PHYSICAL FACILITIES

2020 Consultant’s Handbook
Division 26 Electrical
0573.1 ARC Flash Hazard Analysis

1 Summary

1.1 Provide a complete Arc Flash Hazard Analysis for the project indicated in the accompanying RFP. The Analysis shall be performed:

- Independent of the construction project
- In concert with the A/E of record during the design and construction phases of the project.

1.2 When performed independent of a construction project.

1.2.1 The AFC (Arc Flash Consultant) is expected to survey the building, collect appropriate data and prepare reports as described in the RFP.

1.2.2 Recommendations to reduce Incident Energy levels shall be included in the draft report for review by Purdue. 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.

1.3 When performed in concert with the A/E of record during the design and construction phases of the project.

1.3.1 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.

2 Quality Assurance

2.1 Studies shall be prepared using Power Tools software by SKM Systems Analysis, Inc. updated to the most recent version.

2.2 Studies shall be signed and sealed by a Professional Engineer registered in the State of Indiana.

2.3 Studies shall be prepared per current applicable codes and standards.

2.4 Studies shall be based on systems designed and specified as “fully-rated” systems. “Series-rated” systems are not acceptable.

3 Safety and Security

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

3.2 All access to the project work site shall be coordinated through Purdue.

3.3 The AFC must submit a written request to Purdue University’s Arc Flash Coordinator assigned to the project if an outage is needed for the purpose of data collection.
## On-Site Data Gathering and Reporting

### 4.1 The following data shall be gathered and summarized:

<table>
<thead>
<tr>
<th>Item</th>
<th>Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Locations</td>
<td>Room number of all equipment that will require Arc Flash Hazard labels</td>
</tr>
<tr>
<td>Fuses</td>
<td>Manufacturer, Type, Amp rating, Short circuit rating, etc.</td>
</tr>
<tr>
<td>Circuit Breakers</td>
<td>Manufacturer, Type, Voltage rating, Amp rating, Short circuit rating, Settings, etc.</td>
</tr>
<tr>
<td>Panels and Switchboards</td>
<td>Manufacturer, Type, Voltage rating, Amp rating, Short circuit rating, Circuit breaker / fuse withstand ratings, etc.</td>
</tr>
<tr>
<td>Primary Transformers</td>
<td>Manufacturer, KVA rating, Impedance, Overcurrent protection, Available fault current, etc.</td>
</tr>
<tr>
<td>Secondary Transformers</td>
<td>Manufacturer, Type, Voltage rating, KVA rating, Impedance, Overcurrent protection, etc.</td>
</tr>
<tr>
<td>Wire &amp; Cable</td>
<td>Size, Insulation type, Conductor type, Length, etc.</td>
</tr>
<tr>
<td>SCR and/or Isolation Transformers</td>
<td>Size, Impedance, Fusing, Voltage rating, Current rating etc.</td>
</tr>
<tr>
<td>Disconnects, Combination Motor Starters</td>
<td>Manufacturer, Type, Voltage rating, Amp rating, Short circuit rating, OCPD rating, etc.</td>
</tr>
<tr>
<td>Bus Duct</td>
<td>Manufacturer, Voltage rating, Amp rating, Conductor type, Short circuit rating, Impedance value (based upon model number), etc.</td>
</tr>
<tr>
<td>Bus Heads &amp; Disconnects on Bus Duct</td>
<td>Amp rating, Voltage rating, OCPD Rating, etc.</td>
</tr>
<tr>
<td>Equipment Panels</td>
<td>All end use equipment that is permanently connected to the building electrical system. Document all short circuit ratings, fusing / circuit breakers, etc.</td>
</tr>
<tr>
<td>Motors and other equipment that will contribute to the available short circuit current</td>
<td>Collect motor data for all motors 50 hp and above.</td>
</tr>
<tr>
<td>VFD</td>
<td>Manufacturer, Voltage rating, Amp rating, Bypass, OCPD Rating, etc.</td>
</tr>
<tr>
<td>Engine-Generator</td>
<td>Manufacturer, Type, Voltage rating, Amp rating, KVA rating, KW rating, etc.</td>
</tr>
<tr>
<td>Automatic Transfer Switch</td>
<td>Manufacturer, Voltage rating, Amp rating, etc.</td>
</tr>
</tbody>
</table>
5 Infrared Scan Requirements:
5.1 As required by the RFP, 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.

6 System Short Circuit Analysis
6.1 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.
6.2 Study electrical distribution system scenarios that result in maximum and minimum fault current. These scenarios shall include at a minimum the following:
- Normal configuration.
- Emergency power system operation.
- Tie breaker closed and respective main open where these configurations exist.
6.3 Scenarios evaluated shall also make use where available of the maximum and minimum fault current values available from Purdue Utilities. Request these values from Purdue University.

7 Equipment Evaluation Analysis
7.1 Confirm that interrupting ratings are equal to or higher than calculated ½ cycle symmetrical fault current for all electrical equipment.
7.2 Interrupting Rating Analysis
7.2.1 Calculate momentary and interrupting duties on the basis of maximum available fault current.

8 Shock Hazard Analysis
8.1 Perform a Shock Hazard Analysis in accordance with NFPA 70E.
8.2 The completed study shall determine:
- Voltage exposure at each location.
- Shock Protection Boundaries:
  - Limited Approach
  - Restricted Approach
- Required PPE for shock hazard protection.

9 Overcurrent Protective Device Coordination Analysis
9.1 Protective Device Coordination Study for all system devices (adjustable and fixed).
9.2 Provide TCC curves for each type of breaker down to and including the 20A breakers in branch circuit panelboards.
9.3 The coordination study shall include TCC curves for all devices on the emergency system and shall verify proper coordination thereof per NEC.
9.4 Tabular format of settings selected for OCPD’s shall include the following:
- Device Tag
- Relay-current transformer ratios; and tap, time-dial, and instantaneous-pickup values.
- Circuit-breaker sensor rating; and long-time, short-time, instantaneous settings and ground fault where applicable
- Fuse-current rating and type.
- Ground-fault relay-pickup and time-delay settings.
9.5 Time Current Coordination curves:
9.5.1 Provide settings of overcurrent protective devices to achieve selective coordination.
9.5.2 Graphically illustrate that adequate time separation exists between devices installed in series, including power utility company’s upstream devices.
9.5.3 Prepare separate sets of TCC curves for each switching scenario.
9.5.4 Overcurrent Protection Devices and Fuse Recommendations: (Construction Related Projects)
9.5.5 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 Purdue when such devices are necessary or warranted to achieve Incident Energy criteria.
9.5.6 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.

10 Arc Flash Hazard Analysis

10.1 Arc Flash Study Limits

10.1.1 These study requirements exceed the requirements of the NFPA-70E standards and shall include all electrical equipment on the building's power distribution system as described below:

10.1.1.1 Buildings served by Purdue Utilities shall be evaluated from the primary side of the service entrance transformer at the first system connection in the first existing manhole.

**Note:** The system available fault currents and X/R ratio values at the first existing manhole referenced shall be furnished by Purdue.

10.1.1.2 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.

10.1.1.3 All electrical panel boards and load centers.

10.1.1.4 All three phase electrical equipment disconnect switches.

10.1.1.5 All bus ducts.

10.1.1.6 All open transformers.

10.1.1.7 All Variable Frequency Drives (VFD)

10.1.1.8 DC systems where applicable.

10.1.1.9 UPS Systems where applicable.

10.1.1.10 All disconnect switches that are integral to equipment that is hardwired to the building electrical system (HVAC equipment, Kitchen equipment, etc.)

10.1.2 The intent is that all electrical equipment subject to access while energized or that is a point of a Lockout / Tagout operation is evaluated. Notable exclusions from the study include 20 Amp lighting branch circuits, receptacle branch circuits and enclosed transformers.

10.2 Arc Flash Hazard Analysis:

10.2.1 Analysis methods shall conform to IEEE 1584 - Preferred Method.

10.2.2 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:

- UPS’s shall be assumed to be in bypass mode.
- VFD’s shall be assumed to be in bypass mode.

10.2.3 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.

10.2.4 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.

10.2.5 Prepare recommendations based upon modeling OCPD device settings and ratings to obtain IE levels no higher than 8 cal/cm².

**Note:** Temporary maintenance settings via a maintenance switch may be used to accomplish this if necessary, with Purdue’s approval.

10.2.6 Report shall contain the Arc Flash Evaluation showing the bus name, protective device name, bus voltage (kV), bus bolted fault (kA), protective device arcing fault (kA), trip / delay time (sec.), arc type, arc flash boundary (in.), and working distance (in.), incident energy (cal/cm²).

10.2.7 The completed study shall include:

- Device Tag for each point assessed
- Voltage exposure at each location
- Available bolted fault current
- Arc-Flash Protection Boundary
- Working Distance
- Incident Energy (in cal/cm²)
- Required PPE
- Components or equipment that are over-dutied
- Assessment date
11 Deliverables

11.1 Email Reports

11.1.1 “As-Drawn” Study: These are a series of partial reports as described in the RFP submitted electronically. This report is completed by the Final Review Construction Documents Submittal phase.

11.1.2 “Construction” Study: This report is a partial report as described in the RFP submitted electronically. This is a report conducted in conjunction with the submittal phase of the project to ensure equipment and devices being supplied are acceptable to the AFC and result in the lowest incident energy.

11.2 Draft Reports

11.2.1 Construction and Non-Construction Related Projects have the following draft report as detailed in the RFP:

11.2.2 Final Report Draft: Draft version of final report to convey the pertinent information for review and discussion and document any preliminary recommendations.

11.3 Infrared Scan Report – When required by the RFP.

11.3.1 Report shall be submitted in hardcopy and softcopy format.

11.3.2 Report shall be separately bound from all other study reports.

11.3.3 Report shall contain the following sections:

- Cover sheet that identifies the building name, building abbreviation, date of review, AFC Company contact information.
- Summary that identifies extent of work performed, equipment utilized and significant findings.
- Findings and Recommendations: Identify any equipment that requires further review and preventive maintenance by Purdue staff. Include representative digital images to aid in the review and correction of issues.

11.4 Final Report - Softcopy

11.4.1 Compact Disc #1

- PDF files only
- Label shall read “Report Copy”

11.4.2 Compact Disc #2

- PDF, Excel, DWF, SKM Backup Files with Libraries.
- Label shall read “Archive Copy”

11.5 Final Report Format- Hardcopy

11.5.1 Report binders shall be vinyl covered cardboard nominally 11.75” tall by 10.5” wide with clear plastic sleeves on the outside front, back and spine for insertion of printed coversheets. The integral binder shall be three (3) ring, D shape with minimum size of 1” and maximum size of 4”. The size of binder used shall be consistent with report being bound.

11.5.2 Report covers shall be consistent with the sample reports and shall include the following information:

11.5.2.1 Back Cover: AFC Company contact information centered at bottom of cover.

11.5.2.2 Spine: Information with bottom of text toward back of binder from left to right:

- Left end: Purdue University Logo, “West Lafayette Campus” below logo
- Centered: Building Name with Building Abbreviation (All Caps, large type, bold font) below
- Right end: “Arc Flash Study”, Report Date below in format “09/30/2018”

11.5.2.3 Front Cover: Purdue University Logo, Building Name, Building Abbreviation, “Arc Flash Study”, Date, AFC Company Logo.

11.5.3 Tabbed Dividers: Report shall be tabbed with labeled dividers for each section.

11.5.4 Pages: Pages shall be printed double sided and numbered by section, when appropriate, in the lower right hand corner. (Make note of the requirement for overcurrent protective device tabular information to be located on left side with associated Time Current curve on the facing page located on the right side printed in color.)
11.5.5 Drawing sleeves shall be clear plastic, three hole punched sized for 8.5” x 11” paper. A separate sleeve shall be provided for each drawing. Drawings shall be folded and inserted into the sleeve so that the title block is visible.

11.5.6 Compact Disc Sleeves shall be clear plastic three hole punched and sized to hold two compact disks.

11.5.7 Compact Discs shall have label with Purdue Logo, “West Lafayette Campus”, Building Name, Building Abbreviation (all caps, large type, bold), Arc Flash Study, Report Date (style 09/30/2010) and “Report Copy” or “Archive Copy” as appropriate.

11.5.8 Drawings shall be produced per CADD standards and shall be D-Size or E-Size drawings with a Purdue University standard border that contains the applicable information about the project. Drawing text shall be 13 point and Bus names shall be 12 point bold.

11.6 Final Report Contents – Construction Related projects

11.6.1 Table of Contents with numerical chapters and page numbers indicated.

11.6.2 Introduction

- Brief summary of the study, including the project name, building name and name and contact information for the AFC.
- Description of the format of the report and what is contained within each chapter.

11.6.3 Findings and Recommendations

11.6.3.1 This section of the report shall be separated into three areas:

- A line by line analysis of all locations with a greater than Category 2 hazard level, include recommendations to lower the incident energy to achieve a PPE Category of 2 or lower
- A line by line analysis of any Overcurrent Protective Device coordination issues, including recommendations to improve coordination
- Identification of any protective devices that appear to have inadequate interrupting capacity.

11.6.4 Table of Calculated Arc Flash Data (As Found)

- Narrative summary
- Table Arc Flash Evaluation IEEE 1584 Bus + Line Side Report (Table shall be based on running multiple scenarios to report the worst case condition)

11.6.5 Table of Calculated Arc Flash Data for Recommendations as if they were implemented, where applicable.

- Narrative summary
- Table Arc Flash Evaluation IEEE 1584 Bus + Line Side Report (Table shall be based on running multiple scenarios to report the worst case condition)

11.6.6 Single Line Diagrams

- Narrative description and schedule of drawings included.

- An accurate detailed One-Line electrical diagram of the system shall be created as part of this project. Information on the One-Line Diagram shall include, but not be limited to:
  - Electrical Structure
  - Voltage at each point (e.g. 480/277, 120/240, 120/208, etc.)
  - Bolted short circuit current available at each point in the system.
  - Horsepower of major motors connected to the system from 50hp and above.
  - Plant standard names of all panels and equipment.
  - Room numbers for location of all panels and equipment.
  - Arc Flash Incident Energy Levels at each point in cal/cm²
  - Transformer sizes
  - Show calculated X/R ratios and equipment interrupting rating (1/2-cycle) fault currents on electrical distribution system diagram.

11.6.7 Feeder and Transformer Data

- Table of SKM input data for cables, transformers, utilities, etc.

- Single Line diagram with data blocks indicating the following values:
  - Transformer Data including primary and secondary ampicity.
  - Cable Data
  - Fuse/Circuit Breaker Data
0573.1 ARC Flash Hazard Analysis

11.6.8 Summary of Calculated Fault Currents
- Narrative summary of findings and brief description of analysis.
- “Dapper Unbalanced Fault Report” separate Fault Reports shall be included for each utility and standby power scenario.

11.6.9 Coordination Curves, Device Settings (As Found) – Construction Related projects when project has existing structures when applicable.
- Narrative summary.
- Device information and settings and associated Time vs Current curves on facing pages.

11.6.10 Coordination Curves Device Settings (As Found and per Recommendations as if they were implemented, where applicable)
- Narrative summary.
- Device information and settings and associated Time vs Current curves on facing pages.

11.7 Computer Files and Libraries
11.7.1 Narrative / Reports: A complete soft copy of report shall be submitted in PDF format.
11.7.2 Spreadsheets: All tables located in and referenced within the report shall also be submitted in Microsoft Excel format.
11.7.3 SKM System Analysis Files: A complete set of project data files, libraries and output files in their native format.
11.7.4 Drawing Files: Single line diagrams shall be submitted in AutoCAD DWF format.

12 Label Requirements
12.1 General Requirements
12.1.1 The Brady part numbers are:
- (See Purdue Physical Facilities Engineering for the latest information on Brady part numbers)
12.1.2 Labels shall be standardized and comply with the requirements of the Arc Flash Label Standard that are included in Section 13 of this document.
12.1.3 Labels shall be printed for Line Side Incident Energy Levels only.
12.1.4 Labels shall be supplied, printed and installed by the AFC.
12.1.5 Labels shall be placed on the exterior surface of equipment and panel boards. Surface shall be properly prepared to receive the label. (Exception: Panel boards located in public corridors may be labeled on the inside of the panel board door that is accessible without exposing energized parts.)
12.1.6 Labels shall be self-adhesive

12.2 Label Information and Format
12.2.1 Room
- <Data field with Room #>

12.2.2 Date:
- <Data field with Month (3 Letter Format) / Year (4 Digit Format)>
- Format example: “Apr / 2011”

12.2.3 Device Name:
- <Data field with Device Name>
- Format example: “ELP3L-B-1 (MCB Lineside)”

12.2.4 Fed From:
- <Data field with upstream Device Name>
- Format example: “ESDPPH-1 EDS-3 Disc”

12.2.5 Arc Flash Hazard Boundary:
- <Data field with distance in inches>
- Format example: “4 inches”

12.2.6 Incident Energy at:
- <Data field with distance in inches>
- <Data field with incident energy in #.# cal/cm²>
- Format example: “18 inches 6.00 cal/cm²” (Note: Typical incident energy will be indicated by three digits. Values exceeding 100 cal/cm² may display four digits.)
12.2.7 Shock Hazard Exposure:
- <Data field with voltage in volts>
- Format example: "208 Volts"

12.2.8 Limited Approach Boundary:
- <Data field with distance in inches>
- Format example: "42 Inches"

12.2.9 Restricted Approach Boundary:
- <Data field with distance in inches>
- Format example: "12 Inches"

12.2.10 Calculations per IEEE 1584 (Preprinted on label)

12.2.11 Purdue University Logo (Preprinted on label)"

12.3 Label Application Instructions

12.3.1 Purdue shall witness label application.

12.3.2 The AFC shall verify that the breaker settings in the arc flash study have been programmed into the breakers prior to placing labels on the electrical equipment.

13 See Purdue Physical Facilities Engineering for any recent updates or modifications to the arc flash label requirements (sampled below)