

## 26 05 73 POWER SYSTEMS STUDY: SIGNIFICANT (OR TOTAL) DELETION OF EXISTING TEXT

Delete the following current section in its entirety (deletions are shown struck through).

### ~~.01 General~~

- ~~A. Short circuit Studies, Protective Device Evaluation Studies, Protective Device Coordination Studies and Flash Protection Studies shall be performed by the distribution equipment manufacturer or an independent firm currently involved in high and low voltage power system evaluation. The study shall be performed, stamped and signed by a registered professional engineer in the State of Pennsylvania. Credentials of the individual(s) performing the study and the background of the firm shall be submitted to the Engineer for approval prior to start of the work. A minimum of five (5) years experience in power system analysis is required for the individual in charge of the project.~~
- ~~B. The studies shall be submitted to Engineering Services prior to receiving final approval of the distribution equipment shop drawings and prior to release of equipment for manufacture. If formal completion of the studies may cause delay in equipment manufacture, approval from Engineering Services may be obtained for a preliminary submittal of sufficient study data to ensure that the selection of device ratings and characteristics will be satisfactory.~~
- ~~C. The studies shall include all portions of the electrical distribution system from the normal power incoming primary source or sources, the emergency and standby power source or sources, down to and including all panels and distribution equipment in the distribution system, and as required to comply with NFPA 70E. Normal system connections and those which result in maximum fault and/or are flash conditions, shall be adequately covered in the study.~~
- ~~D. The firm performing the study shall demonstrate capability and experience to provide assistance during start up, as required.~~
- ~~E. The power system studies are required to confirm the adequacy of the ratings of all electrical system components and proper coordination settings of all circuit breakers. These studies shall not be used as a basis to compromise the electrical system and do not imply that short circuit ratings of distribution equipment and devices may be lower than those indicated on the drawings or specified herein.~~
- ~~F. The power distribution equipment manufacturer shall carry in their bid to the Electrical Subcontractor, a sufficient allowance to provide modifications to the equipment, if necessary, based on the results of the studies identified herein.~~
- ~~G. Perform all studies using SKM Systems Analysis software.~~
- ~~H. Submit an electronic copy of the final study in the format used to perform the study.~~

### ~~.02 Coordination Study~~

- ~~A. Perform coordination study to support the selection of instrument transformer ratios, protective relay characteristics and settings, fuse ratings, low-voltage circuit breaker ratings, characteristics, and settings.~~
- ~~B. The study shall demonstrate that the protective devices as selected and set will ensure that the minimum unfaulted load is interrupted when protective devices isolate a fault or overload anywhere in the system while satisfactory protection is provided for equipment against overloads, and short circuits are interrupted as rapidly as possible.~~
- ~~C. Provide technical characteristics, manuals, time characteristic curves, etc. for each protective device along with the calculations used in preparing the study to Engineering Services. Report shall be in paper as well as editable electronic format. Electronic copy shall be SKM Systems Analysis software.~~

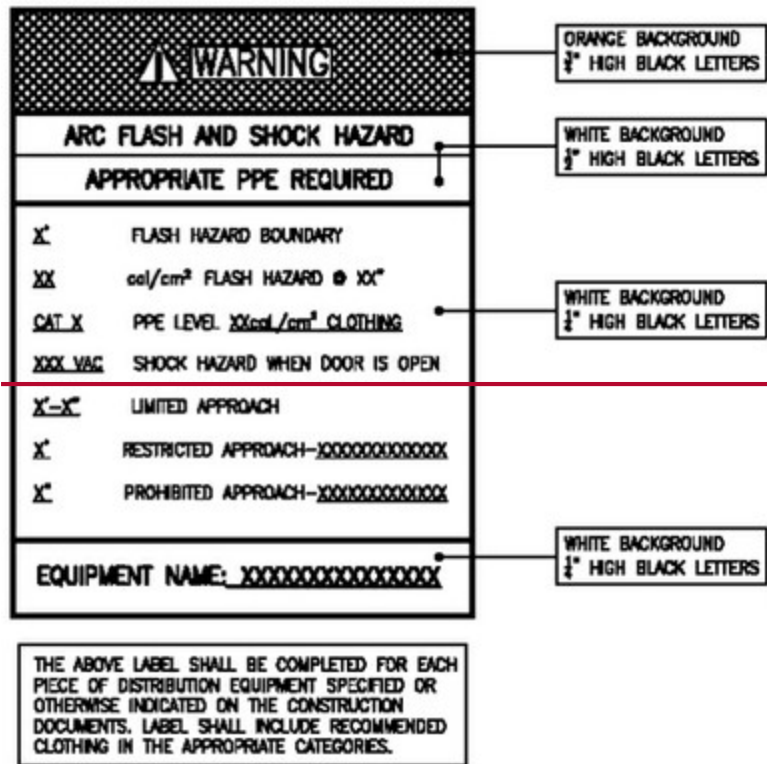
### ~~.03 Fault Current Study~~

- ~~A. The short-circuit current available on the primary feeder will be given to the Professional by Engineering Services.~~
- ~~B. Calculate the maximum available short-circuit current in amperes rms symmetrical at circuit breaker positions of the electrical power distribution system. The calculation shall be for a current immediately after initiation and for a three-phase bolted short circuit at each of the following:
  - ~~1. Switchgear and switchboard bus.~~
  - ~~2. Medium-voltage controller.~~
  - ~~3. Motor control center.~~
  - ~~4. Distribution panelboard.~~
  - ~~5. Branch circuit panelboard.~~
  - ~~6. Other equipment as required.~~~~

### ~~.04 NFPA 70E (Arc Flash Analysis) Study~~

- ~~A. Calculate Arc Flash Incident Energy (AFIE) levels and flash protection boundary distances.~~
- ~~B. The Arc Flash Hazard Analysis shall be performed in conjunction with a short-circuit analysis and a time-current coordination analysis.~~
- ~~C. Results of the Analysis shall be submitted in tabular form, and shall include device or bus name, bolted fault and arcing fault current levels, flash protection boundary distances, personal protective equipment classes and AFIE levels.~~
- ~~D. The analysis shall be performed under worst-case Arc Flash conditions, and the final report shall describe, when applicable, how these conditions differ from worst-case bolted fault conditions.~~
- ~~E. The Arc Flash Hazard Analysis shall be performed in compliance with IEEE Standard 1584 (latest edition), the IEEE *Guide for Performing Arc-Flash Calculations*.~~
- ~~F. The Arc Flash Hazard Analysis shall include recommendations for reducing AFIE levels and enhancing worker safety.~~

- ~~G. The Arc Flash Hazard Analysis shall include the proper settings for arc flash reduction maintenance switch(es), if specified on the project. Provide settings to avoid nuisance tripping.~~
- ~~H. The proposed vendor shall demonstrate experience with Arc Flash Hazard Analysis by submitting names of at least ten actual Arc Flash Hazard Analyses it has performed in the past year.~~
- ~~I. The proposed vendor shall demonstrate capabilities in providing equipment, services, and training to reduce Arc Flash exposure and train workers in accordance with NFPA 70E and other applicable standards.~~
- ~~J. The proposed vendor shall demonstrate experience in providing equipment labels in compliance with NEC 2002 section 110 and ANSI Z535.4 to identify AFIE and appropriate Personal Protective Equipment classes.~~
- ~~K. Engineer shall specify or provide study on all major electrical distribution equipment and downstream distribution and utilization equipment. This shall include, but not be limited to:
  - ~~1. Substation(s), switchgear, and switchboards~~
  - ~~2. Distribution panelboards~~
    - ~~— Lighting and appliance panelboards~~
  - ~~3. Motor control centers~~
  - ~~3. Disconnect switches~~
  - ~~3. Controller equipment such as variable frequency/adjustable speed drives~~
  - ~~3. Fuses and circuit breakers~~
  - ~~3. Rotating equipment~~
  - ~~3. Batteries~~
  - ~~4. Generator(s)~~
  - ~~4. Automatic transfer switches~~
  - ~~4. Feeders~~~~
- ~~K. Provide proper labeling per NFPA 70E on all noted equipment, including any hinged doors of rear accessible equipment. Coordinate study and labeling requirements with Engineering Services. Typical minimum label requirements shown below:~~



~~Label shall be orange and include the date of the study. Specify a second blue label to note arc reduction levels, when using arc flash reduction feature. Require manufacturer representative to provide a letter stating that they have visited the site and confirmed that the stickers have been applied in appropriate locations, per the approved Power System Study.~~

Replace with following text.

**.01 General**

- A. The short-circuit current available on the primary feeder will be given to the Professional by Engineering Services.
- B. The proposed vendor shall demonstrate capabilities in providing equipment, services, and training to reduce Arc-Flash exposure and train workers in accordance with NFPA 70E and other applicable standards.

**.02 Guide Specifications**

- A. Design Professional shall carefully review and edit the guideline specifications below, adapting them as needed to achieve application-specific, fully developed specifications for each project.
- B. These shall be edited using the process described in the instructions contained at the beginning of the document. Proposed modifications shall be reviewed with OPP Engineering Services.
- C. Finalized version shall be included in the project contract documents. Use of other specifications is not acceptable.
- D. The design professional shall utilize the sample arc flash labels and the content within as a baseline for the arc flash labels that are to be generated from the power study.

<u>Document</u>	<u>Version Date</u>	<u>Description</u>
<u>Power Study Guide Specification.docx</u>	<u>June 2016</u>	<u>University’s guide specification for Power Studies of electrical systems; to be used by the design professional.</u>
<u>Power Study Sample Arc Flash Labels</u> <u>PSU Standard Arc Flash Label Sample 1 (PDF)</u> <u>PSU Standard Arc Flash Label Sample 2 (PDF)</u>	<u>June 2016</u>	<u>Typical University Standard Arc Flash label for the Professionals’ use. The details provided are a baseline and it is the responsibility of the professional to design and develop complete labels that are acceptable.</u>

**END of revision**

**Update Commentary:**

Section was updated primarily for the following reasons:

- 1) Deleted old section and replaced with new section, which includes a new guide specification section and sample standard arc flash labels.*



## SECTION 260573 – POWER SYSTEM STUDY

Revise this Section by deleting and inserting text to meet Project-specific requirements.

This Section uses the term "Architect." Change this term to match that used to identify the design professional as defined in the General and Supplementary Conditions.

Verify that Section titles referenced in this Section are correct for this Project's Specifications; Section titles may have changed.

### *General Notes:*

- 1. This guide specification is intended to provide the Design Professional with a basic guideline of minimum OPP requirements.*
- 2. The guide specification shall be carefully reviewed and edited with respect to application-specific project requirements. Proposed modifications shall be reviewed with OPP Staff.*
- 3. Finalized version shall be included in the project contract documents.*

### *Editing Notes*

- 1. This OPP Guide specification must only be altered by notation (i.e. deleted text with strikethrough and additional text with double underline). This shall be accomplished by using Tools /Track Changes / Highlight Changes, and select "Track changes while editing" in MS Word or equivalent.*
- 2. The Review Submittal Specification section shall be provided in electronic form for OPP Review.*
- 3. Leave the following Note ("For Construction Document Review, Design Submittal") as part of the Review Submittal, to aid any Reviewer to understand WHY there are strikeouts and underlines. Also, leave any "DESIGNER NOTE" placed in this Guide Spec.*
- 4. AFTER comments are received from PSU and incorporated, the strikeouts and underlines shall be removed, and the REVIEWER NOTES deleted, before the spec is issued for Bidding.*

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

Retain or delete this article in all Sections of Project Manual.

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. All sections of the project manual are directly applicable to this specification section. Should a conflict arise between specification sections or between specifications and drawings and/or code requirements, the contractor shall notify the Architect/Engineer of the conflict in writing. If

direction is not provided prior to the submission of the bid, the contractor shall price the more extensive system.

## 1.2 SUMMARY

- A. Section includes computer-based, power systems study with the following sections:
  - 1. Overcurrent protective device coordination study to determine overcurrent protective devices and to determine overcurrent protective device settings for selective tripping.
  - 2. Fault current study to determine the minimum interrupting capacity of circuit protective devices.
  - 3. Arc-Flash study to determine the arc-flash hazard distance and the incident energy to which personnel could be exposed during work on or near electrical equipment.

## 1.3 DEFINITIONS

Retain terms that remain after this Section has been edited for a project.

- A. Existing to Remain: Existing items of construction that are not to be removed and that are not otherwise indicated to be removed, removed and salvaged, or removed and reinstalled.
- B. One-Line Diagram: A diagram which shows, by means of single lines and graphic symbols, the course of an electric circuit or system of circuits and the component devices or parts used therein.
- C. Protective Device: A device that senses when an abnormal current flow exists and then removes the affected portion from the system.
- D. SCCR: Short-circuit current rating.
- E. Service: The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.

## 1.4 ACTION SUBMITTALS

- A. Product Data: For computer software program to be used for studies.
- B. Other Action Submittals: Submittals **shall** be in digital form. Upload electronic submittals using Owner's web-based file transfer tool
  - 1. Power system study input data, including completed computer program input data sheets.
  - 2. Study and equipment evaluation reports; Signed, dated, and sealed by a qualified professional engineer.
    - a. Submit study report for action prior to receiving final approval of the distribution equipment submittals. If formal completion of studies will cause delay in equipment manufacturing, obtain approval from Owner/Engineer for preliminary submittal of sufficient study data to ensure that the selection of devices and associated characteristics is satisfactory.



3. Revised single-line diagram, reflecting field investigation results and results of power system study

#### 1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For [**Coordination Study Specialist**] [**Field Adjusting Agency**].
- B. Product Certificates: For overcurrent protective device coordination study software (short-circuit and arc-flash hazard studies), certifying compliance with IEEE 399, IEEE1584, and NFPA 70E.

#### 1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For the overcurrent protective devices to include in emergency, operation, and maintenance manuals.
  1. Include the following:
    - a. The following parts from the Power System Study Report:
      - 1) One-line diagram in .pdf and .dwg format.
      - 2) Complete power system model in SKM format.
        - a) Provide three (3) hard copies of the system model.
        - b) The contractor is required to provide the study project files to the Owner in electronic format.
      - 3) Time-current coordination curves.
    - b. Power system data.
- B. Maintenance procedures according to requirements in NFPA 70E shall be provided in equipment manuals.

#### 1.7 QUALITY ASSURANCE

- A. Coordination Study Specialist Qualifications: Professional engineer in charge of performing the study and documenting recommendations, licensed in the state where Project is located and has a minimum of 5 years' experience utilizing the program. All elements of the study shall be performed under the direct supervision and control of this professional engineer.
- B. Field Adjusting Agency Qualifications: An independent agency, with the experience and capability to adjust overcurrent devices, assist with start-up as required, and to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

## PART 2 - PRODUCTS

### 2.1 COMPUTER SOFTWARE DEVELOPERS

- A. Software Developers: Subject to compliance with requirements, provide software by the following:
  - 1. SKM Systems Analysis, Inc
- B. Comply with IEEE 242, IEEE 399, IEEE 1584, and NFPA 70E.
- C. Analytical features of device coordination study computer software program shall have the capability to calculate "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.
- D. Computer software program shall be capable of plotting and diagramming time-current-characteristic curves as part of its output. Computer software program shall report device settings and ratings of all overcurrent protective devices and shall demonstrate selective coordination by computer-generated, time-current coordination plots.
  - 1. Optional Features:
    - a. Arcing faults.
    - b. Simultaneous faults.
    - c. Explicit negative sequence.
    - d. Mutual coupling in zero sequence.

### 2.2 PROTECTIVE DEVICE COORDINATION STUDY REPORT CONTENTS

- A. Executive summary shall include deficiencies and recommendations as found by the study.
- B. Study descriptions, purpose, basis and scope. Include case descriptions, definition of terms and guide for interpretation of the computer printout.
- C. One-line diagram, showing the following:
  - 1. Protective device designations, ampere ratings, and short-circuit (AIC) rating of equipment.
  - 2. Cable size and lengths.
  - 3. Transformer kilovolt ampere (kVA) and voltage ratings.
  - 4. Motor and generator designations and kVA ratings.
  - 5. Switchgear, switchboard, motor-control center, and panelboard designations.
  - 6. Available fault current at each piece of equipment.
- D. Study Input Data: As described in "Power System Data" Article.
- E. Short-Circuit Study Report: Present information in table format of report summary with nameplate and calculated values and compare with percentages.
  - 1. Protective Device Evaluation:

- a. Evaluate equipment and protective devices and compare to short-circuit ratings.
  - b. Tabulations of circuit breaker, fuse, and other protective device ratings versus calculated short-circuit duties.
  - c. For 600-V overcurrent protective devices, ensure that interrupting ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.
  - d. For devices and equipment rated for asymmetrical fault current, apply multiplication factors listed in the standards to 1/2-cycle symmetrical fault current.
  - e. 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 current.
2. Short-Circuit Study Output:
- a. Low-Voltage Fault Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
    - 1) Voltage.
    - 2) Calculated fault-current magnitude and angle.
    - 3) Fault-point X/R ratio.
    - 4) Equivalent impedance.
  - b. Momentary Duty Report:
    - 1) Voltage.
    - 2) Calculated symmetrical fault-current magnitude and angle.
    - 3) Fault-point X/R ratio.
    - 4) Calculated asymmetrical fault current:
      - a) Based on fault-point X/R ratio.
      - b) Based on calculated symmetrical value multiplied by 1.6.
      - c) Based on calculated symmetrical value multiplied by 2.7.
  - c. Interrupting Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
    - 1) Voltage.
    - 2) Calculated symmetrical fault-current magnitude and angle.
    - 3) Fault-point X/R ratio.
    - 4) No AC Decrement (NACD) ratio.
    - 5) Equivalent impedance.
    - 6) Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a symmetrical basis.
    - 7) Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a total basis.
- F. Protective Device Coordination Study:
1. Report recommended settings of protective devices, ready to be applied in the field (may be provided in table format). Use manufacturer's data sheets for recording the recommended setting of overcurrent protective devices when available.
    - a. Phase and Ground Relays:

- 1) Device tag.
  - 2) Relay current transformer ratio and tap, time dial, and instantaneous pickup value.
  - 3) Recommendations on improved relaying systems, if applicable.
- b. Circuit Breakers:
- 1) Adjustable pickups and time delays (long time, short time, ground).
  - 2) Adjustable time-current characteristic.
  - 3) Adjustable instantaneous pickup.
  - 4) Recommendations on improved trip systems, if applicable.

Low-voltage fuse classes are defined in UL 248-1 through UL 248-18. Medium-voltage fuses are defined in IEEE C37.40.

- c. Fuses: Show current rating, voltage, and class.
- G. Time-Current Coordination Curves: 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 sets of curves for the switching schemes and for emergency periods where the power source is local generation. Show the following information:
1. Device tag and title, one-line diagram with legend identifying the portion of the system covered.
  2. Terminate device characteristic curves at a point reflecting maximum symmetrical or asymmetrical fault current to which the device is exposed.
  3. Identify the device associated with each curve by manufacturer type, function, and, if applicable, tap, time delay, and instantaneous settings recommended.
  4. Plot the following listed characteristic curves, as applicable:
    - a. Power utility's overcurrent protective device.
    - b. Medium-voltage equipment overcurrent relays.
    - c. Medium- and low-voltage fuses including manufacturer's minimum melt, total clearing, tolerance, and damage bands.
    - d. Low-voltage equipment circuit-breaker trip devices, including manufacturer's tolerance bands.
    - e. Transformer full-load current, magnetizing inrush current, and ANSI through-fault protection curves.
    - f. Cables and conductors damage curves.
    - g. Ground-fault protective devices.
    - h. Motor-starting characteristics and motor damage points.
    - i. Generator short-circuit decrement curve and generator damage point.
    - j. The largest feeder circuit breaker in each motor-control center and panelboard.
  5. Provide adequate time margins between device characteristics such that selective operation is achieved per IEEE 242.
  6. Comments and recommendations for system improvements.
- H. Arc-Flash Study Output:

1. Interrupting Duty Report: Provide in table format based on measures taken to reduce incident energy. Provide normal, emergency, and reduced energy let-through settings for each device. Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
  - a. Voltage.
  - b. Calculated symmetrical fault-current magnitude and angle.
  - c. Fault-point X/R ratio.
  - d. No AC Decrement (NACD) ratio.
  - e. Equivalent impedance.
  - f. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a symmetrical basis. Provide worst case value.
  - g. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a total basis. Provide worst case value.

I. Incident Energy and Flash Protection Boundary Calculations:

1. Arcing fault magnitude.
2. Protective device clearing time.
3. Duration of arc.
4. Arc-flash boundary.
5. Working distance.
6. Incident energy.
7. Hazard risk category.
8. Recommendations for arc-flash energy reduction.

J. Fault study input data, case descriptions, and fault-current calculations including a definition of terms and guide for interpretation of the computer printout.

### 2.3 ARC-FLASH WARNING LABELS

- A. Comply with requirements in Section 260553 "Identification for Electrical Systems." Produce a 3.5-by-5-inch thermal transfer label of high-adhesion polyester for each work location included in the analysis.
- B. The label shall have an orange header with the wording, "WARNING, ARC-FLASH HAZARD," and shall include the following information taken directly from the arc-flash hazard analysis:
  1. Location designation and fed from location
  2. Nominal voltage.
  3. Flash protection boundary (Restricted and Limited).
  4. Incident energy.
  5. Working distance.
  6. Engineering report number, Engineering Company Name, revision number, and issue date.
- C. Labels shall be machine printed, with no field-applied markings.

1. For equipment with separate “maintenance mode” settings, a separate Arc Flash label shall be installed. “Maintenance mode” labels shall be printed in blue.
2. Equipment with incident energy levels above 40 cal, a red “Danger” label shall be installed per requirements in Section 260553 “Identification for Electrical Systems.”

## PART 3 - EXECUTION

### 3.1 EXAMINATION

This article lists data needed to conduct the study. Delete data already shown on the one-line diagram; add data that should be considered in the study results.

- A. Obtain all data necessary for the conduct of the study.
  1. Verify completeness of data supplied on the one-line diagram. Call any discrepancies to the attention of Owner.
  2. For equipment provided that is Work of this Project, use characteristics submitted under the provisions of action submittals and information submittals for this Project.
  3. For [**relocated**] equipment [**and**] that [**which**] is existing to remain, obtain required electrical distribution system data by field investigation and surveys, conducted by qualified technicians and engineers. The qualifications of technicians and engineers shall be qualified as defined by NFPA 70E.
- B. Gather and tabulate the following input data to support the short-circuit study. Comply with recommendations in IEEE 551 as to the amount of detail that is required to be acquired in the field. Field data gathering shall be under the direct supervision and control of the engineer in charge of performing the study, and shall be by the engineer or its representative who holds NETA ETT Level III certification or NICET Electrical Power Testing Level III certification approved by owner.
  1. Product Data for Project's overcurrent protective devices involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
  2. Obtain electrical power utility impedance at the service.
  3. Power sources and ties.
  4. Full-load current of all loads.
  5. Voltage level at each bus.
  6. For transformers, include kVA, primary and secondary voltages, connection type, impedance, X/R ratio, taps measured in percent, and phase shift.
  7. For circuit breakers and fuses, provide manufacturer and model designation. List type of breaker, type of trip, SCCR, current rating, and breaker settings.
  8. Generator short-circuit current contribution data, including short-circuit reactance, rated kVA, rated voltage, and X/R ratio.
  9. Busway manufacturer and model designation, current rating, impedance, lengths, and conductor material.
  10. Motor horsepower and NEMA MG 1 code letter designation.
  11. Low-voltage cable sizes, lengths, number, conductor material, and conduit material (magnetic or nonmagnetic).

12. Medium-voltage cable sizes, lengths, conductor material, and cable construction and metallic shield performance parameters.
- C. Examine Project overcurrent protective device submittals for compliance with electrical distribution system coordination requirements and other conditions affecting performance. Devices to be coordinated are indicated on Drawings.
1. Proceed with coordination study only after relevant equipment submittals have been assembled. Overcurrent protective devices that have not been submitted and approved prior to coordination study may not be used in study.

### 3.2 LOAD-FLOW AND VOLTAGE-DROP STUDY

- A. Perform a load-flow and voltage-drop study to determine the steady-state loading profile of the system. Analyze power system performance two times as follows:
1. Determine load-flow and voltage drop based on full-load currents obtained in "Power System Data" Article.
  2. Determine load-flow and voltage drop based on 80 percent of the design capacity of the load buses.
  3. Prepare the load-flow and voltage-drop analysis and report to show power system components that are overloaded, or might become overloaded; show bus voltages that are less than as prescribed by NFPA 70.

### 3.3 SHORT-CIRCUIT STUDY

Note to designer: For preliminary studies, assume 10' of wire.

- A. Perform study following the general study procedures contained in IEEE 399.
- B. Calculate short-circuit currents according to IEEE 551.
- C. Base study on the device characteristics supplied by device manufacturer.
- D. The extent of the electrical power system to be studied is indicated on Drawings.
- E. Begin short-circuit current analysis at the service, extending down to the system overcurrent protective devices as follows:
  1. To normal system low-voltage load buses where fault current is 10 kA or less.

Retain first subparagraph below when authorities having jurisdiction do not require inclusion of all equipment.

2. Exclude equipment rated 240-V ac or less when supplied by a single transformer rated less than 125 kVA.
  3. <Insert description>.
- F. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project. Study all cases of system-switching configurations and alternate operations that could result in maximum fault conditions.

- G. The calculations shall include the ac fault-current decay from induction motors, synchronous motors, and asynchronous generators and shall apply to low- and medium-voltage, three-phase ac systems. The calculations shall also account for the fault-current dc decrement, to address the asymmetrical requirements of the interrupting equipment.
1. For grounded systems, provide a bolted line-to-ground fault-current study for areas as defined for the three-phase bolted fault short-circuit study.
- H. Calculate short-circuit duties for a three-phase bolted fault at each of the following:
1. Electric utility's supply termination point.
  2. Incoming switchgear.
  3. Unit substation primary and secondary terminals.
  4. Low-voltage switchgear.
  5. Motor-control centers.
  6. Control panels.
  7. Standby generators and automatic transfer switches.
  8. Branch circuit panelboards.
  9. Disconnect switches.
  10. **<Insert significant locations in the system>**.
- I. Short Circuit Evaluation:
1. Evaluate equipment and protective devices and compare to short-circuit ratings.
  2. Adequacy of switchgear, motor-control centers, and panelboard bus bars to withstand short-circuit stresses.
  3. Any application of series-rated devices shall be recertified, complying with requirements in NFPA 70.

### 3.4 PROTECTIVE DEVICE COORDINATION STUDY

- A. Comply with IEEE 242 for calculating short-circuit currents and determining coordination time intervals.
- B. Comply with IEEE 399 for general study procedures.
- C. The study shall be based on the device characteristics supplied by device manufacturer.
- D. The extent of the electrical power system to be studied is indicated on Drawings.
- E. Begin analysis at the service, extending down to the system overcurrent protective devices as follows:
1. To normal system low-voltage load buses where fault current is 10 kA or less.

Retain first subparagraph below when authorities having jurisdiction do not require inclusion of all equipment.

2. Exclude equipment rated 240-V ac or less when supplied by a single transformer rated less than 125 kVA.
3. **<Insert description>**.



- F. Transformer Primary Overcurrent Protective Devices:
  - 1. Device shall not operate in response to the following:
    - a. Inrush current when first energized.
    - b. Self-cooled, full-load current or forced-air-cooled, full-load current, whichever is specified for that transformer.
    - c. Permissible transformer overloads according to IEEE C57.96 if required by unusual loading or emergency conditions.
  - 2. Device settings shall protect transformers according to IEEE C57.12.00, for fault currents.
- G. Motor Protection:
  - 1. Select protection for low-voltage motors according to IEEE 242 and NFPA 70.
  - 2. Select protection for motors served at voltages more than 600 V according to IEEE 620.
- H. Conductor Protection: Protect cables against damage from fault currents according to ICEA P-32-382, ICEA P-45-482, and protection recommendations 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 manufacturers, SKM cable data, or from listed standards indicating conductor size and short-circuit current.
- I. Generator Protection: Select protection according to manufacturer's written recommendations and to IEEE 242.
- J. The study shall demonstrate that the protective devices as selected and set will ensure that the minimum unfaulted load is interrupted when protective devices isolate a fault or overload anywhere in the system while satisfactory protection is provided for equipment against overloads and short circuits are interrupted as rapidly as possible.

### 3.5 MOTOR-STARTING STUDY

- A. Perform a motor-starting study to analyze the transient effect of the system's voltage profile during motor starting. Calculate significant motor-starting voltage profiles and analyze the effects of the motor starting on the power system stability.
- B. Prepare the motor-starting study report, noting light flicker for limits proposed by IEEE 141, and <Insert applicable standards>, and voltage sags so as not to affect the operation of other utilization equipment on the system supplying the motor.

### 3.6 POWER SYSTEM DATA

- A. Obtain all data necessary for the conduct of the overcurrent protective device study.
  - 1. Verify completeness of data supplied in the cable schedule and one-line diagram on Drawings. Call discrepancies to the attention of Architect.

2. For new equipment, use characteristics submitted under the provisions of action submittals and information submittals for this Project.
  3. For existing equipment, whether or not relocated obtain required electrical distribution system data by field investigation and surveys, conducted by qualified technicians and engineers. The qualifications of technicians and engineers shall be qualified as defined by NFPA 70E.
- B. Gather and tabulate the following input data to support coordination study. The list below is a guide. Comply with recommendations in IEEE 551 for the amount of detail required to be acquired in the field. Field data gathering shall be under the direct supervision and control of the engineer in charge of performing the study, and shall be by the engineer or its representative who is approved by owner.
1. Short-circuit current at each system bus, three phase and line-to-ground as obtained from the Short-Circuit study completed prior.
  2. For relays, provide manufacturer and model designation, current transformer ratios, potential transformer ratios, and relay settings.
  3. Maximum demands from service meters.
  4. Data sheets to supplement electrical distribution system diagram, cross-referenced with tag numbers on diagram, showing the following:
    - a. Special load considerations, including starting inrush currents and frequent starting and stopping.
    - b. Transformer characteristics, including primary protective device, magnetic inrush current, and overload capability.
    - c. Motor full-load current, locked rotor current, service factor, starting time, type of start, and thermal-damage curve.
    - d. Generator thermal-damage curve.
    - e. Ratings, types, and settings of utility company's overcurrent protective devices.
    - f. Special overcurrent protective device settings or types stipulated by utility company.
    - g. Time-current-characteristic curves of devices indicated to be coordinated.
    - h. Manufacturer, frame size, interrupting rating in amperes rms symmetrical, ampere or current sensor rating, long-time adjustment range, short-time adjustment range, and instantaneous adjustment range for circuit breakers.
    - i. Manufacturer and type, ampere-tap adjustment range, time-delay adjustment range, instantaneous attachment adjustment range, and current transformer ratio for overcurrent relays.
    - j. Panelboards, switchboards, motor-control center ampacity, and SCCR in amperes rms symmetrical.
    - k. Identify series-rated interrupting devices for a condition where the available fault current is greater than the interrupting rating of the downstream equipment. Obtain device data details to allow verification that series application of these devices complies with NFPA 70 and UL 489 requirements.

### 3.7 ARC-FLASH HAZARD ANALYSIS

- A. Comply with NFPA 70E and its Annex D for hazard analysis study.
- B. Calculate maximum and minimum contributions of fault-current size for normal, emergency, and maintenance mode settings.

1. The minimum calculation shall assume that the utility contribution is at a minimum and shall assume no motor load.
  2. The maximum calculation shall assume a maximum contribution from the utility and shall assume motors to be operating under full-load conditions.
- C. Calculate the arc-flash protection boundary and incident energy at locations in the electrical distribution system where personnel could perform work on energized parts.
- D. Include medium- and low-voltage equipment locations, except equipment rated 240-V ac or less fed from transformers less than 125 kVA.
- E. Safe working distances shall be specified for calculated fault locations based on the calculated arc-flash boundary, considering incident energy of 1.2 cal/sq.cm.
- F. Incident energy calculations shall consider the accumulation of energy over time when performing arc-flash calculations on buses with multiple sources. Iterative calculations shall take into account the changing current contributions, as the sources are interrupted or decremented with time. Fault contribution from motors and generators shall be decremented as follows:
1. Fault contribution from induction motors should not be considered beyond three to five cycles.
  2. Fault contribution from synchronous motors and generators should be decayed to match the actual decrement of each as closely as possible (e.g., contributions from permanent magnet generators will typically decay from 10 per unit to three per unit after 10 cycles).
- G. Arc-flash computation shall include both line and load side of a circuit breaker as follows:
1. When the circuit breaker is in a separate enclosure.
  2. When the line terminals of the circuit breaker are separate from the work location.
- H. Base arc-flash calculations on actual overcurrent protective device clearing time. Cap maximum clearing time at two seconds based on IEEE 1584, Section B.1.2.
- I. Report shall include recommendations of reducing fault current levels and enhancing worker safety.
1. Provide arc-flash reduction maintenance settings if specified.

### 3.8 LABELING

- A. Apply arc-flash label(s) as required for 600-V ac, 480-V ac, and applicable 208-V ac panelboards and disconnects and for each of the following locations:
1. Motor-control center.
  2. Low-voltage switchboard.
  3. Switchgear.
  4. Medium-voltage switch.
  5. Control panel.
  6. Transformers (secondary compartment).

### 3.9 APPLICATION OF WARNING LABELS

- A. Install the arc-fault warning labels under the on-site supervision and control of the Arc-Flash Study Specialist.
- B. Prior to final printing of adhesive type labels. The study specialist must print paper copies of all labels for approval by Engineering Services. The study specialist shall field install the printed paper copies. Once paper copies have been installed, the study specialist shall have the labels verified by PSU Electrical Integrity crew. Upon approval by PSU Electrical Integrity crew and Engineering Services the study specialist shall print the final adhesive labels and field install in same locations as the printed labels.

### 3.10 FIELD ADJUSTING

- A. Testing and adjusting shall be by a full-time employee of the Field Adjusting Agency, who holds NETA ETT Level III certification or NICET Electrical Power Testing Level III certification or third party testing agency approved by owner.
  - 1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters. Perform NETA tests and inspections for all adjustable overcurrent protective devices.

END OF SECTION 260573

2. Fault contribution from synchronous motors and generators should be decayed to match the actual decrement of each as closely as possible (e.g., contributions from permanent magnet generators will typically decay from 10 per unit to three per unit after 10 cycles).
- G. Arc-flash computation shall include both line and load side of a circuit breaker as follows:
1. When the circuit breaker is in a separate enclosure.
  2. When the line terminals of the circuit breaker are separate from the work location.
- H. Base arc-flash calculations on actual overcurrent protective device clearing time. Cap maximum clearing time at two seconds based on IEEE 1584, Section B.1.2.
- I. Report shall include recommendations of reducing fault current levels and enhancing worker safety.
1. Provide arc-flash reduction maintenance settings if specified.

The "Power System Data" Article lists data needed to conduct the overcurrent protective device arc-flash study. Delete data already shown in the one-line diagram on Drawings or included in Section 260572 "Overcurrent Protective Device Short-Circuit Study" or Section 260573 "Overcurrent Protective Device Coordination Study." Add data that should be considered in the study results.

### 3.8 LABELING

- A. Apply arc-flash label(s) as required for 600-V ac, 480-V ac, and applicable 208-V ac panelboards and disconnects and for each of the following locations:
1. Motor-control center.
  2. Low-voltage switchboard.
  3. Switchgear.
  4. Medium-voltage switch.
  5. Control panel.
  6. Transformers (secondary compartment).

### 3.9 APPLICATION OF WARNING LABELS

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### 3.10 FIELD ADJUSTING

See Editing Instruction No. 5 in the Evaluations for data on Field Adjusting Agency qualifications.

- A. Testing and adjusting shall be by a full-time employee of the Field Adjusting Agency, who holds NETA ETT Level III certification or NICET Electrical Power Testing Level III certification or third party testing agency approved by owner.

Retain subparagraph below with one of last two paragraphs above. Revise to suit Project. Delete subparagraph if testing is performed by Owner-engaged testing and inspecting agency.

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters. Perform NETA tests and inspections for all adjustable overcurrent protective devices.

END OF SECTION 260573



# WARNING

Arc Flash and Shock Risk

Appropriate PPE Required

<b>8 in</b>	<b>Flash Hazard Boundary</b>
<b>0.33 cal/cm<sup>2</sup></b>	<b>Flash Hazard at <b>18 in</b></b>
<b>480 VAC</b>	<b>Shock Hazard when cover is removed</b>
<b>42 in</b>	<b>Limited Approach</b>
<b>12 in</b>	<b>Restricted Approach</b>


**Penn State**  
**09/28/15**

**University Park**  
**REV: 0 By: LJP**


Name or logo of company performing  
power study is required and should be  
located in this general area.

Device: AHU-2 Prot: AHU-02 BRK

 <b>DANGER</b>		
<b>NO SAFE PPE EXISTS</b>		
<b>ENERGIZED WORK PROHIBITED</b>		
107 cal/cm <sup>2</sup> 279 in	Incident Energy at 18 in Arc Flash Boundary	
480 VAC 00 42 in 12 in	Shock Hazard when cover is removed Glove Class Limited Approach Boundary Restricted Approach Boundary	
<b>Location:</b>		<b>HMDS (main)</b>
Protected by: MaxTripTime @2.0s		<b>NO RELT</b>
<p>Changes in equipment settings or system configuration may invalidate the calculated values shown on this label. To verify system data and for additional information, refer to the Arc Flash Hazard Analysis prepared by:</p>		
Company or name here.	CPSI# 13160	06/25/2015

 <b>WARNING</b>		
<b>Arc Flash and Shock Risk</b>		
<b>Appropriate PPE Required</b>		
0.20 cal/cm <sup>2</sup> 6 in	Incident Energy at 18 in Arc Flash Boundary	
480 VAC 00 42 in 12 in	Shock Hazard when cover is removed Glove Class Limited Approach Boundary Restricted Approach Boundary	
<b>Location:</b>		<b>HV-3</b>
Protected by: HVDP: 100A/FB: HV-3		<b>NO RELT</b>
<p>Changes in equipment settings or system configuration may invalidate the calculated values shown on this label. To verify system data and for additional information, refer to the Arc Flash Hazard Analysis prepared by:</p>		
Company or name here.	CPSI# 13160	06/25/2015

 <b>WARNING</b>		
<b>Arc Flash and Shock Risk</b>		
<b>Appropriate PPE Required</b>		
14 cal/cm <sup>2</sup> 79 in	Incident Energy at 18 in Arc Flash Boundary	
480 VAC 00 42 in 12 in	Shock Hazard when cover is removed Glove Class Limited Approach Boundary Restricted Approach Boundary	
<b>Location:</b>		<b>HMDS (distr.)</b>
Protected by: HMDS: 2500A/WPS: MAIN		<b>RELT OFF</b>
<p>Changes in equipment settings or system configuration may invalidate the calculated values shown on this label. To verify system data and for additional information, refer to the Arc Flash Hazard Analysis prepared by:</p>		
Company or name here.	CPSI# 13160	06/25/2015

 <b>WARNING</b>		
<b>Arc Flash and Shock Risk</b>		
<b>Appropriate PPE Required</b>		
4.4 cal/cm <sup>2</sup> 40 in	Incident Energy at 18 in Arc Flash Boundary	
480 VAC 00 42 in 12 in	Shock Hazard when cover is removed Glove Class Limited Approach Boundary Restricted Approach Boundary	
<b>Location:</b>		<b>HMDS (distr.)</b>
Protected by: PC-A: 1200A/HND: TIE		<b>RELT ON</b>
<p>Changes in equipment settings or system configuration may invalidate the calculated values shown on this label. To verify system data and for additional information, refer to the Arc Flash Hazard Analysis prepared by:</p>		
Company or name here.	CPSI# 13160	06/25/2015