



National Fire Protection Association

ARC FLASH PHENOMENA

Collaborative Research Project

IT'S ALL ABOUT PROTECTING PEOPLE

Over 2000 times a year, workers are admitted to burn centers for extended injury treatment. Although many types of injuries can result from exposure to arcing faults, one major corporation reports that up to 80 percent of all its electrical injuries are thermal burns associated with arcing faults.

According to a study conducted by the Department of Labor's Bureau of Labor Statistics, 2287 U.S. workers died and 32,807 U.S. workers sustained lost time injuries due to electrical shock or burn injuries over a seven year period starting in 1992. The study showed that of the 32,807 non-fatal injuries involving lost time, 38% were classified as electrical burns. Electrical injuries each caused an average of 13 days away from work and nearly one fatality every day of the year.

Electrical incidents, although a small proportion of total worker incidents, are disproportionately fatal. For example, in 1997 there were 6.1 million non-fatal injuries reported, of which 1.3 million were associated with one or more days away from work. Only 1 in every 494 days away from work that year was associated with electrical injuries, but fully 1 in every 20 fatalities was an electrical fatality. The report concluded that: "To decrease the number and severity of non-fatal electrical burn injuries, direct worker exposure to electrical arc energy must be reduced."

A ten-year study involving over 120,000 employees performed by Electricite de France found that electrical arc injuries accounted for 77% of all recorded electrical injuries. While some recorded injuries involved untrained individuals,

the overwhelming majority involved trained electrical workers.

Though electrical incidents represent a relatively small percentage of all work-related incidents; they are disproportionately fatal and, in the case of burns, they may result in extended hospitalization and rehabilitation. The most frequently identified consequences associated with an arcing fault injury are thermal burns, shrapnel injuries, and hearing and sight impairments. In addition, electrical arcs often cause workers to fall, resulting in disabling injuries or death. In such cases, the cause of injury or death may be recorded as a fall, and not electrical, further distorting the real hazard.

The Institute of Electrical and Electronic Engineers (IEEE) and the National Fire Protection Association (NFPA) have agreed to collaborate on an initiative to fund and support research and testing to increase the understanding of the arc flash phenomena. The results of this project will provide information that can improve electrical safety standards, predict the hazards associated with arcing faults and accompanying arc blasts, and provide practical safeguards for employees in the workplace.

Indeed, the IEEE/NFPA Arc Flash Collaborative Research Project is all about protecting people.

WHAT WE NEED TO LEARN

There are several areas of the arc flash phenomena that need further research to provide pertinent information that can be used to develop safety strategies that will protect workers. The areas identified include the following:

Heat. Burns are the most commonly reported effects of arc flash. Validation and extension of information relating electrical energy to burn potential will be conducted.

Pressure. Past incidents and some research have demonstrated that an arcing fault generates a pressure wave. More information is needed to predict the intensity of the pressure wave and determine its consequences. Specifically, the maximum amount of pressure in addition to the pressure differential that a worker might encounter would identify potential injuries and protective strategies. As part of this study, the mitigating or complicating effects of enclosure construction and geometry will be considered.

Sound. Pressure from arcing faults can result in hearing damage to workers. More information is needed about the intensity of these sound pressure waves. As part of this evaluation, research will determine what methods of hearing protection are most practical and how effectively personal protective equipment (PPE) can attenuate sound.

Toxicity. The composition of the plasma in an electrical arc and the resultant gases that are released will be studied. The gases will be analyzed to determine their toxic and corrosive components. The effects of these components on personnel and on PPE will also be evaluated.

PPE. Personal protective equipment has been the primary protective strategy for electrical workers. Research is needed to determine how effective PPE has been in protecting workers from the various hazards of an arc flash/arc blast incident. In addition, injuries to workers who were not wearing appropriate protective clothing will be analyzed.

Medical effects. More needs to be understood about the effect of various wavelengths of energy in arcing faults on the human body. The potential of this energy to cause injury to eyes, ear drums, and other organs needs to be better understood. This information will influence the design and application of various types of PPE as well as work practices.

INDUSTRY SUPPORT IS NEEDED TO FUND THIS IMPORTANT PROJECT

IEEE and NFPA need your support to proceed with this important work. The research program is estimated to cost several million dollars. Please consider carefully your organization's contribution to this fund, as you evaluate the impact that this research and testing program will have on your organization, and on the safety of electrical workers throughout the world.

HOW THE MONEY WILL BE USED

This research and testing initiative will develop deeper insight into arc flash phenomena and the hazards they pose for those working on or near electrical equipment. This collaborative effort brings together the two organizations that have been at the forefront of electrical safety issues and, more importantly, that will apply the knowledge gained to create practices and standards that enhance workplace safety. The data and information generated by this project will strengthen electrical safety standards.

The intent is that the IEEE 1584 Committee will use the new information and data to expand IEEE Standard. 1584 – IEEE Guide for Performing Arc-Flash Hazard Calculations. This guide provides techniques for designers and facility operators to apply in determining the flash hazard area and the amount of energy to which employees can potentially be exposed when working on or near electrical equipment.

The intent is that the NFPA 70E Technical Committee will use the new information and data to enhance work practice requirements in NFPA 70E – Standard for Electrical Safety in the Workplace. This standard, widely cited by OSHA, covers safety-related work practices, including employee training,

hazard/risk evaluation, establishing an electrically safe work condition, establishing approach boundaries, and selecting and using personal protective clothing and equipment.

Test Plan

The proposed research and testing plan will focus on the following:

- » **Engineering-Based Model.** A review of available information suggests that development of a three-base, engineering-based model is not currently possible using available research data. This report presents a list of suggested tests with the goal of developing an engineering-based model of arc flash energy for three-phases of arcs in enclosures.
- » **Thermal Effects.** Current methods of measuring the thermal effects of an arcing fault will be evaluated to determine if they can be extended to areas not yet investigated. This report includes plans for using upgraded calorimeters or isolating calorimeters as an alternative. The calorimeters will be placed in a spherical pattern and closer to the arc than in previous

testing. The research and test plan also recommends an investigation of low-current, long-duration arcs.

» **Heat Transfer and Injury Statistics.**

Sufficient published heat transfer information is available to determine the modes of thermal energy transfer. This report contains a research plan to determine convective, conductive, and radiative components as a percentage of total thermal energy transfer. Sufficient information is available to determine the effect of energy components on human tissue and clothing. The report recommends further review of an electrical injury database provided by NIOSH with the purposes of (1) identifying measures that, if implemented, could have avoided the exposures listed in the database and (2) generating a template that can serve to gather electrical incident information in the future.

» **Hazards Other Than Thermal and**

Electromagnetic. This report describes the known characteristics for blast, pressure, shrapnel, sound, and toxicity hazards (based on a review of existing literature) and discloses significant conditions within each category that are not completely understood. This report recommends a test plan (in conjunction with other recommended arc tests) to better quantify and advance the knowledge of these additional hazards.

» **Electromagnetic Hazards.** The non-thermal effects of an electrical arcing fault have not been studied extensively. The spectrum of the energy radiated during an arcing fault cannot be accurately predicted. The optical portion of the electromagnetic spectrum, including infrared, visible, and ultraviolet energy, is of particular concern. This report presents a test plan to determine the intensity of established bandwidths (including ultraviolet, infrared, and x-ray) and other potentially injurious energy bands in the electromagnetic spectrum released during an electrical fault. The testing should be conducted with a suitable spectrometer to measure the optical radiation released during an arc blast. The results of these measurements should be compared with the Threshold Limit Values provided by the American Conference of Industrial Hygienists.

» **Impact of Enclosures.** This report presents a research and test plan that will improve understanding of the effect of enclosure doors and components, such as contactors, that typically are mounted within the enclosure. The research and test plan is designed to provide information necessary to assess the impact of equipment doors and enclosed components on the energy released during the arcing fault.

HOW YOUR ORGANIZATION CAN BENEFIT

This project is expected to benefit the following industry groups.

ELECTRICAL WORKERS

Employees can expect to benefit from safer work practices and decreased probability of serious injury. People who work on electrical equipment, in other words, electricians, have much greater likelihood of suffering a serious or fatal accident than other craftspeople. When an incident is non-fatal, the length of lost time is frequently quite lengthy due to the healing time of severe burns. The better we understand the hazards, the better we can develop safe work practices, equipment, and the standards that govern workplace practices.

EMPLOYERS

This means safer workers, fewer on-the-job injuries, reduced workers' compensation claims, and reduced insurance premiums, fewer days away from work, more productive employees, and a better reputation as an employer and community member. Electrical incidents in the workplace result in an average of 13 days away from work and are more likely to be fatal when compared to other injuries.

INSURANCE CARRIERS

Claims for these types of injuries, property damage and lost production will go down. Insurers will have better tools to educate insureds about safer work practices.

ELECTRICAL EQUIPMENT MANUFACTURERS

Manufacturers will have access to better arcing fault information, which can be used to design safer components and provide better guidelines for safely maintaining electrical equipment. This can reduce product liability costs and lead to new or improved product lines.

PERSONAL PROTECTIVE EQUIPMENT MANUFACTURERS

Better knowledge about arcing faults can lead to improvements in protective clothing design, new products, and better definition of the operating envelope for this equipment. This can reduce product liability costs .

GOVERNMENT

Workers' compensation and disability claims to state and federal insurance programs can be reduced.