

# STATE UNIVERSITY CONSTRUCTION FUND PROGRAM DIRECTIVES

DIRECTIVE 16-1

Issue date: October 2015

## ELECTRICAL POWER SYSTEM STUDIES

*The basic fee covers the design and construction administration services related to providing electrical power system studies. Unless included in the lump sum fee or the Schedule B of the Consultant's Agreement, the services and fees related to providing the electrical power system studies as described in this Directive may be provided through extra compensation when approved by the Fund.*

### 1. General

Electrical Power System Studies consisting of (1) Short Circuit Study, (2) Protective Device Coordination Study, and (3) Arc Flash Study, shall be performed during both Design and Construction. The Studies shall be performed utilizing recognized computer software, such as SKM or ETAP, and be consistent with the latest engineering standards.

### 2. Design Phase (SUCF Consultant)

The SUCF Consultant shall:

- a. Provide a system One Line Diagram at Design Manual, as detailed in Section 5, defining the portion of the electrical power system to be included in the Studies.
- b. Provide the Studies, as described in Sections 6, 7, & 8, no later than with the Pre-Bid submission.
- c. Provide Electrical Specifications for the Studies to be provided by the Contractor.
- d. Provide a copy of the study report to the Contractor after contract award for use by the Contractor's selected engineer performing the Studies during construction.
- e. During construction, review and provide comments on the study report issued by the Contractor's engineer at the time of equipment submissions.
- f. Provide a copy of the study report issued by the Contractor to SUCF and the campus for informational purposes.

### 3. Construction Phase (Contractor Consultant)

- a. The Contractor shall provide the Electrical Power System Studies, as described below during the submittal phase of Construction along with related equipment submittals.

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- b. The Contractor shall resubmit the study report upon rejection of either related equipment submittals or the study report by the SUCF Consultant.
- 4. Qualifications: The Studies shall be performed and certified (stamped) by a licensed Professional Engineer having a minimum of 5 years' experience in performing such Studies.
- 5. Distribution System One Line Diagram: The SUCF Design Consultant shall develop a software generated Power Distribution System One Line Diagram to be used as the basis for the Studies for both Design and Construction Phases. Include the following information:
  - a. Short-circuit available at the power supply side of the medium voltage feeder(s) to the building substation transformer.
  - b. Medium voltage feeder breaker(s) phase and ground overcurrent relays and related current transformer ratios for the feeders supplying power to the building substation transformer.
  - c. Building substation transformer primary overcurrent protection.
  - d. Building substation transformer. Include information on:
    - 1) Base and any higher kVA ratings.
    - 2) Transformer winding configuration.
    - 3) Transformer primary and secondary rated voltages.
    - 4) Transformer design or nameplate %Z.
  - e. Building substation transformer secondary main and secondary main distribution equipment. Include information on breaker amp frame and amp trip ratings.
  - f. Any medium and low voltage cables. Include:
    - 1) Conductor quantities per phase.
    - 2) Conductor material (copper or aluminum) and sizes.
    - 3) Cable lengths.
    - 4) Conduit construction (magnetic or non-magnetic).
  - g. Generators. Include:
    - 1) kVA and power factor.
    - 2) Voltage rating.
    - 3)  $%X''_d$  (% subtransient reactance).

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- h. Automatic transfer switches, including amp ratings.
  - i. Motors 50 HP or greater.
  - j. Panelboards and switchboards. Include:
    - 1) Voltage ratings.
    - 2) Available Interrupting Capacity (AIC).
    - 3) Amp ratings.
    - 4) Main overcurrent protection, if any.
  - k. Low voltage transformers. Include:
    - 1) kVA rating.
    - 2) Winding configurations.
    - 3) Voltage ratings.
    - 4) Design or nameplate %Z.
  - l. Alternate operating modes that could affect short circuit levels, protective device coordination, or arc flash energy levels, such as:
    - 1) Operation under generator power.
    - 2) Operation under an alternate primary source of power.
    - 3) Key or electric interlocks.
6. Short Circuit Study
- a. Include 3-phase and phase-to-ground (for grounded systems) fault current calculations for all possible modes of operation anticipated to produce the highest levels of short circuit currents.
  - b. Incorporate appropriate short circuit contributions from all sources, in order to produce the maximum expected short circuit levels equipment may be subjected to during a fault.
  - c. Provide a written explanation of all assumptions made in order to perform the short circuit calculations and a summary of short circuit results.
  - d. Tabulate calculated short circuit duties against all new and existing equipment ratings and identify any equipment whose short circuit ratings are exceeded.
  - e. Provide computer printouts of system data used for short circuit calculations and calculated short circuit currents.

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7. Protective Device Coordination Study: Provide a protective device coordination study for purposes of the development of recommended settings for new and, possibly, existing protective devices for the power distribution system as referenced on the One Line Diagram.
  - a. Include evaluations and recommended settings for both overcurrent and other protective devices, such as reverse power and undervoltage relays, that, although not strictly related to overcurrents, must be properly set for added system coordination and protection.
  - b. Include appropriate compromises between system protection and service continuity with system protection and service continuity considered to be of equal importance.
  - c. Provide a sufficient number of computer generated time vs. current log-log plots to indicate the degree of system protection and coordination by displaying the time-current characteristics of series connected overcurrent devices. Time-current plots shall be extended to the maximum fault current to which each overcurrent protective device plotted is expected to operate.
  - d. The log-log plots shall include the following pertinent benchmarks:
    - 1) Transformer damage curves.
    - 2) Transformer full load amps.
    - 3) Cable damage curves.
    - 4) Transformer inrush.
    - 5) Motor starting curves.
    - 6) Maximum short circuit for which each overcurrent protective device must respond.
    - 7) Generator fault current decay curve.
  - e. Represent currents at an appropriate system voltage, preferably the voltage at which the majority of protective devices plotted operate.
  - f. Provide a partial one line diagram depicting the location of all protective devices plotted with devices labeled on the one line.
  - g. Provide device identification by manufacturer, model, range of settings, and recommended settings for each device plotted.
  - h. Provide a table summary of all adjustable protective devices and their recommended, or existing settings. Clarify what settings are new vs. existing.
  - i. Include a discussion describing the intended approach to protective device coordination. Describe:
    - 1) Any special considerations in developing the recommended settings.

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- 2) Assumptions made in performing the study.
  - 3) An evaluation of the degree of system protection and service continuity.
  - 4) Recommendations for addressing system protection or device coordination deficiencies.
8. Arc Flash Study: The Arc Flash Study shall be performed in compliance with latest edition of IEEE Standard 1584, the IEEE *Guide for Performing Arc Flash Calculations* and shall calculate Arc Flash Incident Energy (AFIE) levels and flash protection boundary distances and aid in the preparation of Arc Flash Warning labels in conformance with NFPA 70 and NFPA 70E requirements.
- a. The Arc Flash Study shall be performed in conjunction with the Short Circuit Study and the Protective Device Coordination Study.
  - b. Results of the Study shall be submitted in tabular form, and shall include equipment evaluated, location, bolted fault and arcing fault current levels, flash protection boundary distances, personal-protective equipment classes and AFIE levels.
  - c. The Study shall be performed under worst-case Arc Flash conditions, and the Report shall describe, when applicable, how these conditions differ from worst-case bolted fault conditions.
  - d. The Arc Flash Study shall include recommendations for reducing AFIE levels and enhancing worker safety.
9. Electrical Power System Studies Report during Design: The Report shall be issued in electronic pdf format by the SUCF Consultant for review by SUCF and the Campus and summarize the results of the Electrical Power System Studies consisting of the (1) Short Circuit Study, (2) Protective Device Coordination Study, and (3) Arc Flash Study.
- a. The Report shall include all previously described documentation under each of the Studies performed.
  - b. A Final report shall be issued incorporating any requested changes by SUCF or the Campus.
10. Electrical Power System Studies Report during Construction: The Report shall be provided by the Contractor and prepared by engineers from one of the major distribution equipment manufacturers providing new equipment for the Project.
- a. The Study Report shall be provided at the same time as equipment submittals. Additional copies of the Study Report in electronic form shall be distributed to the Campus and SUCF for review.
  - b. Submittal approvals will include an approval by the SUCF Consultant of the submitted Study Report. A revised Study Report shall be resubmitted should either the equipment or the Report submitted need revision.

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- c. The Contractor shall utilize the recommended settings in the Protective Device Coordination Study of the Study Report issued for protective device adjustments and settings.
- d. The Contractor shall provide printed combination arc flash and shock hazard warning equipment labels in compliance with NFPA 70, NFPA 70E, and ANSI Z535.4 and apply such labels to power distribution equipment as directed by the SUCF Consultant. The arc flash protection portion of the labels shall include the following information:
  - 1) Nominal system voltage.
  - 2) Arc flash boundary.
  - 3) Available incident energy and the corresponding working distance.
  - 4) Arc Flash PPE Category.
  - 5) Minimum arc rating of clothing.
  - 6) Location and name of equipment.
  - 7) A statement reading: "WARNING: Changes in equipment settings or system configuration will invalidate the calculated values and PPE requirements."

The shock hazard portion of the warning labels shall include the following information:

- 1) The shock hazard voltage with covers removed.
- 2) Limited Approach Boundary in inches.
- 3) The Restricted Approach Boundary in inches.
- 4) The Prohibited Approach Boundary in inches.

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