FREQUENTLY ASKED QUESTIONS

What is NFPA 70E?
The NFPA 70E is a consensus standard written to help with Electrical Safety.

Whom does the NFPA 70E apply to in the US?
The NFPA 70E Standard Applies nationwide in all Manufacturing, warehouse, mining, production, industrial, and commercial establishments. NFPA 70E also applies to all contractors working in these facilities.

When is an Electrical Safety Program (ESP) Required and how often do you update it?
An electrical safety program is required anytime you are working on or near electricity. The 2018 standard currently states that facilities must perform an updated of their Electrical Safety Program at an interval not to exceed three (3) years.

How often is the Electrical Safety Training required?
The 2018 standard currently states that facilities must train all employees working on or near electrical equipment at an interval not to exceed three (3) years. Training shall include general Awareness for those individuals not qualified to work on or near electricity, as well as qualified worker training which shall include task-specific instruction.

Who is required to have an arc flash study, and how often is an update required?
NFPA 70E requires Arc Flash Studies for owners and renters of all manufacturing, warehouse, mining, production, industrial, and commercial establishments. The 2018 standard currently states that facilities must update their Arc Flash Study at an interval not to exceed five (5) years.

How does EPSCO handle reviewing studies previously performed by other engineering firms?
The process for performing a 5-year update is very similar to performing an arc flash study for the first time, with the added benefit of having a portion of the facility already completed. Many industrial and manufacturing facilities are always changing, which then requires on-site data collection as well as engineering and label application.

What is the essential requirement for Rubber Gloves(PPE)?
All electrical safety PPE should be inspected before each use and should be free of cuts and damage that would hinder its performance and effectiveness. When inspecting voltage rated gloves, verify a test date on the cuff of the glove that is less than six (6) months before the time of inspection. Also, verify that a facility has electrical gloves rated for all voltages within the facility and note that glove selection shall require the use of the closest voltage rating above the equipment voltage to be worked on as to help worker dexterity. Gloves must be worn with leather protectors and stored correctly to prevent damage.

What is the essential requirement for Electrical Safety PPE as it relates to Arc Flash?
The incident energy calculation shall be used to select the proper arc flash PPE when performing tasks. This information shall be represented in Calories per CM Squared and shall be posted on equipment with a decal that includes additional information such as approach boundaries and date of study.

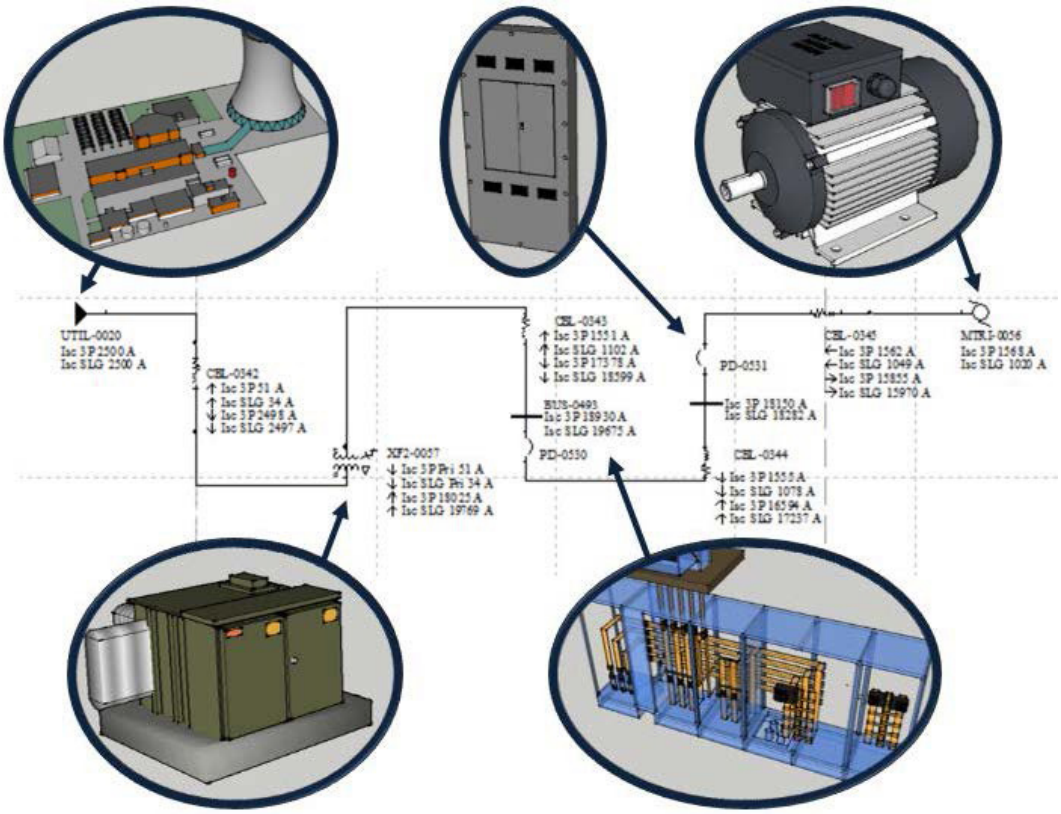
What are the best ways to perform an audit of a facilities arc flash study, electrical safety training, and electrical safety program?
Generally, what is involved in performing an audit of the above list items is as follows:

- **Arc Flash Study**
  Inspect for labels on equipment with Incident Energy Calculations, Approach Boundaries, and specific PPE recommendations. The label should have a date that is less than five (5) years before the time of inspection. If the label is more than for (4) years old, it is recommended to start the process for completing the next study.
- **Electrical Safety Training**
  Verify all staff working on or near electrical equipment has a certification of training with a date that is less than three (3) years before the time of inspection. Also, verify awareness training certificates for staff whom may need to recognize and avoid electrical hazards within their facility with a date that is less than three (3) years before the time of inspection.
- **Electrical Safety Program**
  The ESP is required to be audited at an interval not to exceed three (3) years. It should include but is not limited to: Task Specific Forms, Hierarchy of Risk Control, Roles & Responsibilities, LOTO, Safe Work Conduct Instruction, Qualified Worker Requirements, Managing Electrical Hazards, Employee Audit Forms, LOTO Documentation, Hazard Risk Assessment Info, Energized Work Permits, And More Found Within NFPA 70 E.

TECHNICAL ANNEX

SHORT CIRCUIT STUDY

When an energized conductor contacts another energized conductor or ground, the load for the circuit is bypassed, and the impedance is greatly decreased. By simply using ohms' law we can conclude that the amount of current will greatly increase. The total amount of available or prospective short circuit current is variable to several various aspects including utility contribution, upstream transformer credentials, system architectural design, voltage, etc. Generally, in a short circuit fault, the energy is contained to the current carrying conductors and protective devices opening the circuit.



To perform an incident energy calculation for arc flash purposes, a short circuit study and data collection is required. The calculations performed in an EPSCO short circuit study are completed via data collection technicians for data entry, SKM Power Tools for calculations, and electrical and professional engineering for review. To simplify these calculations, we can use circuit impedance and voltage to calculate short circuit values as shown above.

TECHNICAL ANNEX

EQUIPMENT EVALUATION

In the event of a bolted fault, a large amount of thermal energy and magnetic force can be produced. In accordance with various standards, protective devices and current carrying components are to be properly rated to withstand and interrupt the fault.

As seen in Figure 8.1, fault current can "flow" down or up a circuit when a short is created. The current flowing from the utility (the larger amount) is represented by the arrows pointing in the direction of the motor, and the contribution returning from the motor (the smaller amount) can been seen in the arrows pointing back toward the utility. The reason for this back contribution is the spinning rotor of the motor will not instantaneously stop, and the magnetic field will remain for a short number of cycles. This occurs even though voltage in the event of a bolted fault would theoretically equal zero (0).

The danger is that if equipment is not properly rated for the available fault current, catastrophic failure can occur. Through the use of specialized software and the associated equipment libraries, Electrical Power and Safety Company can help advise if your existing electrical infrastructure is rated to handle a worst-case scenario bolt fault. Please keep in mind that with an ever-changing electrical grid and utility power supply, the worst-case bolted fault can vary over time.

Short-Circuit Current Rating. The prospective symmetrical fault current at a nominal voltage to which an apparatus or system is able to be connected without sustaining damage exceeding defined acceptance criteria. [**70:**100]

The short-circuit current rating is marked on equipment, such as the one shown in Exhibit 100.16. Wire, bus structures, switching, protection and disconnect devices, and distribution equipment will be damaged or destroyed if their short-circuit ratings are exceeded.

EXHIBIT 100.16

Short-circuit rating clearly labeled on equipment.

The basic purpose of overcurrent protection is to open the circuit before equipment and conductors or conductor insulation is damaged when an overcurrent condition occurs as the result of an overload, a ground fault, or a short. But merely providing overcurrent protective devices with sufficient interrupting ratings does not ensure adequate short-circuit protection for the equipment. Overcurrent protective devices should be selected to ensure that the short-circuit current rating of the components are not exceeded should a short circuit or high-level ground fault occur. The overcurrent protective device must limit the let-through energy to within the short-circuit current rating of the electrical components. Adequate short-circuit protection can be provided by fuses, molded-case circuit breakers, and low-voltage power circuit breakers, depending on specific circuit and installation requirements.

The short-circuit current rating (SCCR) is based on the actual symmetrical (rms) fault current not exceeding the SCCR, the period of time the device was tested for, or the X/R ratio of the test circuit. The SCCR is the rms current that can be withstood for a period of time where the X/R of the fault circuit does not exceed that of the test circuit. It could be 3 cycles, 15 cycles, 30 cycles or some other time period depending upon the standard to which the equipment or component was tested.

Utility companies usually determine and provide information on available short-circuit current levels at the service equipment. Literature on how to calculate short-circuit currents

NFPA 70E (2015) Handbook Article 100

TECHNICAL ANNEX

PROTECTIVE DEVICE COORDINATION

The Protective device coordination can be viewed as a planned reliability measure using trip characteristics of protective devices to select and minimize effected equipment in the event of abnormal system conditions.

To break this down let's use an example: An operating paper mill has multiple devices being supplied power from the same distribution switchgear. The main breaker is rated at 3200 amps continuous, and the distribution breakers vary from 800-1600 amps. A system such as this can be seen in Figure 10.1 shown below.

If one of our 1600 amp breakers have an instantaneous setting of 10x, this means that if the equipment is operating correctly, it will not interrupt a fault until it reaches 16,000 amps (+/- 10%). This system may be designed this way for various reasons such as to allow for a large motor to start up or to avoid nuisance trips during current spike. (More likely the instantaneous level has been turned up over time by maintenance staff not following the correct trouble shooting procedures.) If the main breaker with a similar trip unit and clearing time has the instantaneous set to 4x, this means the breaker will interrupt a fault at roughly 12,800 amps, which is less than our 1600 amp distribution breaker. This can be problematic as the main breaker will clear a fault with a lesser magnitude then the distribution breaker causing for an unnecessary outage on all additional equipment being supplied power only from the 3200 amp main.

Figure 10.1 Sample Distribution System

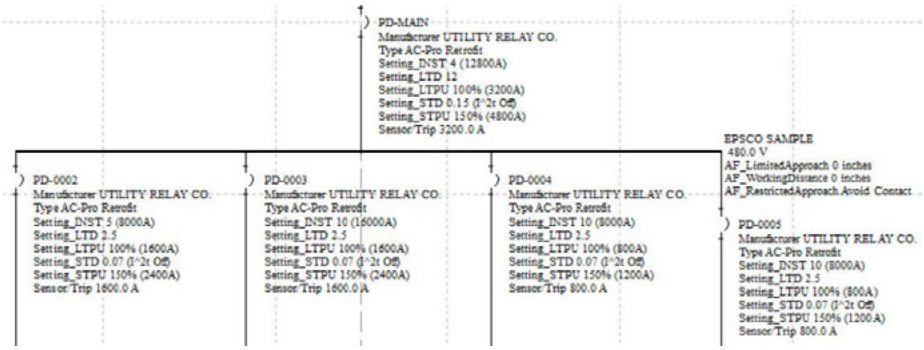
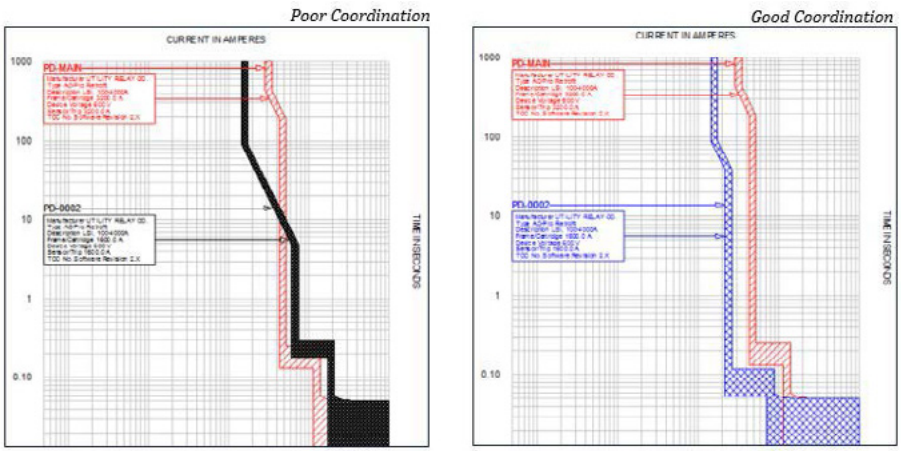


Figure 10.2 System Coordination



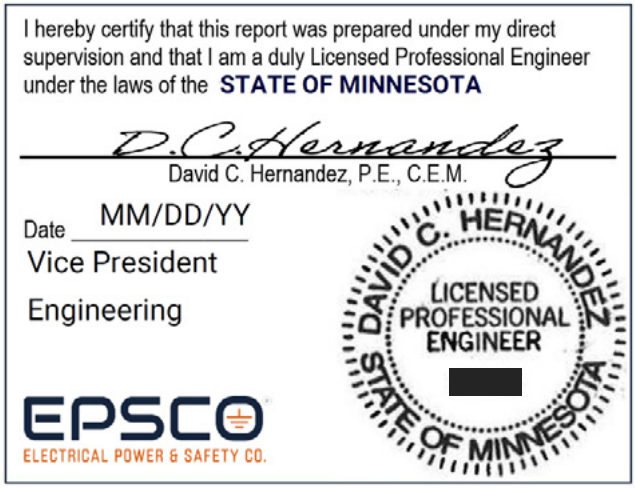
TECHNICAL ANNEX

PROFESSIONAL ENGINEERING REVIEW

Insert Disclaimer: Regarding the PE Review, in no event shall the Client copy or use any of the concepts, plans, drawings, specifications, designs, models, reports, photographs, computer software, surveys, calculations, construction and other data, documents, and processes produced by the Consultant in connection with the Project (the "Instruments of Service") for any purpose other than those noted above or in relation to any project other than the Project without the prior written permission of the Consultant. The Consultant shall not unreasonably withhold or deny such consent but shall be entitled to receive additional equitable remuneration about its grant of consent."

If it is contemplated that a report, drawings or designs may be provided to a third party, steps should be taken to ensure that the third party understands it is not entitled to use or rely upon the work product or is aware of and accepts any limitations the engineer has placed upon the work. The Contract Documents are made available for your review for informational purposes only in relation to Customer Power Systems Analysis. The Contract Documents may not be copied, reproduced, or distributed in any way or for any purpose whatsoever. The Contract Documents are provided "as is" without any guarantee, representation, condition or warranty of any kind, either express, implied, or statutory. The engineer assumes no liability with respect to any reliance you place on the Contract Documents. If you rely on the Contract Documents in any way, you assume the entire risk as to the truth, accuracy, currency, or completeness of the information contained in the Contract Documents.

All Arc Flash labeling is to be completed to the National Electrical Code. All stickers should be labeled and time stamped accordingly. Any internal changes completed after this report need to be review to make sure all arc flash requirement are met. This must be approved via Customer at an additional cost. Any changes of facility electrical infrastructure results in The Electrical Power and Safety Company report has been reviewed and background information completed. We hereby certify this report.



TECHNICAL ANNEX

INCIDENT ENERGY CALCULATION

Incident Energy, as defined by IEEE 1584 & NFPA 70E, is the amount energy impressed on a surface, a certain distance away from the source, generated during an electrical arc event. As definitions go, this is straight forward, but how do we calculate this? Well, the most common way is per equations found in IEEE 1584. (This is how our arc flash calculator app calculated incident energy) Where voltage is between 208 & 15kV, bolted fault current is between 700 & 106,000 Amps, and conductor gap is between 13mm & 153mm, we use the following steps (please note this process has been simplified and should not be used independently.)

First - Calculate the Arcing Fault Current

lg (Ia) = K + 0.662 lg (IB) + 0.0966 V + 0.000526 G + 0.5588 V lg (IB) – 0.00304 G lg (IB)

Where:
(lg) = log10
(Ia) = arcing fault current at the bus
(K) = –0.153 for open configuration or –0.097 for box configuration
(IB) = bolted fault current – 3phase sym rms kA at the bus
(V) = bus voltage in kV
(G) = is bus bar gap between conductors in mm

Then - Convert lg

Ia = 10 lg (Ia)
Ia br = Ia * IB br / IB

Where:
(IB br) = the Bolted Fault Current through each protective device.
(Ia br) = the arcing fault current through each protective device.

Next - Calculate the Incident Energy

lg (En) = K1 + K2 + 1.081 lg (Ia) + 0.0011 G

Where:
(En) = incident energy (J/cm2) normalized for a arcing duration of 0.2s and working distance of 610mm
(K1) = –0.792 for open configuration or –0.555 for box configuration
(K2) = 0 for ungrounded and high resistance grounded systems or –0.113 for grounded systems
(G) = the gap between bus bar conductors in mm
Solve En = 10 ^ lg En

Lastly - Convert Incident Energy from Normalized

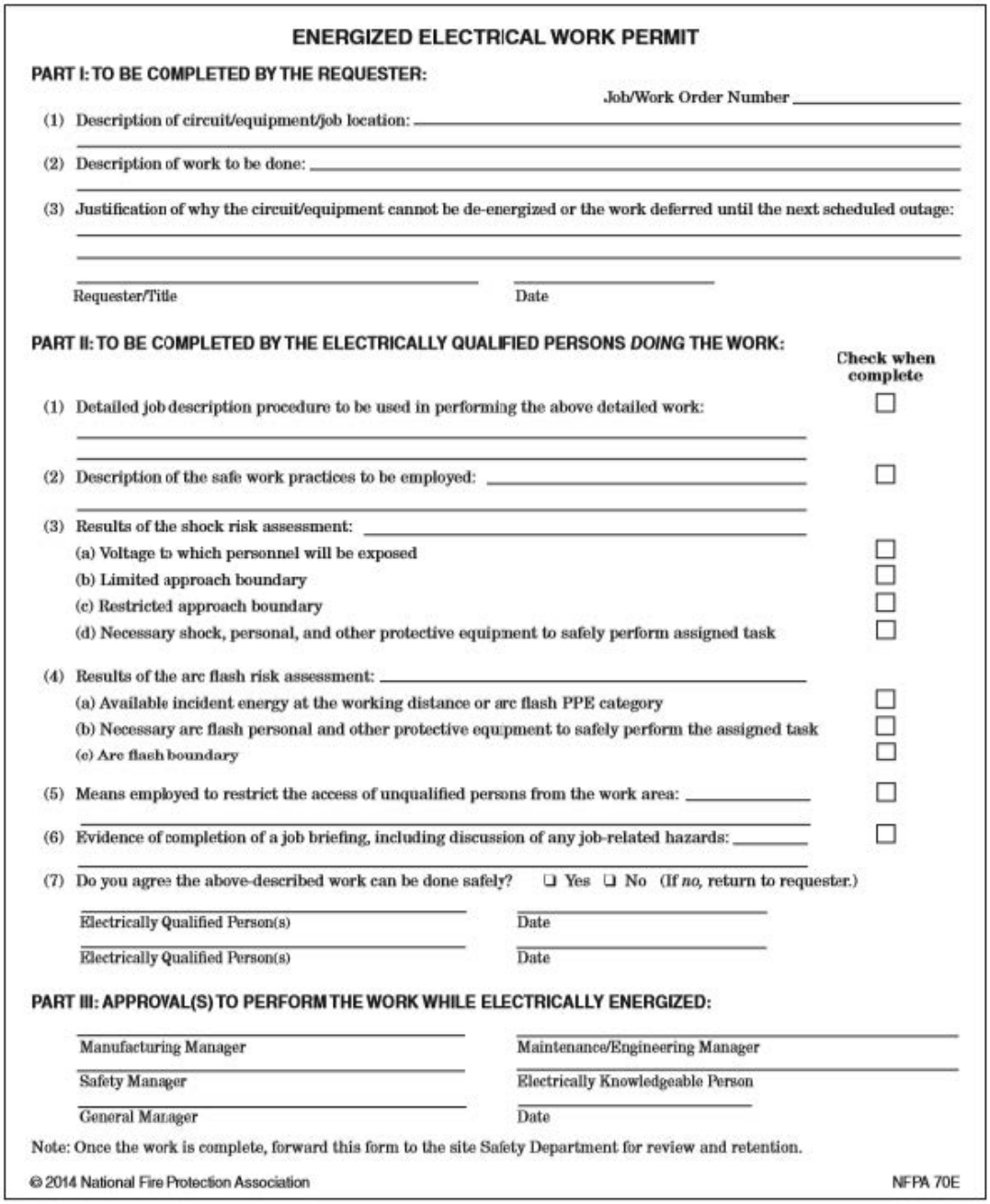
E = 4.184 Cf En (t/0.2) (610^X / D^X)

Where:
(E) = incident energy (J/cm2)
(Cf) = 1.0 for voltage above 1 kV or 1.5 for voltage at or below 1 kV (t) = arcing duration in seconds
(D) = the working distance
(x) = the distance exponent

TECHNICAL ANNEX

ENERGIZED WORK PERMITS

Informative Annex J illustrates an energized electrical work permit. The format of this work permit example is not fixed by requirement, although many employers have used this template successfully. The basic purpose of a work permit is to ensure that people in responsible positions are involved in the decision whether or not to accept the increased risk associated with working on energized electrical conductors or circuit parts. An additional benefit of the work permit is that its review might initiate a decision to perform the work de-energized.



ENERGIZED ELECTRICAL WORK PERMIT

PART I: TO BE COMPLETED BY THE REQUESTER:

Job/Work Order Number _____

(1) Description of circuit/equipment/job location: _____

(2) Description of work to be done: _____

(3) Justification of why the circuit/equipment cannot be de-energized or the work deferred until the next scheduled outage: _____

Requester/Title _____ Date _____

PART II: TO BE COMPLETED BY THE ELECTRICALLY QUALIFIED PERSONS *DOING* THE WORK:

Check when complete

(1) Detailed job description procedure to be used in performing the above detailed work: ☐

(2) Description of the safe work practices to be employed: ☐

(3) Results of the shock risk assessment:
- (a) Voltage to which personnel will be exposed ☐
- (b) Limited approach boundary ☐
- (c) Restricted approach boundary ☐
- (d) Necessary shock, personal, and other protective equipment to safely perform assigned task ☐

(4) Results of the arc flash risk assessment:
- (a) Available incident energy at the working distance or arc flash PPE category ☐
- (b) Necessary arc flash personal and other protective equipment to safely perform the assigned task ☐
- (c) Arc flash boundary ☐

(5) Means employed to restrict the access of unqualified persons from the work area: ☐

(6) Evidence of completion of a job briefing, including discussion of any job-related hazards: ☐

(7) Do you agree the above-described work can be done safely? ❑ Yes ❑ No (If *no*, return to requester.)

Electrically Qualified Person(s) _____ Date _____

Electrically Qualified Person(s) _____ Date _____

PART III: APPROVAL(S) TO PERFORM THE WORK WHILE ELECTRICALLY ENERGIZED:

Manufacturing Manager _____ Maintenance/Engineering Manager _____

Safety Manager _____ Electrically Knowledgeable Person _____

General Manager _____ Date _____

Note: Once the work is complete, forward this form to the site Safety Department for review and retention.

 NFPA 70E

FIGURE J.1 Sample Permit for Energized Electrical Work.
NFPA 70E (2015) Handbook Annex J

TECHNICAL ANNEX

EQUIPMENT LABELING

The following information outlines the labeling convention as a result of the arc flash analysis.

1 Warning

Designation between a "Warning" or "Dangers" classification. (Danger listed in red.)

2 Bus

Equipment identification for label, schematics, time current curves, work permits, etc...

3 Flash Risk Boundary

Distance from a prospective arc source within which a person could receive a second degree burn if an electrical arc flash were to occur.

4 System Voltage

Voltage at location of label.

5 Minimum Arc Rating

Minimum incident energy rating of clothing to work on or near circuit.

6 Arc Flash PPE List

Outlines required minimum arc rated PPE for safe work at this specific location.

7 Cal/cm^2

Calculated incident energy at working distance for specific location.

8 Date

This is the date when the labels are printed. Generally used for 5-year review info.

9 Restrictive Approach

Increased likelihood of electric shock, due to electrical arc-over combined with inadvertent movement.

10 Protective Device

Last device to trip in the event of a fault.

11 Limited Approach

Distance from an exposed energized electrical conductor or circuit part within which a shock hazard exists.

12 Glove Class

Glove to be worn when working with shock approach boundaries.

13 PPE Image

Pictorial representation of arc flash PPE recommended per location.

TECHNICAL ANNEX

RECOMMENDATIONS – SAMPLE

The following information outlines arc flash and equipment recommendation as a result of the arc flash analysis.

ARC FLASH MITIGATION RECOMMENDATIONS

Note: Load monitoring and other system considerations should be considered before protection device changes are made. EPSCO, Inc does not hold liability for results for changes made via recommendations.

Device:	(800P) MAIN-PAINT PLANT	**Existing:**	68 cals/cm2	**Recommended:**	<8 cals/cm2
Recommendation:	Must install upstream protective device to lower incident energy.				
Device:	(801P)MAIN SERVICE PAINT	**Existing:**	68 cals/cm2	**Recommended:**	<8 cals/cm2
Recommendation:	Unable to lower due to nuisance tripping with downstream device.				
Device:	(819P)PANEL-DS-1	**Existing:**	37 cals/cm2	**Recommended:**	<8 cals/cm2
Recommendation:	Recommend installing integral trip unit with LTPU, LTD, STPU, STD, INST.				
Device:	(802P)PANEL-DS3	**Existing:**	19 cals/cm2	**Recommended:**	1.6cals/cm2
Recommendation:	By lowering the feeder fuse from 600amp to 400amps, it will lower the incident energy level from 19 to 1.6 cals/cm2.				
Device:	BUS BAR-7 BUS PLUGS	**Existing:**	27 cals/cm2	**Recommended:**	<1.2cals/cm2
Recommendation:	By lowering the INST setting on the feeder breaker from 4 to 3 it will lower the incident energy from 27 cals/cm2 to 0.41.				
Device:		**Existing:**		**Recommended:**	
Recommendation:					
Device:		**Existing:**		**Recommended:**	
Recommendation:					
Device:		**Existing:**		**Recommended:**	
Recommendation:					
Device:		**Existing:**		**Recommended:**	
Recommendation:					
Device:		**Existing:**		**Recommended:**	
Recommendation:					
Device:		**Existing:**		**Recommended:**	
Recommendation:					
Device:		**Existing:**		**Recommended:**	
Recommendation:					

TECHNICAL ANNEX

PROGRAM IMPLEMENTATION

The following program implementation is the Esler 4R process for driving change within industrial facilities as it relates to safety.

1. Release

Electrical safety has been overlooked by many operational and implementation staff. This may be a result of poor previous education, dangerous work habits, or governance. As it is not our goal to determine the resulting factors outside of assisting in absolute resolution, but to implement a safe work environment, these are not areas to associate blame but to view past organizational attributes to be overcome.

To help properly educate your employee, following these steps:

Explain what change are to be made
"I understand we are currently performing "X" procedure. This we need to replace with "Y" procedure."

Explain why the changes are to be made and the benefits or new procedure
"Organizationally we have been lucky that we have not had an accident in results to procedure "X' (or if you have had an accident outline here), but nationwide other companies who also previously practiced procedure "X" have had injuries and deaths totaling 300+ per year. Procedure "Y" helps to mitigate risk of injury by …"

Explain corporate acknowledgment and plan to remove obstacles:
"[Company] as a whole recognizes that procedure "X" is placing its employees in a dangerous position, and feels it is important to protect you and your family's best interest. To help assist in procedure.

"Y", [Company] has {explain associated "remove obstacle" measure from Section 2}.

Receive Acknowledgment
"If [Company] {repeat how removed obstacle}, will you start replacing procedure "X" with procedure "Y"?"

Note: Properly presented signed contracts can be beneficial in increasing compliance with a new safety measure. This may result in operational staff revealing additional issues to procedural change that should be noted and rectified via internal problem-solving techniques. Training during this process is important if the new safety measure is not understood. Often the addition of PPE or order of operations change is all that is needed to increase safety. Posting procedure "Y" can be beneficial, and operational staff understand new procedure.

TECHNICAL ANNEX

2. Remove Obstacles

It is important for organizations to help replace poor habits by helping streamline new ones. This not only increases the likelihood of compliance via improved efficiency, but shows operational staff that the organization is taking these changes seriously. When removing obstacles, be sure to start with a full list of what the organization plans to accomplish. Also, take time to utilize internal problem solving techniques with special attention to additional safety and operational hazards associated with the change. If you need help with the problem-solving techniques, read “Sprint” by Jake Knapp, John Zeratsky, and Braden Kowitz, and “Traction” by Gino Wickman (specifically Chapter 6).

Examples of obstacle removing measures are:

- Handily placed PPE adjacent to work area
- Installation of remote operation, viewing windows, or protective devices
- Adjustment of existing protective devices
- High Resistance Grounding

Look to the recommendation section of Electrical Power & Safety Companies report for further assistance.

3. Repeat

When changing operational habits, it is important to understand that one “harum-scarum” meeting or demonstration will not return long-term results. This is where we recommend utilization of repetition for reinforcement. This can be done by utilizing time during regular schedules weekly meeting and/or “tool box talks.

This can be done by asking the following questions:

“How is everyone doing with procedure “Y”?”

“Are the {removed obstacles} helping?”

“Are there any additional issues resulting from procedure “Y”?”

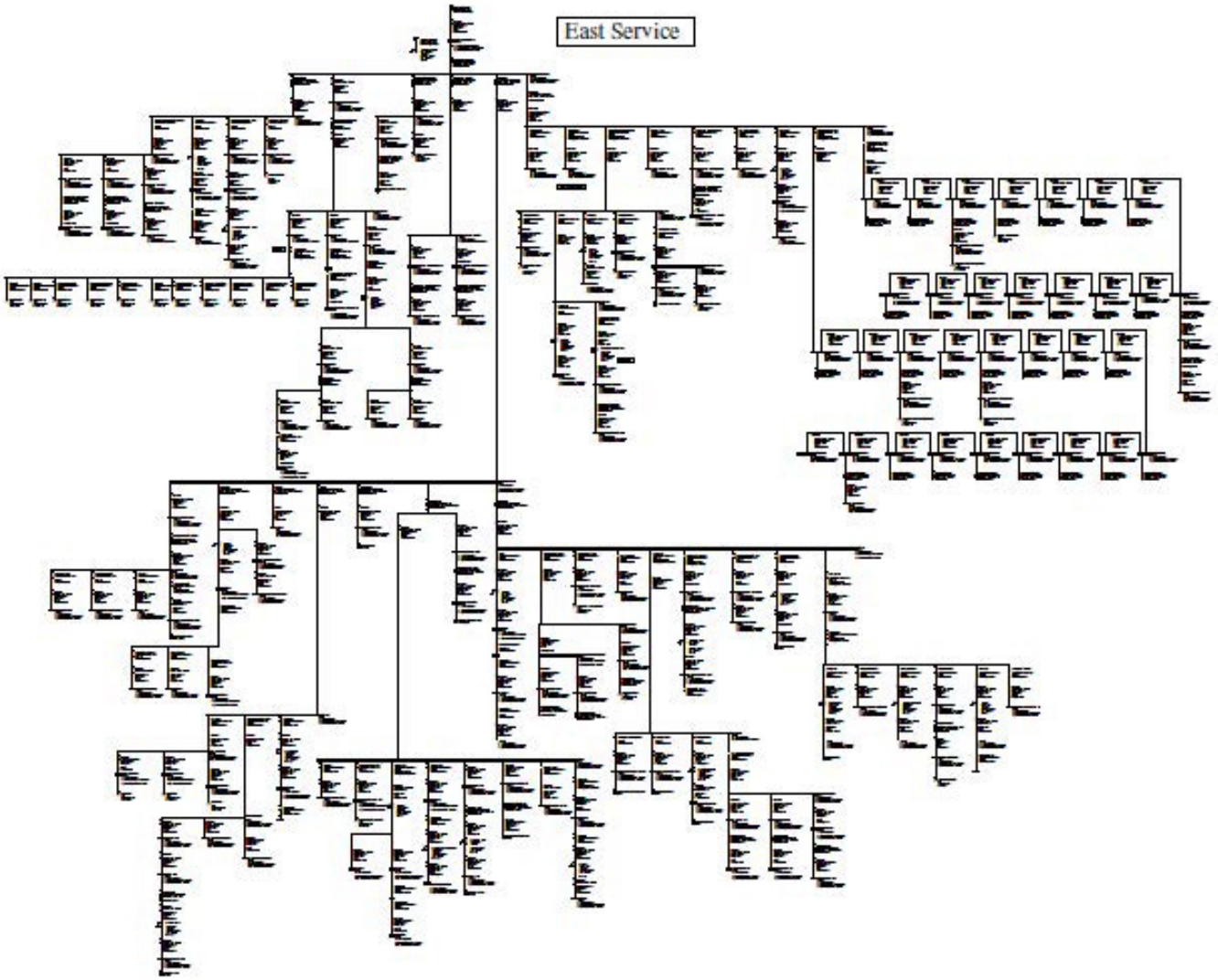
4. Reward

After visiting thousands of industrial facilities, one item that always stood out was that organizations with a good safety record not only reprimanded unsafe work practices, but rewarded employees when safety procedures were adequately followed. This can take the form of delivered lunch, camping trinkets, or paid time off.

TECHNICAL ANNEX

ARCH E (36” X 48”) SCHEMATIC

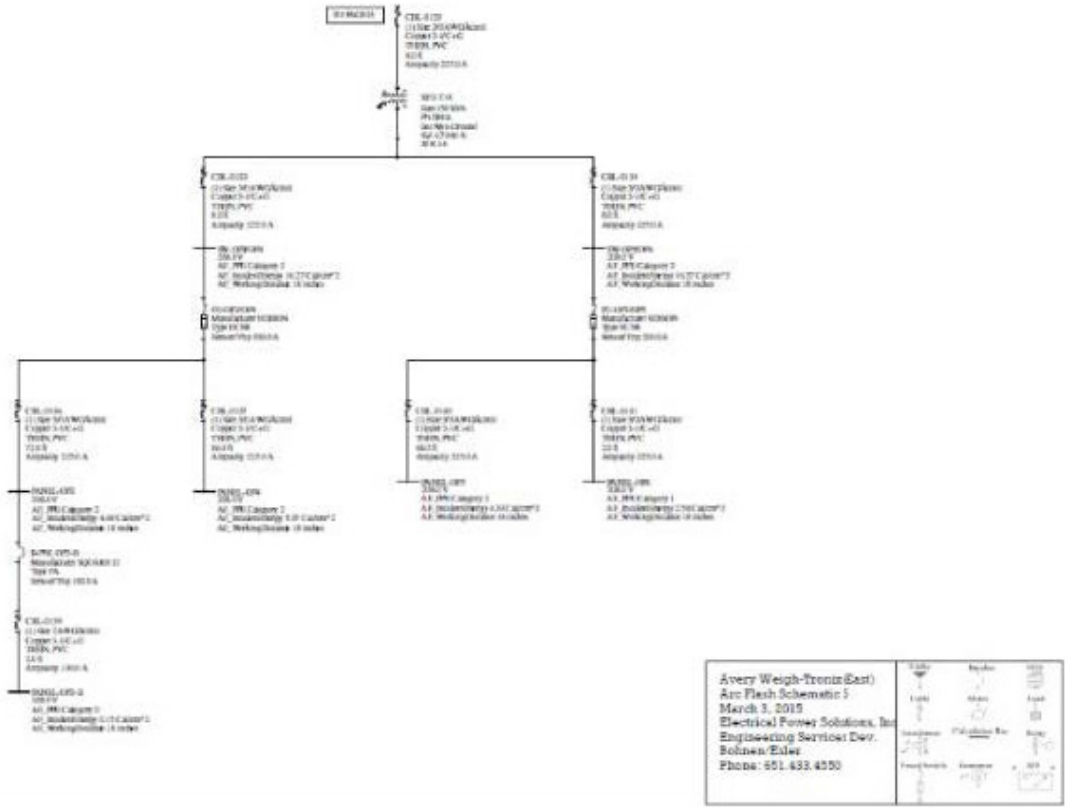
In the effort to provide a comprehensive view of your existing facility, the Arch E 36” X 48” schematics encompasses a top down view of one or multiple of your electrical services. The information included in the data block of each device is what we have termed as the “Input Date” block, based on a default template provided by SKM Power*Tools. This data block is very robust and includes information entered directly into your study. Please note that some information may be estimated due to lack of access or information.



TECHNICAL ANNEX

FIELD (11” X 17”) SCHEMATIC

The 11” X 17” Field Schematic contains identical data block information to the Arch E 36” X 48” comprehensive schematics but is designed to be more portable for use in the field. This document utilizes text boxes to help staff navigate to the desirable area.



TECHNICAL ANNEX

SHORT CIRCUIT (11" X 17") SCHEMATIC

In contrast to the 11" X 17" Field Schematic that provides device information, the 11" x 17" Short Circuit Schematic contains fault current info. Please note that the short circuit current is dependent on many factors and can change without notice.