Facilities Services

Arc Flash Analysis and Documentation SOP

I. Purpose

These procedures are intended to provide guidance for the implementation and the continuing compliance of the University of Texas at Austin Arc Flash Analysis Program. The guidelines for work involving electrical hazards and the selection of arc flash protective equipment are provided by the 2012 National Fire Protection Association's (NFPA) standard 70E. The standard for calculating the arc flash energy levels at different points in the electrical power system is that of Institute of Electrical and Electronics Engineers (IEEE) standard 1584.

II. Roles & Responsibilities

A. Facilities Maintenance (FM)

1. Implement arc flash analysis on existing buildings at the Main Campus and Pickle Research Campus without a current arc flash analysis.
2. Maintain documents and electronic files for site studies. This includes short-circuit coordination studies, arc flash studies, single-line diagrams, as well as documentation on later electrical system changes.
3. Implement five year electrical single-line review and arc flash analysis review.
4. Provide or coordinate general training for electrical work.
5. Alex Hershey and Darnell Mack are the electrical arc flash analysis engineers.
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B. Zone Supervisors/ Shop Foremen

1. Ensure employees comply with all provisions of the Electrical & Arc Flash Safety Program.
2. Assist arc flash team in 5 year review and update of arc flash analysis.
3. Report any discrepancies between SKM single-line and field conditions to Facilities Arc Flash Engineer.

C. PMCS & CPC

Project Management & Construction Services (PMCS) & Capital Planning and Construction (CPC)

1. Work with Facilities Maintenance Arc Flash Engineer to maintain up-to-date single-line diagrams, panel schedules and SKM models.
2. Include a review of the arc flash study in any major modification or renovation to the electrical system of a building.

3. Deliver reviewed and completed SKM files and other electrical power system documentation to Facilities Arc Flash Engineer at the completion of a project as a part of the project signoff.

III. Procedures

A. Conducting Analysis

1. Data Collection

a) Gather facility documentations: single-line diagrams, power floor plans showing locations of electrical equipment, overcurrent protective device information, component impedances for cable, transformers and bus-way, minimum and maximum fault current at the electrical service entrance to the facility, etc.

(1) Field verify existing documentation to ensure arc flash analysis will be performed using accurate settings and field conditions.

2. Generation/update of SKM single-line diagram

(1) Update existing SKM system single-line or create a new single-line of the facility on the SKM software.

(2) The system single-line diagram shall clearly include conductor lengths, number of conductors per phase, conductor impedance values, protective device settings, transformer impedances and X/R ratios, motor size, and other circuit information.

3. Short Circuit Study

a) Calculate the available short circuit current at each point in the electrical system using the SKM software.

b) The computer calculated values shall represent the highest short-circuit current that the equipment could be subjected to under fault conditions.

c) A tabular printout shall be produced which lists the calculated maximum available short-circuit currents, X/R ratios, equipment short-circuit interrupting or withstand current ratings, and notes regarding the adequacy or inadequacy of the equipment. Identify in report any inadequacies of the equipment and make recommendations for appropriate improvements.

4. Time-Current Coordination Study

a) A time-current coordination analysis shall be performed with the aid of the SKM software and shall include the determination of settings, ratings, or types for the overcurrent protective devices supplied.

b) Log-log plots which indicate the degree of system protection and coordination by displaying the time-current characteristics of series connected overcurrent devices and other pertinent system parameters shall be generated.

c) A tabular printout shall be produced which lists existing settings as well as the recommended settings of all adjustable overcurrent protective devices, the equipment designation where the device is located, and the device number corresponding to the device on the system single-line diagram.

d) Identify in report any significant deficiencies in protection and/or coordination and recommendations as required for addressing system protection or device coordination deficiencies

5. Arc Flash Hazard Analysis

a) Perform the arc flash analysis using the SKM software to obtain Arc Flash Incident Energy (AFIE) levels and arc flash protection boundary distances.

b) Arc flash hazard 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.

c) Arc Flash Hazard Analysis shall be performed in compliance with IEEE Standard 1584-2002, the IEEE Guide for Performing Arc Flash Calculations.

6. Equipment Labeling

a) Switchboards, panel boards, industrial control panels, motor control centers or other electrical equipment which require regular examination, adjustment, servicing or maintenance shall be have a visible arc flash label.

b) Labels shall comply with relevant NEC and NFPA 70 E standards and must include the following information:

(1) Equipment Name

(2) AFIE value (cal/cm^2)

(3) System voltage

(4) PPE Required

(5) Arc Flash Hazard Boundary

(6) Hazard Risk Category

(7) Limited Approach Boundary

c) Updates to existing and missing panel schedule will be done as electrical panels are field inspected.

B. When the Arc Flash Analysis should be reviewed

1. Arc flash analysis shall be updated when a major electrical modification or renovation takes place. These are projects which lead to significant changes to the utilities short-circuit current and arc flash analysis results. Such projects include but are not limited to the following:

a) The addition or reduction of three phase ac transmission and distribution lines, substations and similar equipment to accommodate load changes.

b) Changes or additions involving: motors 50 HP or above, and over-current protective devices.

2. Changes to equipment rated 240 V and below that does not involve at least one 125 kVA or larger low impedance transformer in its immediate power supply and changes to single-phase ac and dc systems do not require an Arc Flash Analysis review but they should be documented properly on panel schedules and the system single-line diagrams. Generic arc flash hazard labels (1.2 cal/cm2) should be applied to appropriate equipment.

Such projects include but are not limited to the following:

a) Addition of receptacle circuits and lighting circuits.

b) The addition or reduction of panel boards under 240 V supplied from transformers less than 125 kVA.

3. Arc flash hazard analysis shall be reviewed periodically every 5 years. Each building will have a FAMIS EQ ID associated with its arc flash analysis and a review cycle of 5 years for that EQ ID.

C. Document Storage and Distribution

1. SKM Project File

a) All SKM project files will be delivered to Facilities Maintenance arc flash analysis engineers at the end of each project for review. FM will store and maintain copies of the SKM files in the Archive Projects directory.

2. Document Control

   a) Copies of completed arc flash analysis will be stored in the archive project directory and on meridian.

   b) Copies of existing electrical single line or arc-flash files can be checked out from the arc flash engineer and from meridian file database.

   c) Finalized SKM project files must be transferred back to responsible arc flash analysis engineer for review and work order close out.

3. Code compliance issues should be noted and reported to zone supervisors. The arc flash analysis group will review system changes and update the folder as necessary.

D. Hard Copies

1. A printed copy of the completed electrical power system studies and single-line diagrams shall be provided upon request only.

2. A clear folder with copies of the as built single-line will be stored in the building main electrical room for qualified UT employees.

IV. Training Requirements

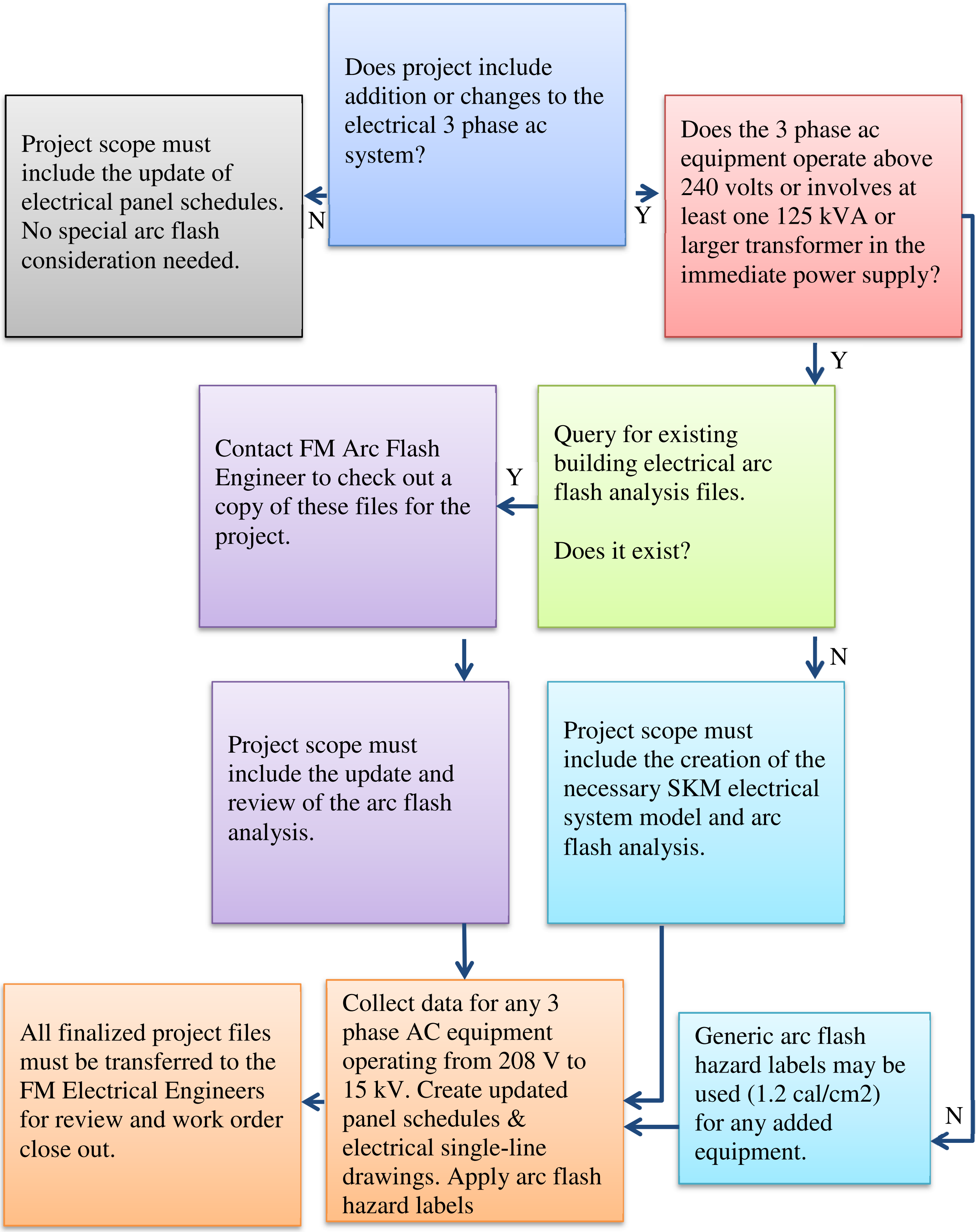
Employees of this program shall be trained and knowledgeable of the operation of electrical equipment and safe work methods. They shall be trained to recognize and to avoid the electrical hazards that might be present with respect to that equipment or work method.

Such persons shall receive all training required for a qualified electrical person as listed in NFPA 70E Article 110 (D).

Power system data collection shall be performed by or under the direction of a professional engineer.

Calculations must be performed by an engineer with working knowledge of Power*Tools for Windows the SKM arc flash and equipment evaluation software.

V. Appendix A: Project Management Arc-Flash Analysis Flow Chart



VI. Appendix B: Incident energy calculations energy

$lg\ En = K1 + K2 + 1.081 * lgIa + 0.0011 * G \quad (1)$

En - incident energy J/cm2 normalized for time and distance. The equation above is based on data normalized for a distance from the possible arc point to the person of 610 mm. and an arcing time of 0.2 sec.

K1 = -0.792 for open configurations, and is -0.555 for box configurations / enclosed equipment.

K2 = 0 for ungrounded and high resistance grounded systems, and equals -0.113 for grounded systems.

G - gap between conductors in millimeters.

Ia - predicted three phase arcing current in kA. It is found by using formula 2 a) or b) so the operating time for protective devices can be determined.

For 1000V and lower systems:

$lgIa = K + 0.662 * lg\ Ibf + 0.0966 * V + 0.000526 * G + 0.5588 * V * lgIbf - 0.00304 * G * lgIbf \quad (2a)$

lg - is logarithm base 10 (log10).
Ia - arcing current in kA.
En - normalized incident energy in J/cm2 as calculated by (1).
K - equals -0.153 for open configurations. and -0.097 for box configurations.
Ibf - bolted fault current for three phase faults in kA symmetrical rms.
V - system voltage in kV.
G - gap between conductors in millimeters.

$E = 4.184 * Cf * En * (t / 0.2) * (610x/Dx) \quad (3)$

E - incident energy exposure in J/cm2.
Cf - calculation factor equal to 1.0 for voltages above 1 kV, and 1.5 for voltages below 1 kV.
En - normalized incident energy in J/cm2 as calculated by (1) above.
t - arcing time in seconds.
D - distance from possible arcing point to the person in millimeters.
x - distance exponent.

Flash Protection Boundary is found using the equation below:

$DB = [4.184 * Cf * En * (t / 0.2) * (610x/EB)]1/x \quad (4)$

DB - distance of the boundary from the arc point in millimeters.
Cf - calculation factor equal to 1.0 for voltages above 1 kV, and 1.5 for voltages below 1 kV.
En - normalized incident energy in J/cm2 as calculated by (1).
EB - incident energy in J/cm2 at the boundary distance.
Ibf - bolted fault current for three phase faults in kA symmetrical rms.
t - arcing time in seconds.
x - distance exponent.

EB is usually set at 5 J/cm2 (1.2 cal/cm2) for bare skin, or at the rating of proposed personal protection equipment.

For protective devices operating in the steep portion of their time-current curves, a small change in current causes a big change in operating time. Incident energy is linear with time, so arc current variation may have a big effect on incident energy. The solution is to make two arc current and energy calculations: one using the calculated expected arc current and one using a reduced arc current that is 15% lower.

The calculator makes possible both calculations for each case considered. The IEEE 1584 procedure requires that an operating time be determined for both the expected arc current and the reduced arc current. Incident energy is calculated for both sets of arc currents and operating times and the larger incident energy is taken as the model result. This solution was developed by comparing the results of arc current calculations using the best available arc current equation with actual measured arc current in the test database. The calculator predicts arcing fault current for a given configuration and bolted fault short circuit current. It also predicts bolted fault current required to cause 15% reduction of the predicted arcing current for the given configuration. Arc duration should be adjusted for the predicted and 15% reduced arc fault values.

Incident Energy Exposure

This is the amount of thermal incident energy to which the worker's face and chest could be exposed at working distance during an electrical arc event. Incident energy is measured in joules per centimetre squared (J/cm2) or in calories/cm2 (5 J/cm2 = 1.2 cal/cm2) . Incident energy is calculated using variables such as available fault current, system voltage, expected arcing fault duration and the worker's distance from the arc. The data obtained from the calculations is used to select the appropriate flame resistant (FR) PPE.

VII. Appendix C - Definitions

- Arc flash hazard. A dangerous condition associated with the possible release of energy caused by an electric arc.
- Arc flash hazard analysis. A study investigating a worker's potential exposure to arc flash energy, conducted for the purpose of injury prevention and the determination of safe work practices, arc flash boundary, and the appropriate levels of personal protective equipment (PPE).
- Arc rating. The value attributed to materials that describe their performance to exposure to an electrical arc discharge. The arc rating is expressed in cal/cm2 and is derived from the determined value of the arc thermal performance value (ATPV) or energy of break open threshold (EBT) whichever is the lower value.
- Boundary
  - Arc flash boundary. The approach limit at a distance from a prospective arc source within which a person could receive a second degree burn if an electrical arc flash were to occur.
  - Limited approach boundary. The approach limit at a distance from an exposed energized electrical conductor or circuit part within which a shock hazard exists.
  - Prohibited approach boundary. The approach limit at a distance from an exposed energized electrical conductor or circuit part within which work is considered the same as making contact with the electrical conductor or circuit part.
  - Restricted approach boundary. The approach limit at a distance from an exposed energized electrical conductor or circuit part within which there is an increased risk of shock, due to electrical arc-over combined with inadvertent movement, for personnel working in close proximity to the energized electrical conductor or circuit part.
- Electrical hazard. A dangerous condition such that contact or equipment failure can result in electric shock, arc flash burn, thermal burn, or blast.
- Energized. Electrically connected to, or is, a source of voltage.
- Incident Energy. The amount of energy impressed on a surface, a certain distance from the source, generated during an electrical arc event.
- Qualified person. One who has skills and knowledge related to the construction and operation of the electrical equipment and installation and has received safety training to recognize and avoid the hazards involved.
- Single-line Diagram. A diagram that 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 in the circuit or system.