DEPARTMENT OF THE ARMY
U.S. Army Corps of Engineers
CESO Washington, DC 20314-1000

EP 385-1-100

Pamphlet
No. 385-1-100

30 September 2014

Safety and Occupational Health
IMPLEMENTATION OF ARC FLASH HAZARD PROGRAM

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IMPLEMENTATION OF ARC FLASH HAZARD PROGRAM

1. Purpose. This document provides procedures to establish and maintain an Arc Flash Hazard (AFH) Program to be utilized by the US Army Corps of Engineers (USACE). This program is referred to herein as the AFH Program and is a major component of a complete electrical safety program.

2. Applicability.

a. This document is applicable to all USACE-operated facilities that contain energized electrical equipment with AC or DC voltages of 50 volts to ground or more where the potential for AFHs exists.

b. This document is to be used in conjunction with Engineering Regulation (ER) 385-1-100, U.S. Army Corps of Engineers, Arc Flash Hazard Program.

c. This document does not address safety considerations other than for AFHs and is to be used in conjunction with safety requirements for other hazards associated with examination, adjustment, servicing or maintenance activities.

d. This document is not applicable to private leased facilities on USACE properties.

3. Introduction.

a. An Arc Flash Hazard is defined as a dangerous condition associated with the possible release of energy caused by an electric arc. An AFH may exist when energized electrical conductors or circuit parts are exposed, or when they are within equipment in a guarded or enclosed condition, provided a person is interacting with the equipment in such a manner that could cause an electric arc. Under normal operating conditions, enclosed energized equipment that has been properly installed and maintained is not likely to pose an AFH.

b. Employees working on energized electrical equipment, operating at 50 volts or more, have the potential for injury from arcing faults by conditions such as un-insulated tools contacting electrical buses, insulation failures, loose connections, improper work procedures,

impurities or dust buildup, corrosion, condensation, over-voltage conditions, improperly maintained electrical equipment, or equipment malfunctions. Arcing faults produce hazards of extreme temperatures, light, sound, and pressure.

c. The complete mitigation of AFHs is not possible in all cases. The most effective method to mitigate an AFH is to de-energize electrical equipment before examination, adjustment, servicing or maintenance of the equipment. Only trained, qualified, and properly equipped personnel should be near exposed, energized equipment. The calculations and recommendations of applicable standards and this document are intended to identify and reduce arc flash (AF) incident energy (IE) levels. These procedures do not guarantee complete protection from AFHs. However, compliance with these procedures will reduce the possibility of burns and other injuries. Personnel that work in USACE facilities must be adequately protected from the risk of exposure to electric energy.

4. Background.

a. Shock and electrocution have long been recognized as risks to those who work with electricity. In recent years, additional emphasis has been placed on the dangers associated with arc flash and arc blast energy. This risk arises, not from the passage of electric current through the body, but from the concentrated energy during an arcing fault. An electric arc can instantly vaporize material such as copper or steel. The arc, passing through the vaporized material, can create an extremely bright AF of very high and dangerous temperatures. The result could be severe burns to the hands, face, and body; hearing loss; physical trauma from blast pressure; and possible death.

b. In 1979, the National Fire Protection Association (NFPA) introduced NFPA 70E, *Standard for Electrical Safety in the Workplace*. This standard covers methods of protecting workers from harm due to exposure to electrical systems and devices. In 1995, NFPA 70E was revised to help protect individuals from AF dangers.

c. The USACE *Safety and Health Requirements Manual*, EM 385-1-1, 2003 added requirements for an AFH analysis to be conducted in accordance with NFPA.

d. Protection from AF energy is required by:

(1) OSHA 29 CFR 1910.269(l)(6)(iii) and 1910.335(a)(1);

(2) NFPA 70E;

(3) EM 385-1-1;

(4) Additional references are included in 0.

5. General.

a. The AFH Program is a portion of a total Electrical Safety Program that includes electrical safe working practices. The AFH Program includes policies, practices, documentation, and standard operating procedures (SOPs) consistent with the requirements of this document and in accordance with ER 385-1-100.

b. Once the AFH analysis or assessment is complete, mitigation techniques will be incorporated. There may be scenarios identified that are either not covered or are in a category rating above the maximum value that can be mitigated by Protective Clothing and Personal Protective Equipment (PPE). To deal with these situations the facility will need to develop a mitigation plan to address the specific hazard.

6. Arc Flash Hazard Analysis. An AFH analysis is required if there is a possibility that employees may be exposed to energized electrical equipment with AC or DC voltages of 50 volts to ground or more. The AFH analysis shall be reviewed periodically, not to exceed five years, to account for changes in the electrical distribution system that could affect the results of the AFH analysis. There are two forms of AFH analyses: Task Based Assessment and a Detailed Incident Energy (IE) Analysis.

a. Task Based Assessment. The Task Based Assessment refers to the tables 130.7(C)(15)(a), 130.7(C)(15)(b), and 130.7(C)(16) included in NFPA 70E. Required PPE is determined based on equipment voltage and task, however, the values of available short circuit current and protective device clearing times must be known (see the parameters of NFPA 70E Table 130.7(C)(15)(a) & Table 130.7(C)(15)(b) for details). The Task Based Assessment may be used at the following facilities, if determined appropriate by a Qualified Engineer: recreational areas, offices, remote communications sites, or similar type facilities. Task Based Assessment may be performed by an AFH qualified person.

(1) The Task Based Assessment should be used as an interim step, to protect employees, at all facilities until a Detailed IE Analysis is able to be funded and completed, for up to a maximum of two years from the effective date of this document, at which point a Detailed IE Analysis must have been completed.

(2) The NFPA 70E Task Based Assessment method has two major drawbacks, which may result in either too much or too little protection. First, the fault current is not calculated. Instead, current magnitude is assumed based on system parameters. The determined IE is therefore only approximate, and may be significantly in error, depending on the local configuration of cable, bus size, and effective system impedance. Second, the task based tables take into account maximum allowable clearing times of fuses and circuit breakers (not actual clearing times), which greatly affect the IE.

b. Detailed IE Analysis. The Detailed IE Analysis is based on IEEE 1584. It is required for the following facilities: recreational facilities, powerhouses, spillways, navigation facilities (locks and dams), flood control (flood damage reduction) facilities, floating plant, fish facilities, pumping stations, irrigation and domestic water facilities, maintenance shops, laboratories, mobile equipment, or similar type facilities. The Detailed IE Analysis determines the IE exposure of the worker, the arc flash boundary (AFB), hazard/risk category, and required PPE. It is the most accurate AFH analysis and provides tools for reducing potential IE exposure.

(1) Detailed IE Analysis results are used to identify the AFBs and the IE at assigned working distances throughout any position or level in the electric generation, transmission, distribution, or utilization system. Once the AFBs and IE are calculated, they become a basis for developing strategies to minimize burn injuries. Strategies include modifying protective device settings or ratings, specifying the thermal rating of PPE, working de-energized, applying arc-resistant switchgear, installing current limiting devices, and following other control techniques and work practices as described in Paragraph 4.

(2) Detailed IE Analysis must be performed in association with a fault study and protective device coordination study. Fault study results are used to determine the momentary duty, interrupting rating, and the fault (withstand) rating of electrical equipment. Coordination study results are used to determine the time required for protective devices to isolate overload or fault conditions. Both studies provide information used for a Detailed IE Analysis and must contain current data as the results of each study directly affect the Detailed IE Analysis results.

(3) The level of IE that a worker might be exposed to depends on the magnitude of the fault current, the duration of the fault, and the worker’s distance from the arc.

(4) The Detailed IE Analysis must take into consideration the design of the overcurrent protective device and its opening time, including its condition of maintenance. Improper or inadequate maintenance can result in increased opening time of the overcurrent protective device, thus increasing the incident energy.

(5) Arc Flash Boundary (AFB). When using the empirically-derived equation from IEEE 1584, the AFB is calculated based on the incident energy, equipment type, and voltage. As such, the results can vary from very small to very large numbers. To facilitate work planning and training, it is recommended the calculated AFB be rounded up to the nearest whole foot with the minimum AFB being three feet.

c. DC and Single Phase. DC and single phase AF analyses are not included in IEEE 1584 at this time.

(1) NFPA 70E added guidance in the 2012 edition for DC AF analysis. There is a task based look-up table, Table 130.7(C) (15) (b), which associates tasks to hazard/risk categories under

certain parameters. These parameters are voltage, DC arcing current, maximum arc duration of two seconds, and a working distance of 18 inches. The DC arcing current can be calculated from the bolted fault current. For a more detailed analysis there are two methods presented in Annex D of NFPA 70E-2012: Maximum Power Method and Iterative Solution Method.

(2) Until further tools are available, when working on energized 120 VAC single phase control, lighting conductors or circuit parts, the recommended level of protection is Category 0.

(3) The AFH Program shall include procedures to address these conditions.

d. High Voltage Work Activity (Voltages above 15kV).

(1) Where equipment above 15kV is maintained by the facility, the equipment must be included in a Detailed IE Analysis. The Task Based tables in NFPA 70E only go up to 38kV and IEEE 1584 is limited to below 15kV. Therefore, the equations from Ralph Lee's paper, as identified in Appendix A, References, must be used to calculate the IE for voltages above 15kV. The calculations are based on the worst-case arc impedance. It is recommended that the working distance to where the equipment will actually be operated or maintained be used. (e.g., from a motor operated disconnect station to the energized conductors). At no point should the working distance be smaller than the minimum approach distance listed in Table 441-1 or Table 441-4 of IEEE C2 or as calculated in sections 4.6 and 4.7 of IEEE 516.

(2) Until a detailed analysis can be conducted, Tables 410-2 or 410-3 in IEEE C2 may be used to determine the effective arc rating of PPE to be worn by employees working on or near energized lines, parts, or equipment at voltages 1.1kV to 800kV. However, the fault current and clearing time must be known in order to use these tables.

e. Resources for AFH Analysis. Only Qualified Engineers (See Appendix B) may complete the Detailed IE Analysis. Qualified Engineers may be found:

(1) Within USACE: the Hydroelectric Design Center (HDC) employs Qualified Engineers. In addition, districts or regions may employ Qualified Engineers.

(2) Engineering firms or other government agencies may also be able to complete the Detailed IE Analysis. If engineering firms or other government agencies are to be used, they must utilize Licensed Professional Qualified Engineers. Persons performing analyses are required to have similar experience with generation, heavy industry, and low to high voltage equipment. See Appendix D for an example statement of work containing required experience, tasks, and reports requirements.

f. Tools for AFH Analyses. There are many engineering software packages available to assist in AFH analyses. All must be used in conjunction with IEEE 1584 and NFPA 70E guidelines. Engineering judgment must be used in any analysis.

g. Modification or Renovation. The AFH analysis must be updated when a major modification or renovation takes place.

(1) If a Task Based Assessment was deemed appropriate per paragraph 6.a. above, the updated Task Based Assessment shall be performed prior to placing the affected components in service.

(2) If a Detailed IE Analysis was required by paragraph 6.b. above, the Detailed IE Analysis should be updated during the modification or renovation. If this is not feasible, then a Task Based Assessment shall be performed prior to placing the affected components in service. The Task Based Assessment shall be considered as an interim step, to protect employees for a period no longer than 3 months after completion of the modification or renovation at which time the Detailed IE Analysis shall have been completed.

7. Mitigating Hazards.

a. Hierarchy of controls shall be used to remove, reduce, or achieve an acceptable level of risk. The control strategies list the substitution and elimination of hazards as the first steps towards meeting the commitment to providing a safe workplace. Lower-tiered strategies are then considered in descending order of effectiveness, until workers are adequately protected. The mitigation of arc flash hazards is best achieved by a combination of controls in which PPE is always considered last.

AFH Mitigation on floating plant may become infeasible due to plant configuration and confined areas (e.g. switchboards on vessels are in the pilot house with the Captain/operator). These situations shall be identified. When mitigation methods cannot bring risk to an acceptable level, an SOP must be developed that details how the crew will deal with these situations. These situations should not pose an AFH during normal operating conditions but do during maintenance. For AF hazards on U.S. Coast Guard inspected USACE Floating Plant, hazard mitigation must not violate applicable USCG protective device coordination requirements, thereby maintaining the reliability of the vessel's electrical power and distribution systems.

b. NFPA 70E is largely focused on the last three strategies: Warnings, Administrative Controls, and PPE. An informative annex (Safety Related Design Requirements – Annex O) of NFPA 70E discusses the other methods. This document will describe providing worker safety with a standard of care that meets current best practices and improves on measures contained in NFPA 70E.

c. Substitution/Elimination.

(1) Substitution and Elimination must be considered as the first steps towards hazard reduction. Working on de-energized circuits is the ideal method minimizing the probability of AF injuries and must be taken into account in all work processes.

(2) Substitution for less hazardous processes, materials, operations, and equipment can be achieved in many forms. Examples of design considerations are:

(a) Existing Installations;

- Substituting older breaker trip elements with newer solid-state trip elements, which have more options to allow for better coordination between protective devices.

- Reducing energy levels as a result of device coordination studies, which could allow for tightening time delays for faster circuit interrupting.

- Properly maintaining protective devices to ensure they operate as intended.

(b) New Installations.

- NFPA 70E, Annex O states that owners have a responsibility to apply electrical hazard analysis during the design of electrical systems/installations. This informative annex suggests this responsibility is indicated by the mandatory Electrical Hazard Analysis contained in 130.3(B)(1).

- Consider specifying arc resistant switchgear, finger safe electrical components, insulated buses, transformers with high impedance values, and current limiting fuses or circuit breakers with high speed operation.

- Remote monitoring of motor control equipment allows for information transfer and troubleshooting without opening unit doors. Similar emerging technologies (remote switching and racking devices) that separate workers from energized equipment and reduce required PPE levels should always be considered.

d. Engineering Controls. Engineering Controls are defined as barriers, covers, enclosures, insulated tools, and associated equipment that increases workers distance from energized circuits. Voltage meters designed with shotgun (hot stick) adapters are an example of an engineering control that provides distance.

e. Warnings. Warnings are designed to inform and remind employees about hazards. AFH protection warnings include highly visible barricades, labels, signage, and danger warnings in equipment manuals/operating instructions. NFPA 70E requires the use of electrical equipment labels that contains specific hazard information (See Paragraph 10).

f. Administrative Controls. Administrative controls generally include procedures and training and are addressed in detail in NFPA 70E. Examples include:

(1) Job briefings;

(2) Performing AFH analyses;

(3) Implementing and documenting a complete Electrical Safety Program of which safety-related work practices is a component;

(4) Developing Energized Electrical Work Permits on those occasions when Qualified Persons must work on circuits that are not in an electrically safe work condition;

(5) Hazardous Energy Control Procedures;

(6) Maintenance requirements such as maintaining overcurrent protective devices in accordance with manufacturer's instruction or industry consensus standards;

(7) Program Audits/Oversight;

(8) Providing for safety in the equipment and system design stages;

(9) Changing Control Procedures - How to document and obtain approval for equipment setting changes;

(10) Training.

g. Protective Clothing and Personal Protective Equipment (PPE). Although PPE (includes protective clothing and equipment) is the last stage in the hierarchy of controls, its use is critical to providing comprehensive worker protection. In combination with the higher tiered controls, PPE is intended to provide workers with the necessary equipment to protect vision and, hearing, and prevent burns more severe than second degree. Paragraph 9 discusses PPE in detail.

8. Integration of Controls into Work Practices.

a. There are several work practices that need to be altered to ensure that employees are protected from and identify the potential damage of an AFH in the workplace. The facility shall review and alter established work practices to include protecting employees from this hazard. The following established safety tools may require alteration/update to address this hazard:

(1) Facility standard operating procedures (SOPs);

(2) Preventive maintenance and work order job tasks;

(3) Documented, formalized switching orders (including arc flash reduction maintenance switches);

(4) Safe Clearances;

(5) Position Hazard Analyses;

b. Develop an Activity Hazard Analysis (AHA) whenever the work involves a potential for AFHs. The AHA shall include each work task, identify associated AFHs, and list control or mitigation techniques that will eliminate, reduce, or control each AFH to an acceptable level. The AHA shall include PPE and other equipment needed. The AHA shall be a living document and can change as conditions and/or personnel change. It shall also address potential emergency situations. A sample of the AHA which addresses AFHs is located in Appendix C.

9. Protective Clothing and Personal Protective Equipment (PPE).

a. Background. NFPA 70E has created five hazard/risk category levels that relate directly to the arc thermal performance (arc-rating) of the PPE required, see NFPA 70E, Table 130.7(C)(16). PPE consists of protective and arc-rated (AR) clothing. For the purposes of this document, the term PPE will encompass protective clothing, AR clothing and personal protective equipment.

b. General. The AFH analysis determines the AFBs and the Hazard/Risk Category for selecting the minimum PPE that people within the AFB must use. The PPE used by the worker must be selected based on the characteristics of the hazard. Appropriate levels of PPE are intended to protect a worker from AFHs (to limit the thermal injury to the worker's face and chest to a second-degree, i.e., curable, burn). PPE does not address protection against physical trauma injuries that could occur, other than exposure to the thermal effects of an AF.

c. Employees working within the AFB shall use PPE that is designed and constructed for the specific part of the body to be protected and for the work to be performed. The entire body (to include the back of the head and torso) must be protected from thermal injury.

d. Each facility shall develop and maintain a list of needed PPE as determined by the results of the AF analysis.

e. AFH/Risk Categories and Associated Clothing and PPE Requirements.

(1) The five hazard/risk category levels defined by NFPA 70E are Hazard/Risk Categories 0, 1, 2, 3 and 4. Each of these categories requires that all clothing that is non-AR consists entirely of natural materials, as identified below. Non-AR clothing is comprised of non-melting, flammable materials. Clothing made of flammable, synthetic materials or blends are prohibited within an AFB.

(2) Levels above Category 4 are determined as Category Dangerous. There is no approved PPE for this category. The facility shall develop local procedures for situations requiring work within Category Dangerous AFBs. Administrative or Engineering controls must be used to mitigate the hazard.

(3) Flammable, synthetic materials are prohibited within an AFB. These synthetic materials include acetate, acrylic, nylon, polyester, polyethylene, polypropylene and spandex, alone or in blends. These materials melt as a result of AF exposure conditions, form intimate contact with the skin, aggravate the burn injury, and are prohibited to be worn by workers who have the potential for exposure to AFHs. Other apparel (such as hard hat liners, hair nets, ear warmers, head covers, etc) made from materials that do not meet these requirements for melting, or made from materials that do not meet the flammability requirements are not permitted to be worn. Ear warmers, head covers, hair nets, etc that are made of arc-rated materials are available and may be worn.

(4) Flammable, non-melting, non-AR materials are permitted within an AFB. These materials include untreated cotton, silk, rayon, and wool fabrics (standard denim jeans, chinos, khaki slacks, etc.). Although permitted, these fabrics could ignite and continue to burn on the body, resulting in serious burn injuries.

(5) At facilities using a Task Based Assessment, only non-melting, non-AR (untreated natural fiber) undergarments shall be worn under PPE while employees are within the AFB, regardless of work being performed. Other clothing shall not be worn as research has shown that there is a potential that it could ignite and be trapped between the employee's skin and the PPE if an AF were to occur that had a higher IE than the energy of breakopen threshold. This does not apply to facilities where a Detailed IE Analysis has been completed. Synthetic material clothing, including undergarments, must not be worn beneath AR clothing.

(6) At facilities where a detailed IE analysis has been completed, all employees within the AFB , regardless of work being performed, must wear non-melting, non-AR (untreated natural fiber) clothing, including undergarments as a base, as identified in the Detailed IE Analysis and AHA, to protect the body from severe injury from an AF. Synthetic material clothing, including undergarments, must not be worn beneath AR clothing.

f. PPE. When AR clothing is worn, it must cover and prevent all ignitable clothing (to include undergarments) from igniting and burning. See also NFPA 70E-2012, paragraph 130.7.

(1) AR clothing and equipment must contain a label or other mark that describes the maximum IE rating.

(2) AR clothing must allow for movement and visibility.

(3) Fit. The fit of AR clothing is important to the safety of the worker. When the surface of AR clothing is heated, heat is conducted through the material and any AR clothing touching the skin can result in a burn. To minimize this, AR clothing must fit loosely to provide additional thermal insulation, but must not fit so loose that it interferes with the worker's movements. The ability of the worker to see in the necessary direction must also not be restricted. One size does NOT fit all.

(4) Employees must remove all contents of pockets so clothing fit is loose in the pocket areas.

(5) AF Suits. The suit design chosen shall permit easy and rapid removal by the wearer (avoid zippers in the back of the suit).

(6) Head, Face, Neck and Chin (Head Area) Protection. Workers must wear non-conductive, AR, head protection (ANSI Z89.1, Class E or G) and non-conductive PPE for the face, neck and chin wherever there is a danger of injury from electric shock, burns, arcs or flashes or from flying objects resulting from electrical explosion. If employees use hair-nets and/or beard nets, these items must be non-melting and AR.

(7) Eye Protection. Workers must wear protective eyewear whenever there is a danger of injury from electric arc, flashes or from flying objects resulting from electrical explosion. If the worker's head is within the AFB, the worker's eyes must be protected from the thermal hazard as well. If a face shield is worn, it must have an AR at least as great as the predicted IE. If a hood is worn for thermal protection, viewing window must protect the worker's eyes from the thermal hazard. Care must be taken when wearing eyeglasses or spectacles that have exposed conductive components as they could fall into an exposed energized electrical conductor and initiate an arcing fault. AR safety glasses meeting requirements of ANSI Z87.1 provide protection from impact and also filter damaging UV energy.

(8) Hearing Protection. Workers shall wear appropriate hearing protection whenever working within the AFB.

(9) Body Protection. Workers must wear AR clothing when they are within the AFB and wherever there is possible exposure to an electric AF above the threshold IE level for a second-degree burn [5 J/cm2 (1.2 cal/cm2)].

(a) Clothing must cover potentially exposed areas as completely as possible. Fasten shirt sleeves at the wrist and fasten top buttons of shirts and jackets to minimize chance that heated air could reach underneath the AR clothing.

(b) All flammable, non-melting clothing in exposures above Hazard/Risk Category 0 must be protected by at least one layer of AR clothing that has an established IE rating. This clothing may be provided as an AR suit jacket and AR suit pants, shirts and pants or as coveralls or as a combination of jacket and pants, or, for increased protection, as coveralls with jacket and pants.

(c) Various weight fabrics are available and shall be considered for comfort, heat stress, fit, ease of movement, etc. Generally, the higher degree of protection is provided by heavier weight fabrics and by layering combinations of one or more layers of AR clothing.

(d) In some cases, for only those facilities with a detailed IE analysis, one or more layers of AR clothing may be worn over flammable, non-melting clothing to achieve the degree of protection necessary. Layering increases the overall protective characteristics of AR clothing. If

AR clothing is worn in layers, some air is trapped between the layers and provides extra thermal insulation.

(e) Outer Garments. Garments worn as outer layers over AR clothing (i.e., jackets, rainwear) shall also be made from AR material.

(f) Underlayers. Significant injuries occur when fabrics melt onto a worker's skin. Clothing made from materials that melt (i.e., acetate, nylon, polyester, polypropylene, spandex) are not permitted in fabric underlayers (underwear) next to the skin. An incidental amount of elastic used on non-melting fabric underwear or socks is permitted.

(10) Hand and Arm Protection. Workers shall be provided and shall wear hand and arm protection where required for AF protection. See also, NFPA 70E, paragraphs 130.7(C)(7)(a), (b) and (c).

(a) The hands are normally the most exposed part of a worker's body. If an arcing fault does occur, the worker's hands are likely to be much closer to the AF than their torso. AR gloves are available and shall be worn within the AFB. If entering into the limited approach boundary, the employee must use voltage rated gloves with leather protectors to address the shock hazard in lieu of AR gloves. Although not rated for thermal protection, voltage-rated gloves with leather protectors provide significant thermal protection. Shirt sleeves should fit under the gauntlet of protective gloves to minimize chance that thermal energy could enter the shirt sleeves.

(b) The same clothing worn for body protection must provide AF protection for the worker's arms. Clothing selected and worn to protect the upper torso from thermal exposure must have long sleeves, fastened at the wrist. The sleeves must not be shortened or rolled up. Apparel that provides thermal protection for the worker's arms shall be an integral part of the apparel that protects the upper torso. Arm protection shall be accomplished by apparel described in NFPA 70E 130.7(C)(7).

(11) Foot/Leg Protection. Experience has shown that worker's feet are less exposed than his/her hands or head. AR shoes are not available. Heavy-duty leather safety-toed shoes provide some AF protection to the feet and must be used in all tasks in Hazard/Risk Category 2 and higher and in all exposures greater than 4 cal/cm2. Shoes made from lightweight material must not be selected.

(12) Conductive Articles Being Worn. Conductive articles of jewelry and clothing (i.e., large belt buckles, watchbands, bracelets, rings, key chains, necklaces, metalized aprons, cloth with conductive thread, metal headgear or metal frame glasses) are prohibited within a AFB.

g. Maintenance. PPE must be maintained in a safe, reliable condition per the manufacturer's recommendations.

(1) Inspection. Workers must inspect their AR clothing, per the manufacturer's instructions, visually before each use to ensure that the clothing is not soiled or contaminated with grease, oil, flammable liquid or combustible materials. The clothing must be free from tears, cuts or rips. Workers shall be trained to understand how to inspect AR clothing and how to determine when the rating of the AR clothing is voided (presence of materials discussed above). PPE or AR suits that are contaminated or damaged to the extent their protective qualities are impaired, shall not be used.

(2) Storage. PPE shall be stored in a manner to prevent physical damage and damage from moisture, dust or other deteriorating agents or contamination from flammable or combustible materials. Contamination reduces the thermal protection provided by the clothing.

(3) Cleaning, Repairing and Affixing Items. AR clothing and PPE must be maintained in a clean and sanitary condition and must be cleaned and maintained as defined by the clothing manufacturer. The manufacturer's instructions for cleaning and care of their products will be very specific, since certain cleansers and chemicals will affect the characteristics. AR clothing slowly loses its FR characteristics when cleaned.

(a) Options. When workers launder their own PPE, they must follow the manufacturer's instructions, which generally require different wash/rinse cycles than are used for household washing and use mild, non-bleaching detergents. Drying is typically on warm setting or hung to dry without the use of fabric softeners or dryer sheets. Laundry service: the laundry facility must be aware of the AR clothing manufacturer's laundering instructions which must be implemented with regard to retaining the characteristics. Dry cleaning is not allowed as the chemicals used will damage the AR characteristics of the fabric.

(b) If AR clothing is shared by workers, consider health aspects of shared PPE when determining laundering frequency.

(c) When AR clothing is repaired, the same AR materials used to manufacture the clothing shall be used to provide repairs.

(d) When trim, name tags, patches or labels are affixed to AR clothing, guidance in ASTM F 1506 (Standard Performance Specification for Textile Material for Wearing Apparel for Use by Electrical Workers Exposed to Momentary Electric Arc and Related Thermal Hazards) shall be followed. They must also be made of AR material.

10. Labeling and Boundary Markers.

a. Electrical equipment, such as switchboards, panel boards, industrial control panels, meter socket enclosures, and motor control centers that are in other than dwelling occupancies and are likely to require examination, adjustment, servicing, or maintenance while energized shall be field marked to warn qualified persons of potential AFHs.

b. Label Design. Labels may be based on ANSI Z535.4. Category 0 should contain the word “CAUTION” in black letters on a yellow background. Category 1 through 3 should contain the word “WARNING” in black letters on an orange background. Category 4 should contain the word “DANGEROUS" in black letters on a red background. Category Dangerous (above category 4) should contain the word “DANGEROUS” in white letters on a red background. If the facility chooses to use only one style for the labels regardless of category rating, it should contain the word “WARNING” in black letters on an orange background.

c. Label Style for detailed IE analysis. The style of label provided for the equipment being studied depends on the physical location of the main protective device(s). Both label styles are explained below, followed by two one-line diagram examples of where each style would be used. These are general examples only and should not be considered applicable for all applications. The detailed IE analysis must be used to determine the exact type of label for each situation.

(1) Bus Side Fault Label. The bus side fault label is used for equipment that is main lug only or has non-automatic mains. See Figure 1 for equipment arrangement example for a bus side only fault. Notice that for any fault located inside equipment LQ1.1, protective device PD-1 is the only device capable of clearing the majority arcing fault current. This arrangement yields only one possible arc hazard category at the studied equipment dictating that a bus side label be used.

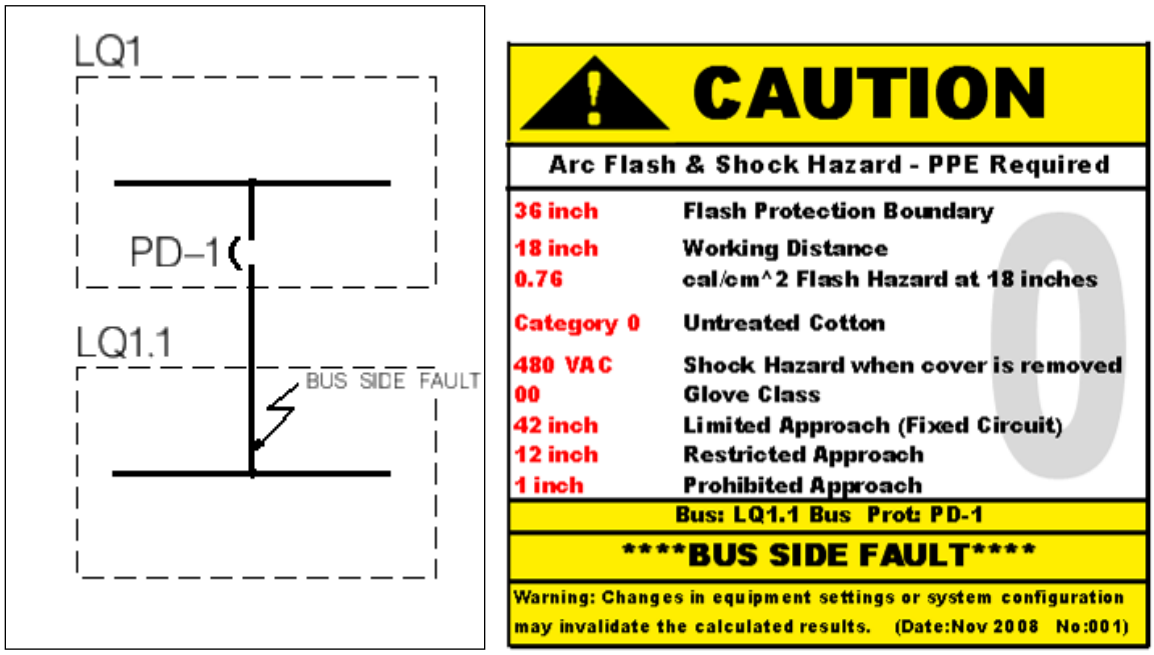

Figure 1. Label Layout for Bus Side Fault

(2) Bus and Line Side Labels. Bus and line side labels are used for equipment that has a protective device local at the equipment being studied. See Figure 2 for an equipment arrangement example for a line side fault.

(a) Notice that for a fault located inside equipment LQ2.1 on the bus side of local protective device PD-2, protective devices PD-2 and PD-3 are both capable of clearing the majority arcing fault current. If proper protective device coordination is present, the arcing fault clearing time will be dictated by device PD-2 and a bus side fault arcing hazard category for this scenario is applicable. The bus side label dictates the required PPE for working on this equipment.

(b) However, notice that for a fault located inside equipment LQ2.1 on the line side of local protective device PD-2, protective device PD-3 is the only device capable of clearing the majority arcing fault current. This arrangement yields a line side fault arcing hazard category that may be significantly different from the bus side fault arcing hazard previously explained.

(c) Bus side labels and line side labels are placed on LQ2.1 to give both arcing hazard values so that an informed decision based on the work being performed can be made on a case by case basis.

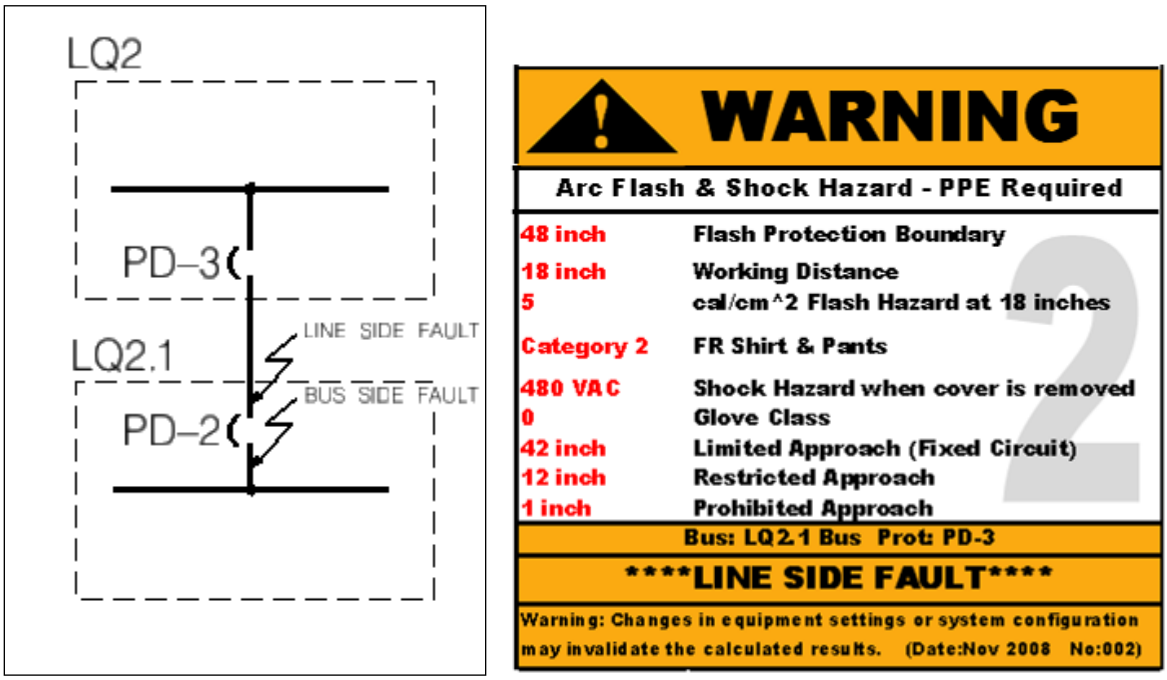

Figure 2. Label Layout for Line Side Fault

(3) Minimum Information on Label. At a minimum, the incident energy, PPE requirement, arc flash boundary, and working distance should be included on the labels. See Figure 3 for an example of a simplified label.

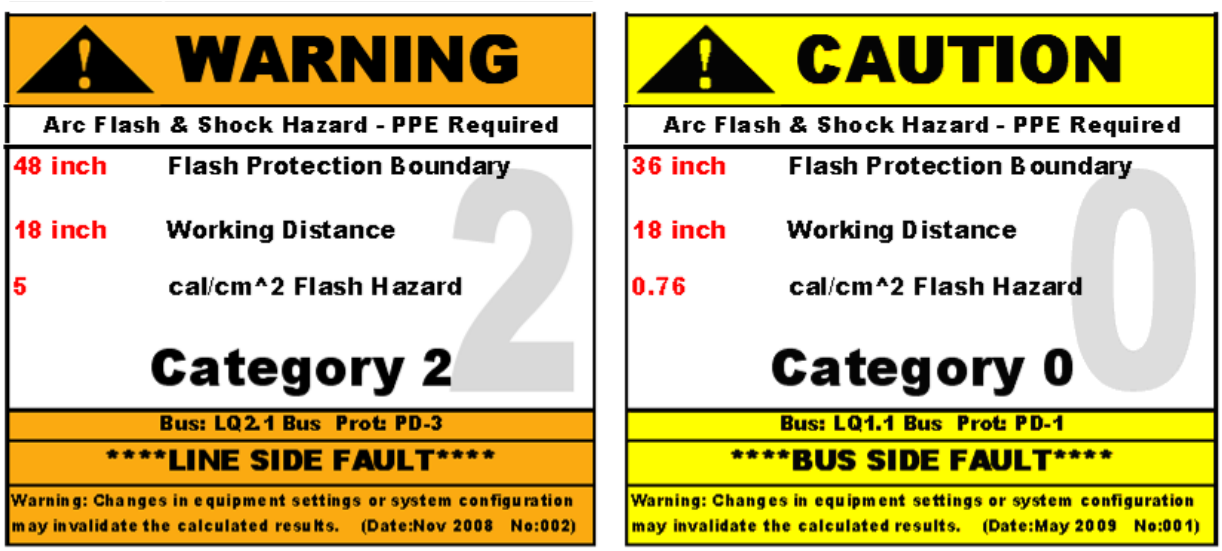

Figure 3. Simplified Label

(4) Other information may be included such as PPE level description, shock hazard, glove class as well as limited, restricted, and prohibited approach boundaries.

d. Labels for Task Based Analysis. For facilities where a Task Based Assessment has been performed, the information required to meet the label requirements of NFPA 70E is not available. Labels for these facilities will have to be generic in nature, such as the warning label in Figure 4. The AFH Program for the facility should include a task list similar to those provided in NFPA 70E-2012, Table 130.7(C)(15)(a). This label must be replaced when the Detailed IE Analysis is completed.

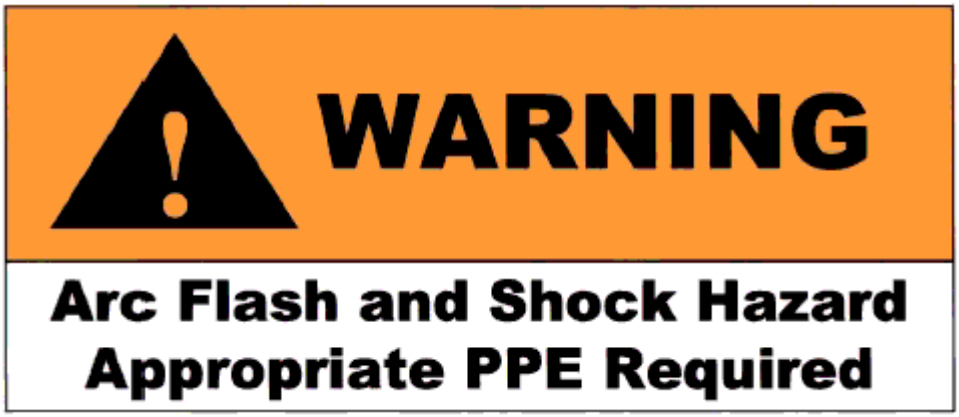

Figure 4. Label for Task Based Analysis

e. Placement on Equipment. Locate the label so it is clearly visible to qualified persons before examination, adjustment, servicing, or maintenance of the equipment. Even if equipment is in close physical proximity, its electrical characteristics can vary greatly; therefore all equipment may require different labels.

f. Boundary Markers. Boundary markers must clearly identify the AFB when an AFH exists. They may be of the retractable belt barrier type, safety tape, spotter, or similar.

11. Training.

a. Qualified Persons. A qualified person shall be trained and knowledgeable of the construction and operation of equipment or a specific work method and be trained to recognize and avoid the electrical hazards that might be present with respect to that equipment or work method.

(1) In addition, they shall also be familiar with the proper use of the special precautionary techniques; PPE, including arc flash suit; insulating and shielding materials; and insulated tools and test equipment.

(2) A person can be considered qualified with respect to certain equipment and methods but still be unqualified for others.

(3) Such persons permitted to work within the limited approach boundary of exposed energized electrical conductors and circuit parts operating at 50 volts or more shall, at a minimum, be additionally trained in all of the following:

(a) Skills and techniques necessary to distinguish exposed energized electrical conductors and circuit parts from other parts of electrical equipment;

(b) Skills and techniques necessary to determine the nominal voltage of exposed energized electrical conductors and circuit parts;

(c) Approach distances specified in Table 130.4(C)(a) and Table 130.4(C)(b) and the corresponding voltages to which the qualified person will be exposed;

(d) Decision-making process necessary to determine the degree and extent of the hazard and the PPE and job planning necessary to perform the task safely;

(e) Review of the local AFH Program;

(f) How to avoid exposure to AFHs;

(g) How to determine the degree of each hazard: labels, work permits, one-line diagrams;

(h) How to minimize risk by body position;

(i) How AFBs are identified, implemented, and enforced;

(j) Required level, proper use, fit, and location of PPE for each hazard/risk category;

(k) Required maintenance and inspection procedures of PPE;

(l) Required maintenance practices and insulated tools to mitigate energy levels;

(m) Emergency procedures;

(n) Incident/Accident reporting.

(4) An employee who is undergoing on-the-job training for the purpose of obtaining the skills and knowledge necessary to be considered a qualified person and who, in the course of such training, has demonstrated an ability to perform specific duties safely at his or her level of training, and who is under the direct supervision of a qualified person, shall be considered to be a qualified person for the performance of those specific duties.

(5) Tasks that are performed less often than once per year shall require retraining before the performance of the work practices involved.

(6) Employees shall be trained to select an appropriate voltage detector and shall demonstrate how to use a device to verify the absence of voltage, including interpreting indications provided by the device. The training shall include information that enables the employee to understand all limitations of each specific voltage detector that might be used.

(7) The employer shall determine, through regular supervision or through inspections conducted on at least an annual basis that each employee is complying with the safety-related work practices required by this standard.

b. Unqualified Persons.

(1) Unqualified persons shall be trained in, and be familiar with, any electrical safety related practices necessary for their safety.

(2) Unqualified persons routinely exposed to possible AFHs shall be trained in the following:

(a) Review of local AFH Program;

(b) AFH awareness – definition and recognition;

(c) How AFHs affects the body;

(d) How to recognize an AF label and AFB;

(e) Emergency Procedures;

(f) Incident/Accident reporting;

(g) The prohibition of crossing the AFB or the limited approach boundary.

c. AFH training may be performed by classroom training or on the job training but most effective training will be comprised of both types. Any training given, whether classroom or on the job, must be documented with instructor, trainee, content, and date the training was received.

d. Instructors, whether government or contractor, must have an appropriate level of technical knowledge, skills, or abilities in the subject of AFHs.

12. Inspection and Program Review. Periodic program reviews must cover all elements of the written AFH Program, assess implementation of this program in the facility, and employee understanding. As a minimum, the following shall be reviewed:

a. Is there a written program?

b. Is there a current (within last 5 years) AFH analysis – has current AFH analysis been reviewed and documentation exists that shows it is valid?

c. Hazard Mitigation Plans – have they been developed? Do they exist? Have they been implemented with the hierarchy of controls used as a basis?

d. Have controls been integrated into Work Activities, AHAs, PHAs, SOPs?

e. PPE – Are SOP's provided for proper inspection, maintenance, and storage? Do site visits reveal these are being followed?

f. Labeling – Is all required equipment fully labeled? Do labels meet the requirements of this document?

g. Training records – Are they maintained as appropriate? Do they indicate proper documentation?

h. Are qualified persons in writing and up to date?

i. Are past Inspections and Program Review records are available? Have corrective actions been completed?

j. Have there been any AF-related Incidents or Accidents; were they reported properly?

k. Have any Outside Contractors (Service Personnel) been onsite? Documentation of contractor AFH program coordination?

FOR THE COMMANDER:

4 Appendices
(See Table of Contents)

WILLIAM H. GRAHAM
COL, EN
Chief of Staff

APPENDIX A

References

1. Industry Standards.

a. 29 Code of Federal Regulation (CFR) 1910.147, The Control of Hazardous Energy Sources (Lockout/Tagout)

b. 29 Code of Federal Regulation (CFR) 1910.269 (l) (6), Electric Power Generation, Transmission, and Distribution

c. 29 Code of Federal Regulation (CFR) 1910.331-.335, Electrical Safety-Related Work Practices

d. ANSI Z10, American National Standard for Occupational Health and Safety Management Systems

e. ANSI Z87.1, Occupational and Educational Personal Eye and Face Protection Devices

f. ANSI Z89.1, American National Standard for Industrial Head Protection

g. ANSI Z535.4, American National Standard for Product Safety Signs and Labels

h. ASTM International (ASTM) F1506-08, Standard Performance Specification for Flame Resistant Textile Materials for Wearing Apparel for Use by Electrical Workers Exposed to Momentary Electric Arc and Related Thermal Hazards

i. IEEE Std. 1584A, Guide for Performing Arc Flash Calculations

j. IEEE C2-2012 National Electric Safety Code

k. IEEE 516-2009 Guide for Maintenance Methods on Energized Power Lines

l. NFPA 70, National Electric Code (NEC)

m. NFPA 70B, Recommended Practice for Electrical Equipment Maintenance

n. NFPA 70E, Standard for Electrical Safety in the Workplace

o. Ralph Lee,“The Other Electrical Hazard: Electrical Arc Blast Burns,” in IEEE Trans. Industrial Applications. Vol. 1A-18. No. 3, Page 246, May/June 1982

2. US Army Corps of Engineers Standards.

a. Engineering Manual (EM) 385-1-1, U.S. Army Corps of Engineers, Safety and Health Requirements Manual

b. Engineering Regulation (ER) 385-1-100, U.S. Army Corps of Engineers, Arc Flash Hazard Program

APPENDIX B

Definitions

Accident - An unplanned event related to an activity that results in a recordable property damage (over $5,000), employee injury or illness or fatality.

Arc Blast - A rapid gas pressure buildup caused by an arcing fault.

Arc Flash (AF) - A concentrated release of electric energy caused by an arcing fault.

Arc Flash Boundary (AFB) - When an arc flash hazard exists, an 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.

Arc Flash Hazard (AFH) - A dangerous condition associated with the release of energy caused by an electric arc. An arc flash hazard may exist when energized electrical conductors or circuit parts are exposed or when they are within equipment in a guarded or enclosed condition, provided a person is interacting with the equipment in such a manner that could cause an electric arc. Under normal operating conditions, enclosed energized equipment that has been properly installed and maintained is not likely to pose an arc flash hazard. See NFPA 70E, Article 100.

Arc Flash Hazard (AFH) Analysis - A study investigating a worker's potential exposure to arc flash energy, conducted for the purpose of injury prevention, the determination of safe working practices, and the appropriate level of PPE.

Arc Flash Related Incident and Accident - When an arc flash hazard exists, an incident and accident which involves an arc flash.

Arc-rated (AR) - Refers to clothing or equipment and indicates that it has been tested for exposure to an electric arc. Flame-Resistant (FR) clothing without an arc rating has not been tested for exposure to an electric arc.

Arc Rating - The value attributed to materials that describes 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 breakopen threshold (EBT) (should a material system exhibit a breakopen response below the ATPV value). Arc rating is reported as either ATPV or EBT, whichever is the lower value.

Arc Thermal Protection Value (ATPV) - Fire-retardant rating by ASTM International. The ATPV for a piece of clothing or fabric is the minimum incident thermal energy that will cause the onset of a second-degree burn based on the energy transmitted through the clothing.

Breakopen - A material response evidenced by the formation of one or more holes in the innermost layer of arc-rated material that would allow flame to pass through the material. Category Dangerous - Levels above category 4 are determined as Category Dangerous. There is no approved PPE for this category.

Deenergized - Free from any electrical connection to a source of potential difference and from electric charge; not having a potential different from that of the earth.

EBT (Breakdown Threshold Energy) - The largest amount of incident energy that a garment can protect a worker from in cal/cm2 before the onset of second-degree burns or before the garment breaks open and fails.

Exposed (as applied to live parts) - Capable of being inadvertently touched or approached nearer than a safe distance by a person. It is applied to parts that are not sufficiently guarded, isolated, or insulated from accidental contact or arc.

Flammable, Non-FR Materials - Cotton, silk, rayon and wool fabrics. Although permitted within an AFB, these fabrics could ignite and continue to burn on the body, resulting in serious burn injuries.

Flammable, synthetic materials - These materials melt as a result of AF exposure conditions, form intimate contact with the skin and aggravate the burn injury (i.e., acetate, acrylic, nylon, polyester, polyethylene, polypropylene and spandex, alone or in blends shall NOT be used.

Flash Suit – A complete arc rated FR clothing and equipment system that covers the entire body, except for the hands and feet. This includes pants, jacket, and bee-keeper-hood fitted with a face shield.

Hazard/Risk Category Level - A number (level 0 through level 4) based on the energy released during an arcing fault. A Higher number indicates a higher energy level. The PPE needed to protect a worker is determined by the risk category level.

Incident - An unplanned event that did not result in injury, illness, or damage – but had the potential to do so. Sometimes called a “close call” or “near miss”.

Incident Energy (IE) – The amount of energy impressed on a surface, a certain distance from the source, generated during and electrical arc event. One of the units used to measure incident energy is calories per centimeter squared (cal/cm2).

Incidental Worker - An employee who, under normal circumstances, would not be in an area where a system is under lockout and tagout but is required to enter or pass through such an area.

Insulated tools or equipment - Tools or equipment designed to provide insulation from an energized part or conductor. It may have conductive parts and be coated or covered by a dielectric material, or be composed entirely of insulating materials. Insulated industrial hand tools are typically stamped on the handle with an emblem (a double triangle) and a voltage rating. Such tools must be ASTM certified.

Limited Approach Boundary - An approach limit at a distance from an exposed live part within which a shock hazard exists. This boundary is also referred to as the safe approach distance in National Fire Protection Association (NFPA) 70E, "Standard for Electrical Safety in the Workplace," Annex C.

Live Parts - Energized conductive components.

Natural Fibers - Fibers produced by natural processes, as opposed to manufactured synthetic fibers. Cotton, silk, and wool are examples of natural fibers. Rayon and nylon are examples of synthetic fibers.

PPE - See Protective Clothing and Personal Protective Equipment

Prohibited Approach Boundary - An approach limit at a distance from an exposed live part within which work is considered the same as making contact with the live part.

Protective Clothing and Personal Protective Equipment (PPE) - Items of arc-rated clothing or equipment, that provide a barrier between an AF hazard and a worker. PPE consists of protective and arc-rated (AR) clothing. For the purposes of this document, the term PPE will encompass protective clothing, arc-rated clothing and personal protective equipment.

Qualified Engineer - An electrical engineer who has skills and knowledge related to the engineering and design of the electrical equipment and installations to include fault studies, coordination studies, arc flash studies.

Qualified Person (Electrical) - One who has received training in and has demonstrated skills and knowledge in the construction and operation of electrical equipment and installations and the hazards involved. This includes the skills and techniques necessary to distinguish exposed live parts from other parts of electric equipment, to determine the nominal voltage of exposed live parts, the clearance distances and corresponding voltages to which the qualified person will be exposed.

Note 1: Whether an employee is considered to be a "qualified person" will depend upon various circumstances in the workplace, e.g., an individual may be considered "qualified" with regard to certain equipment in the workplace, but "unqualified" as to other equipment.

Note 2: An employee who is undergoing on-the-job training and who, in the course of such training, has demonstrated an ability to perform duties safely at his level of training and who is under the direct supervision of a qualified person is considered to be a qualified person for the performance of those duties.

Restricted Approach Boundary - An approach limit at a distance from an exposed live 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 live part. This boundary is to be crossed by only qualified persons.

Unqualified Person - A person that is not a Qualified Person.

Working Distance (WD) - The dimension between the possible arc point and the head and body of the worker positioned in place to perform the assigned task.

Working On (energized electrical conductors or circuit parts) - Intentionally coming in contact with energized electrical conductors or circuit parts with the hands, feet, or other body parts, with tools, probes, or with test equipment, regardless of the personal protective equipment a person is wearing. There are two categories of "working on":

(1) Diagnostic (testing) is taking readings or measurements of electrical equipment with approved test equipment that does not require making any physical change to the equipment;

(2) Repair is any physical alteration of electrical equipment (such as making or tightening connections, removing or replacing components, etc.).

APPENDIX C

Activity Hazard Analysis Sample

ACTIVITY HAZARDS ANALYSIS

Page 1 of 5

Date Prepared: 12-05-2013

Project: Safe Ty Power Plant Job: Maintenance on 480V Motor & Controls

Prepared By: S. Marty, Snr. Electrician Reviewed By: O. Verwatch, Superintendent

Risk Assessment Code(RAC): M

E = Extremely High Risk
H = High Risk
M = Moderate Risk
L = Low Risk

Severity	Probability: Frequent	Likely	Occasional	Seldom	Unlikely
Catastrophic	E	E	H	H	M
Critical	E	H	H	M	L
Marginal	H	M	M	L	L
Negligible	M	L	L	L	L

Recommended Protective Clothing & Equipment:
Hard hats, Leather Gloves, Safety Shoes, Eye Protection, Hearing Protection, Arc Rated Clothes/Balaklava/Hood, Insulated Gloves, Insulated Tools, and Remote Racking Device

JOB STEPS	HAZARDS	ACTIONS TO ELEMINATE OR MINMIZE HAZARDS	EM 385-1-1 (PARA REF)
1. Planning	Miscommunication, personnel being unfamiliar with work to be performed or equipment.	Discuss work and AHA with all personnel and insure everyone understands the scope of work.	01.B.05 NFPA 70E 110.3(G)
2. Inform the personnel who will be affected by the equipment outage as to the plan to remove the equipment from service	Adverse effects to the affected persons/process/operation which could jeopardize safety and integrity	Coordinate the equipment outage with the affected personnel so as to minimize the adverse impact of the outage	01.E.02 NFPA 70E 120.2(D)(3)
3. Identifying Equipment & Developing/Maintaining a Clear Work Space	Confusing similar/identical equipment with the equipment desired to be maintained.	Identify the equipment to be maintained by a definite means. (i.e use of identifying tags, prints, markings, etc).	NFPA 70E 130.7(E)(4)
	Obstacles in the work area that could cause physical harm to the personnel in the work area.	Develop and mark a safe work area with barriers or use personnel to keep unauthorized persons out of the work area.	11.A.08 NFPA 70E 130.7(E)
4. Clearing equipment and placing it under a Safe Clearance & returning it to service	Arc flash, electrical shock, switching the wrong equipment, strains, cuts, slips, trips, and falls.	Follow the EM 385-1-1/Local Lock Out, Tag Out Program.	12.A.02
		Perform switching from written instructions.	12.A.12 & NFPA 70E 120.2(D)(2)(b)

APPENDIX C

Activity Hazard Analysis Sample (cont'd)

ACTIVITY HAZARDS ANALYSIS

Date Prepared: 12-05-2013

Project: Safe Ty Power Plant

Job: Maintenance on 480V Motor & Controls

JOB STEPS	HAZARDS	ACTIONS TO ELEMINATE OR MINMIZE HAZARDS	EM 385-1-1 (PARA REF)
(Cont.)		Plan additional switching steps to eliminate/limit personnel's Arc Flash Exposure.	NFPA 70E 120.2(F)(1)&(2) NFPA 70E 130.6(J)
		Use proper PPE and body positioning.	11.B.02 thru 11.B.08 NFPA 70E 130.7(C)
		Clear and as necessary mark the area where switching will be performed.	11.A.08 14.C NFPA 70E 130.7(E)2
5. Operating breakers/disconnects, removing/installing fuses, racking breakers/buckets, and exposing electrical conductors/apparatuses	Electrical shock, arc flash, cuts, strains, and contusions.	Use the hierarchy of arc flash hazard elimination and apply to all steps (Substitution/Elimination, Engineering Controls, Administrative Controls, & then PPE/Tools)	
		Personnel performing switching and working in an arc flash/limited approach boundary must be designated in writing as a "Qualified Person and follow the local Arc Flash Safety Program	11.A.01 12.A.02 NFPA 70E 110.2
		Operate electrical apparatuses/devices with remotely located controls, where available, to minimize exposure to electrical hazards.	NFPA 70E 120.1
		If manual switching is required operate the devices in a de-energized state where possible.	NFPA 70E 120.1
		A means of verifying the absence of voltage is required (i.e panel meters, electronic indication, volt meters, etc.) in order to verify a de-energized state. Where possible use remote means to verify absence of voltage so as to limit Arc Flash exposure.	11.A.02 11.A.09 NFPA 70E 120.1

APPENDIX C

Activity Hazard Analysis Sample (cont'd)

ACTIVITY HAZARDS ANALYSIS

Date Prepared: 12-05-2013

Project: Safe Ty Power Plant

Job: Maintenance on 480V Motor & Controls

JOB STEPS	HAZARDS	ACTIONS TO ELEMINATE OR MINMIZE HAZARDS	EM 385-1-1 (PARA REF)
(Cont.)		If verification of a de-energized state is not possible before performing switching on a device or before entering an arc flash boundary/limited approach boundary employ the use Arc Flash/Electrical Shock PPE and tools. Remember this is the least desirable and last line of safety protection from arc flash and electrical shock hazards. When operating valves and other mechanical devices use proper tools to minimize the possibility of excessive straining.	11.B.02 THRU 11.B.08 14.A
6. Maintenance procedures	Electrical Shock, Arc Flash, cuts, contusions	Wear proper arc flash and electrical shock PPE and verify the absence of voltage within the motor controller enclosure, motor, and other work places with possible exposed live parts. Verify correct operation of voltage sensing meters before and after check of voltage absence. (Proximity Voltage Sensors may not be used to verify voltage absence.) If complete voltage absence is not obtained with in the arc flash boundary/limited approach boundary, the proper arc flash and electrical shock protection must used while inside the arc flash boundary/limited approach boundary.	11.A.02 11.B.02 THRU 11.B.08 05.I NFPA 70E 130.3 & 130.4 NFPA 70E 110.4(A)& 120.1 11.A.02 11.B.02 THRU 11.B.08 05.I NFPA 70E 130.3 & 130.4

APPENDIX C

Activity Hazard Analysis Sample (cont'd)

ACTIVITY HAZARDS ANALYSIS

Date Prepared: 12-05-2013

Project: Safe Ty Power Plant

Job: Maintenance on 480V Motor & Controls

JOB STEPS	HAZARDS	ACTIONS TO ELEMINATE OR MINMIZE HAZARDS	EM 385-1-1 (PARA REF)
(Cont.)		You may only enter the prohibited boundary for testing purposes and nothing else. If live work must be performed or entry in the prohibited boundary is required, further de-energization will be required or as a last resort a live work permit should be requested.	11.A.02 11.B.02 THRU 11.B.08 05.I NFPA 70E 130.2
7. Use of Power and Hand Tools	Electrocution, Rotating Parts, Metal Chips, Dust, Cutting Edges, and Sharp Points	Use of electrically rated insulated tools are required when in the limited approach boundary.	11.A.04 05.I NFPA 70E 130.7(D)
8. Use of Chemicals	Chemical Irritation and Fires	Use only 3 wire Grounded Devices or Double Insulated Devices. Do not wear loose fitting clothing. Wear Eyes, Ears, and Hand PPE	13.A Section 5 NFPA 70E 110.4(B),(C),(D)
		Read product SDS before use, and follow as directed.	6.A 6.B
		Insure contact cleaner has evaporated and residue has been wiped off prior to energizing the equipment.	NFPA 70E 130.6(I)
9. Emergency Rescue	Electric Shock, Arc Flash, Disabling Injuries, and Death	When personnel are inside an Arc Flash and/or Limited Approach boundary a rescue person must be stationed beyond the boundaries and prepared to execute an emergency rescue.	
		The rescue personnel must be qualified to enter said boundaries and be trained in CPR/First Aid.	NFPA 70E 110.2(C)

Appendix C

Activity Hazard Analysis Sample (cont'd)

ACTIVITY HAZARDS ANALYSIS

Date Prepared: 12-05-2013

Project: Safe Ty Power Plant

Job: Maintenance on 480V Motor & Controls

JOB STEPS	HAZARDS	ACTIONS TO ELEMINATE OR MINMIZE HAZARDS	EM 385-1-1 (PARA REF)
9. (Cont)		The rescue personnel must dressed in the appropriate PPE & have on hand appropriate safety rescue tools. Rescue personnel must be familiar with the procedures for performing an electrical emergency rescue. Rescue personnel must remember not to place themselves in a dangerous situation in order to perform a rescue, but only enter when the situation poses no additional threat to themselves.	11.A.01 12.A.02 NFPA 70E 110.2(C)

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APPENDIX D

Analysis Statement of Work

DETAILED STATEMENT OF WORK 2 March 2014

CONTRACT NO. _____, TASK ORDER NO. 00XX, ARC FLASH HAZARD ASSESSMENT AND POWER SYSTEM ANALYSIS

1. FACILITY BACKGROUND. National Fire Protection (NFPA) 70E Standard for Electrical Safety Requirements for Employee Workplaces requires that an arc flash hazard (AFH) analysis be performed in order to protect personnel from the possibility of being injured by an arc flash (AF). The analysis is based on the available fault current and the fault clearing time. This information is used to determine the arc flash boundary (AFB) and the Protective Clothing and Personal Protective Equipment (PPE) that people within the boundary shall use. Switchboards, panel boards, control panels, motor control centers and other industrial locations that are likely to require examination, adjustment, servicing, or maintenance while energized must be analyzed and field marked to warn Qualified Persons of potential electric AF hazards.

To comply with the NFPA safety standard, all existing electrical equipment (including supply, distribution, and load for AC system at all voltages and ratings) that has a potential to produce an AFH at _____ must be assessed. This includes, but is not limited to, all the components within the powerhouse, spillway, navigation facilities, flood control facilities and fish facilities.

2. SERVICES TO BE PERFORMED. The Contractor shall conduct a power system analysis for the _____ electrical system, and other electrical systems at the _____ Facility, including the Navigation Lock, Service Building, Spillway, Fish Facilities, Visitor Center, and Warehouse. These electrical systems are defined on the attached one line diagram. These analyses shall include a short circuit study, protective device coordination, and an AFH assessment report detailing all the existing electrical equipment that has a potential to produce an AFH. This equipment is defined by NFPA 70E to include all medium voltage equipment (greater than 600 Volts), all low voltage equipment rated 600 Volts but greater than 50 Volts AC, and all equipment rated at 240 Volts and below that has a source transformer sized at 125 KVA and greater. These analyses shall include recommendations to minimize AFHs in the powerhouse electrical system and other ancillary electrical systems. Recommendations for improvements of protective coordination shall be included.

The following shall be included as part of the power system analysis for each area:

a. Base Data Collection. The Contractor shall gather necessary data to perform a detailed power system analysis including one-lines, nameplate data, breaker and relay settings, and manufacturer's data. Also included in this effort shall be the review of both the electronic files and data associated with the 1999 System Coordination Study for the applicable area and the

software model and data provided by HDC. This effort shall culminate in a submission of a technical memorandum.

(1) The Contractor shall conduct site visits as necessary to collect data, verify system configurations and interview operations personnel on operating procedures.

(2) The Contractor shall determine possible operating conditions including both normal and abnormal. Available documentation shall be reviewed to determine the normal operating configurations. Following the review of the normal configurations, interviews shall be conducted with the operating staff to determine configurations that may be utilized during abnormal conditions.

(3) The Contractor shall prepare a technical memorandum that provides an executive summary of the data collection effort and tabulate any missing data that might preclude full completion of the computer model. The Contractor shall include recommendations as to additional data to be collected, as well as provide an estimate of associated cost and schedule for completion of the data collection, in the technical memorandum.

b. Model Analysis and Recommendations. The Contractor shall use the most recent version of the [SKM System Analysis, Inc.'s Power*Tools® for Windows] [ESA EasyPower®] software to directly model the system and perform the studies in order to provide fully useable data files after completion of the study.

(1) Upon completion of the data collection tasks, the Contractor shall transfer the gathered data into the modeling software to verify a representation of the system for simulation and analysis.

(2) The Contractor shall perform analyses as necessary to complete the following:

- System Short Circuit Study under worst case conditions,
- Protective Device Coordination study, and
- AFH Assessment/Study

(3) The system short circuit study shall include circuit breaker interrupting ratings and available fault current. Breakers in which available fault currents exceed breaker ratings shall be included in the report.

(4) Protective device coordination study shall include time current curves of protective devices. Protective devices that are not coordinated with upstream or downstream devices shall be identified and recommendations to coordinate those devices shall be included in the report.

(5) The study shall include an AFH analysis at all locations and configurations defined as being subject to AFHs using the IEEE 1584 method of calculation. The following shall be included in the report:

- Equipment's state of maintenance
- Fault location
- Protective device for location
- Arcing fault (kA)
- Clearing time
- Incident Energy
- Arc Flash Boundary
- PPE Category
- Recommended hazard mitigation solutions, if an arc flash hazard is present
- Cost estimate for recommended hazard mitigation solutions, if any
- Working distance
- Equipment labels
- Where the existing relays and breakers can't be modeled in [SKM][ESA], then manual modeling shall be carried out and separate results furnished.
- A summary of calculated best engineering judgment values for data, which could not be collected or determined by tests.

c. Report. The Contractor shall provide a report detailing the analysis, results, and recommendations for the AFH assessment. The report shall consist of the following:

(1) Executive Summary. The executive summary shall include an overview of the current system, a summary of the results of the analyses, and recommended actions.

(2) Detailed Information. The detailed portion of the report shall contain the following:

- A narrative of how the analyses were conducted
- A discussion of the results of the analyses.
- All information required in paragraphs 2.a and 2.b, above.
- Recommended hazard mitigation shall be provided and may include, but not be limited to, suggestions regarding equipment setting changes such as new over current protection settings during normal conditions, temporary settings to be used during the performance of work on the system, suggested equipment upgrades such as new devices to be incorporated into the system, replacement of existing equipment with newer equipment, and change in work practices and/or system configurations.
- A hand calculation of the three phase bolted fault current available at one point in the system to compare with the results of the software analysis.

(3) Summary of Conclusions.

(4) Supporting Documentation. This shall include, but not be limited to, all relevant drawings, a list of the existing equipment and data collected, one-line drawings for all analyzed scenarios, time current curves for the existing settings where possible, and the time current curves for all recommended settings and/or configurations.

3. DELIVERABLES. All deliverable products and working papers shall be the property of USACE. Two paper copies of all non-electronic files shall be submitted. Deliverables for this task order are as follows:

a. Technical Memorandum. The draft and final technical memorandum shall be prepared in Microsoft Word and submitted electronically to the Technical POC.

b. Electrical System Study and AFH Assessment Report. The draft and final assessment report shall be prepared in Microsoft Word and submitted electronically to the Technical POC.

c. Electronic Files. All data files used to perform the analysis shall be provided in the electronic format necessary to easily update the Government's computer model. Additional files to be provided in electronic format are the report itself, and any other supporting documents which have an electronic file associated with them.

d. [SKM][ESA] data source files.

e. Electronic versions of [SKM][ESA] reports.

f. Electronic files of time current curves.

g. [SKM][ESA] software and associated license documentation.

h. Adhesive labels.

4. SCHEDULE. All services under this task order shall be completed by [insert date]. Specific milestones are as follows:

MILESTONE	Completion Date
Notice to Proceed	**April 20, 2013**
Begin Data Collection	**2 weeks after NTP**
Submit Draft Technical Memo to _____	**75 calendar days after NTP**
Submit Draft Hazard Assessment Report to _____	**60 calendar days after submission of draft technical memorandum**
Draft Hazard Assessment Report Comments to Contractor	**2 weeks after submission of draft report**
Final Hazard Assessment Report to _____	**60 calendar days after receipt of review comments**
Task Order Completion	**_____, 20xx**