided by others, and include control wiring required for equipment operation if not provided by others. Do not rely solely on specification statements or general drawing notes to identify Contractor scope. Provide sufficient information so that quantities can be determined easily.

Specifications

Number specification sections in accordance with the CSI specification numbering system.

Use the U-M Master Specification sections applicable to the project. Turn on hidden text, follow the hidden text editor's notes and edit the sections to make them project specific.

Eliminate from general specifications the requirements that do not apply to the project.

Shop Drawing Review

The Review Contractor submitts shop drawings and product literature. Approve submittals that comply with the contract documents, and mark up or reject submittals that do not comply. Approved submittals shall include adequate information to prove that the proposed products comply fully with the contract documents. Each submittal shall be marked to indicate the specific models, sizes, types and options being provided. Submittals not so marked shall be rejected.

Testing

Specify testing in accordance with Design Guideline 260800, Electrical Acceptance Tests. Request approval before specifying testing beyond what is listed in Design Guideline 260800.

Commissioning

Edit and insert Commissioning Master Specification 019100 or 019110 into the project specifications (unless an edited version will be provided by the U-M Commissioning Authority during CD design). Refer to this specification section rather than specifying commissioning requirements in the other specification sections.

Operation and Maintenance Manuals

Edit and insert Master Specification 017823 into the project specifications. Refer to this specification section rather than specifying O&M manual requirements in the other specification sections.

Review and approve Contractor submitted operation and maintenance manuals. These manuals shall be marked to indicate the specific models, sizes, types and options of the systems and equipment that will be provided. Manuals not so marked shall be rejected.

Training

Refer to Specification 019100 or 019110 when specifying Owner training requirements. Training shall not take place until the Owner's Personnel have been given 2 weeks to review the approved Operation and Maintenance Manuals. The Contractor shall notify the Project Manager 3 working days in advance of training sessions.

Record Drawings

Review and approve Contractor submitted as-built information and provide the information to the University in accordance with Design Guideline 2.4. The drawings shall show the locations of equipment, light fixtures, switches, receptacles and junction boxes, riser information, the sizes of conduits and conductors, circuit numbers, and deviations from the design. Buried, embedded and concealed primary and feeder conduits shall be dimensioned from permanent building features.

Products

Specify products that conform to the applicable standards of the American National Standards Institute (ANSI), the Institute of Electrical and Electronic Engineers (IEEE), the National Electrical Manufacturers Association (NEMA) and the National Fire Protection Association (NFPA).

Specify that products be listed or labeled by a Nationally Recognized Testing Laboratory. When components are combined to form a major assembly, the entire assembly shall be listed or labeled.

Specify multiple manufacturers from the Electrical Trades Preferred Manufacturers List when multiple manufacturers produce products meeting the project requirements.

Do not use the term "Or Equal" or any similar language to specify products or services.

Specify products that are known to have been used with success elsewhere. Do not specify newly developed or unproven products.

When designing new electrical systems, specify major power distribution equipment shall be from one manufacturer. When designing renovations, match the existing equipment where practical.

Specify that equipment and materials shall be provided from the manufacturers specified. Substitutions for specified products shall be acceptable only if proposed and approved in writing before the project is awarded.

During Contractor shop drawing submittal review, approve only those submittals which comply with the project specifications.

Execution

Ensure the following additional Contractor actions are specified in the contract documents.

Temporary Services

Temporary lighting and power shall be provided as specified in the project's Supplemental General Conditions. Project design shall include investigation of proposed power sources, available capacities, and impact on end users. For UMHS projects, contractors shall coordinate temporary power sources with FPD.

Permanent electrical systems or equipment used during construction shall be replaced or cleaned and fully refurbished prior to acceptance by the University.

Lamp and Ballast Recycling

The Contractor shall recycle lamps and ballasts. Insert verbatim into the project specifications the recycling requirements contained in Master Specification 260500.

Quality Assurance

Specify the Contractor shall contact the Owner's Code Inspection Department at (734) 764-2457 before the start of the project to arrange for periodic inspections. Do not specify code inspections by the city of Ann Arbor or any other jurisdiction prior to coordination with the Owner's Code Inspection Department.

Specify that electrical systems, equipment and materials shall be tested by an independent testing agency prior to final acceptance of the work. Acceptance tests shall be performed in accordance with applicable codes, standards and manufacturers' instructions. The contractor shall provide written test reports, signed and dated, for all tests prior to acceptance of the electrical equipment by the Owner.

Warranty

Specify that electrical work shall be guaranteed for a period of one year from the date of acceptance of the project by the University. A manufacturer's warranty beginning upon equipment receipt or startup shall be extended to one year from final project acceptance. A manufacturer's warranty in excess of one year shall remain in effect for its entire time period.