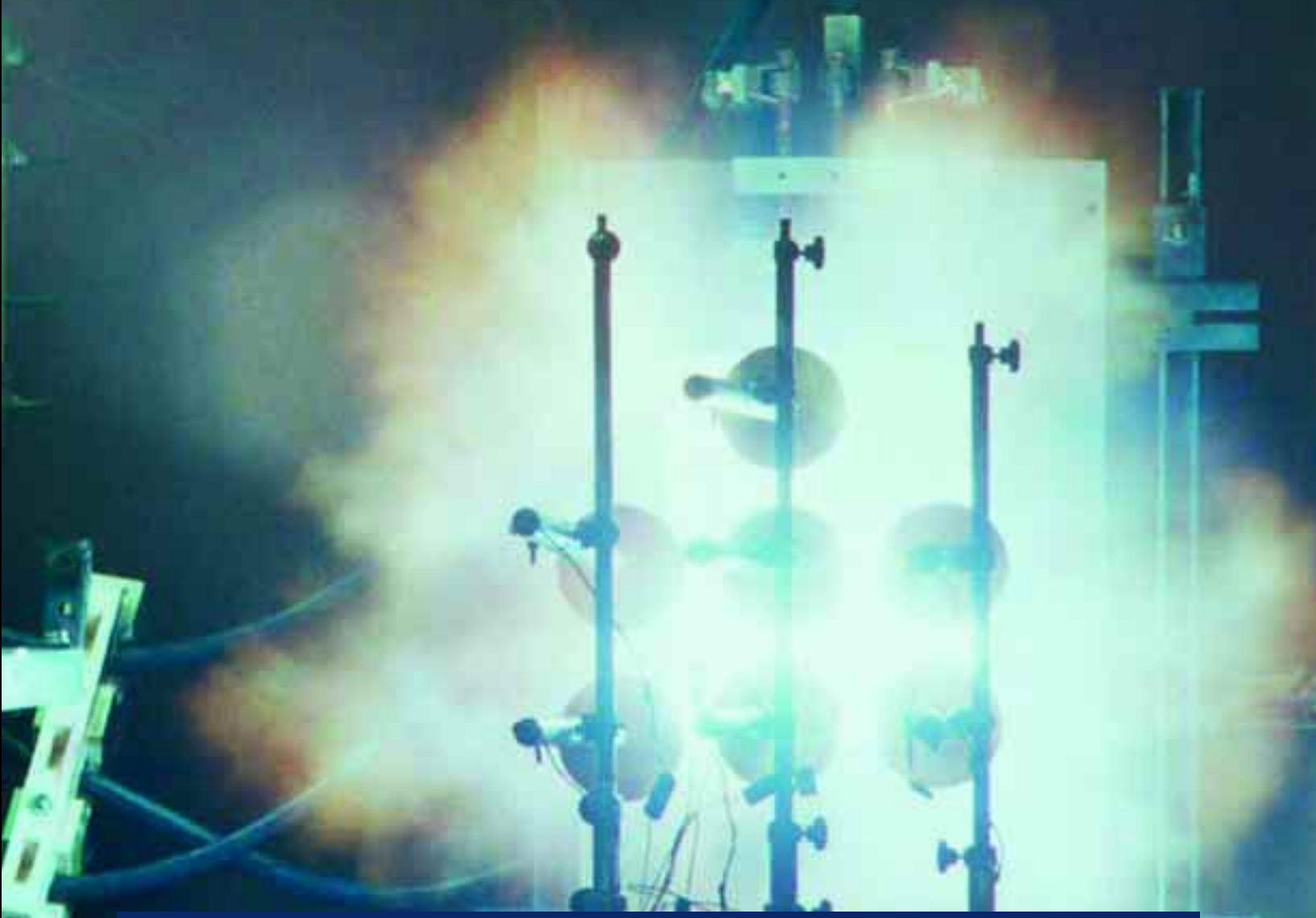
IEC INSIGHTS
The Magazine for Today's Independent Electrical Contractor

Understanding Arc Flash Hazards

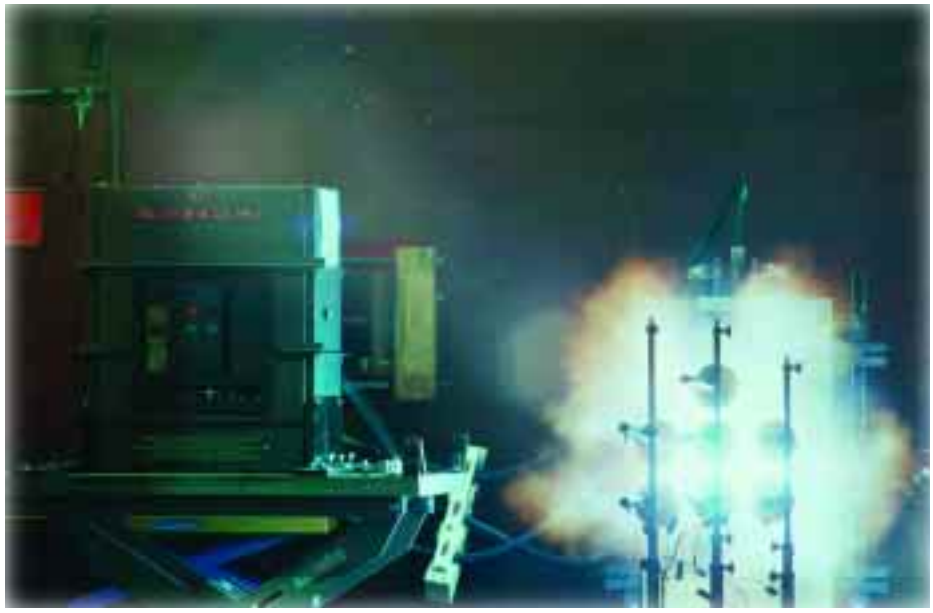


Reprinted From May/June 2004 Issue Of *IEC Insights Magazine*, The Official Publication Of Independent Electrical Contractors, Inc., Alexandria, VA.
For More Information, Contact The IEC At www.ieci.org

Understanding Arc Flash Hazards

Kevin Lippert

INTRODUCTION



AT A VERY YOUNG age, children learn that touching an energized electrical conductor will "shock" them; many even understand that this could kill them. As individuals working in the electrical industry, we learn more details of this hazard. At about 40 mA of current, a shock lasting for one second or longer can be fatal due to the possibility of ventricular fibrillation, or the heart ultimately stopping altogether. Currents as low as 6 mA can cause a person to be unable to "let-go" of (or release) an energized object. Another hazard encountered by contractors, electricians, engineers and others in the electrical industry is arc flash. This phenomenon is less well understood and is the subject of this article.

An electrical arc flash is the release of a tremendous amount of energy due to an uncontrolled arc within equipment. This energy takes the form of intense light, dangerous sound and pressure waves, expelled molten metal and shrapnel, and arc temperatures of several thousand degrees Celsius. An arc flash incident is commonly characterized as an explosion, which occurs in milliseconds, much too fast for human reaction time. The consequences of an arc flash can be an extended loss of power, loss of production, ruined electrical equipment, permanent personal injuries and even death. Anything that establishes an electrically conductive path between energized conductors of opposite polarity, or between an energized conductor and ground potential, creates the possibility for an arc flash. When working equipment live, a simple slip of a wrench, or drop of a tool, wire or any conductive object is enough to start this event. Even though the initial contact may be a brief touch, the resulting arc flash can create a ball of plasma that allows the ionized air to continue to conduct the electrical current.

CODES & STANDARDS

The 2002 edition of the *National Electrical Code® (NEC), NFPA 70*, added the term arc flash, and created a new Article 110.16 that reads as follows:

> *"Flash Protection. Switchboards, panelboards, industrial control panels, 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 electric arc flash hazards. The marking shall be located so as to be clearly visible to qualified persons before examination, adjustment, servicing, or maintenance of the equipment.*
>
> *FPN No. 1: NFPA 70E-2000, Electrical Safety Requirements for Employee Workplaces, provides assistance in determining severity of potential exposure, planning safe work practices, and selecting personal protective equipment.*
> *FPN No. 2: ANSI Z535.4-1998, Product Safety Signs and Labels, provides guidelines for the design of safety signs and labels for application to products."*

This requirement was intended to raise the level of awareness of the arc flash hazard, in turn reducing their occurrences, along with their damaging and dangerous consequences. The NEC mandates that the marking label be field installed. It is the responsibility of the contractor/electrician/installer to properly affix this marking. See **Figure 1** for an example of a label that meets this NEC requirement.

Figure 1 — Label Meets NEC Requirement

Proposals for the 2005 edition of the NEC suggested expanding the required marking to indicate the incident energy in calories per square centimeter for a worker at a distance of 18 inches. Other proposals suggested requiring the marking of the flash protection boundary and the Personal Protective Equipment (PPE) needed. If these proposals ever become adopted, it will become burdensome for the installer to correctly determine these quantitative values. It will also create enforcement problems when the Authority Having Jurisdiction (AHJ) attempts to verify them.

Referenced from FPN No. 1 of NEC Article 110.16 is NFPA 70E, *Electrical Safety Requirements for Employee Workplaces*. This is a comprehensive electrical safety document that was created in collaboration with OSHA. It requires an employer to implement an overall electrical safety program. Key principles of such a program are the identification and education of the hazards involved. The appropriate tools, equipment and procedures must then be provided to minimize these hazards. NFPA 70E promotes the first level of prevention as placing the equipment in an electrically safe working condition (lock-out/tag-out) before an employee works on or near the equipment. An exception to this rule is when an employer can demonstrate that de-energizing introduces additional or increased hazards, or is infeasible due to equipment design or operational limitations. For these situations, the employer is further tasked to protect their workers from electrical hazards, one portion of which is arc flash.

Only qualified persons are permitted to work on energized conductors. The NEC defines a qualified person as "One who has skills and knowledge related to the construction and operation of the electrical equipment and installations and has received safety training on the hazards involved." The employer is additionally required to conduct an arc flash hazard analysis before the qualified person may approach any energized conductors. An outcome of this analysis will determine the incident energy exposure of the worker, in units of calories per square centimeter. Two important factors in the determination of this numerical value are the electrical system's available fault current, and the operation time of applicable overcurrent protective devices. For this reason, it is very important to have the most accurate and up-to-date electrical system parameters available. Once the arc flash hazard analysis identifies the energy level, the proper Personal Protective Equipment (PPE) can be selected.

The *IEEE (Institute of Electrical and Electronic Engineers) 1584 Guide for Performing Arc Flash Hazard Calculations* is a dependable method for quantifying arc flash incident energy. However, it is intended for use by electrical designers and those knowledgeable about electrical distribution systems and their components.

PERSONAL PROTECTIVE EQUIPMENT (PPE)

Properly selected PPE is designed to minimize the worker's risk of sustaining more than a second-degree burn during an electrical arc flash incident (defined as occurring at 1.2 cal/cm^2). Choosing inadequate PPE can lead to even more severe burns. Injuries occur because of flash burns from the heat generated by the electric arc and by flame burns from the ignition of clothing or other combustible materials. Clothing that is not flame retardant (FR) can increase the severity of burns. Even FR fabric can ignite, but it will self-extinguish after the external ignition source (flame or arc) has finished burning. Non-FR fabrics that ignite (start to burn) will continue to burn even after the ignition source has been removed.

ASTM F1506, Performance Specification for Flame Resistant Textile Materials, calls for every flame resistant garment to be labeled with an electric arc energy rating, ATPV-Arc Thermal Performance Exposure Value. To specify the right protection, the rating of the garment must be matched to the energy level value identified by the arc flash hazard analysis. Synthetic fabric made from Acetate, Nylon, Polyester or non-FR rayon must not be used unless the clothing meets ASTM F1506. These fabrics can melt and drip, and the melted fabric can stick to the skin with a resulting increase in the severity of the injury.

In addition to flame resistant clothing comprised of flash suits and hoods for high incident energy exposure, PPE also includes: insulating gloves; insulated tools; normally used hard hats; safety shoes; safety glasses; and hearing protection.

PROCEDURES FOR AVOIDING ARC FLASH HAZARDS

Having explained the fundamentals about arc flash hazards, it is important to consider ways to reduce these hazards. There are many common sense procedures that will help to reduce the incident energy hazard.

- Improved workplace training programs to increase awareness of the hazards associated with arc flash energy.
- De-energizing the equipment. Although it sounds simple, ***no electrical accident can occur when equipment is not energized.*** Users should look for new ways to reduce or eliminate the necessity for personnel to work on energized equipment. Inconvenience should not be an excuse for exposing workers to unnecessary hazards. Improving safe work practices must be a priority.
- Hazard analysis. When there is no alternative to working on energized equipment, an arc flash hazard analysis should always be performed. When this analysis indicates the possibility of severe burns, the use of Personal Protective Equipment (PPE) is typically required. The user should look for the ATPV rating label in the clothing/equipment, and match that value to the specific arc hazard determined.
- Positioning. When operating electrical equipment, use the "left-hand rule" when possible (stand to the right side of the equipment and operate the disconnect with your left hand). This will remove the worker from the direct path of any expulsion from the equipment.
- Use of remote racking/operating systems. Remote racking or operation systems allow operators to perform these procedures from a safe distance instead of directly in front of the equipment. The further the distance from the energy source, the lower the incident energy.
- Optimum adjustment of the time settings on power circuit breakers. Short-time delay settings should be carefully considered when applying low voltage power circuit breakers in systems where employees will be exposed to live parts. There is a tradeoff between selective coordination achieved with the use of a short-time setting and the level of arc flash due to extended arcing time. The shortest delay setting should be used compatible with the desired level of coordination.

DESIGN CONSIDERATIONS FOR REDUCING ARC FLASH HAZARDS

When arc flash considerations are a significant factor in the design and selection of electrical distribution equipment, there are a number of existing technologies to consider. These include: selection of current-limiting circuit breakers and fuses; addition of ground fault protection; use of zone selective interlocking of breakers; specification of arc resistant medium voltage switchgear; use of high resistance system grounding; and requiring "finger-safe" electrical components and insulated bus in equipment.

CONCLUSION

Electrical arc flash hazards have the potential for devastating consequences. To totally avoid this hazard, personnel should only work on equipment that is de-energized following the appropriate lock-out/tag-out procedures. When it is impossible to work on de-energized equipment, an arc flash hazard analysis should be conducted to determine the proper Personal Protective Equipment (PPE) that qualified personnel should use to prevent serious burn injuries. Although recently published information is helpful to select the proper level of PPE, it should be clearly understood that PPE is a "last line of defense." IEC

Kevin Lippert is Managing Director of Codes & Standards with Eaton's Electrical business in Pittsburgh, PA.

Eaton's electrical business is a global leader in electrical control, power distribution, and industrial automation products and services. Through advanced product development, world-class manufacturing methods, and global engineering services and support, Eaton's electrical business provides customer-driven solutions under brand names such as Cutler-Hammer®, Powerware®, Durant®, Heinemann®, Holec® and MEM®, which globally serve the changing needs of the industrial, utility, light commercial, residential, and OEM markets. For more information, visit www.EatonElectrical.com.

Eaton Corporation is a diversified industrial manufacturer with 2004 sales of $9.8 billion. Eaton is a global leader in electrical systems and components for power quality, distribution and control; fluid power systems and services for industrial, mobile and aircraft equipment; intelligent truck drivetrain systems for safety and fuel economy; and automotive engine air management systems, powertrain solutions and specialty controls for performance, fuel economy and safety. Eaton has 59,000 employees and sells products to customers in more than 125 countries. For more information, visit www.eaton.com.

Eaton Electrical Inc.
1000 Cherrington Parkway
Moon Township, PA 15108
United States
tel: 1-800-525-2000
www.EatonElectrical.com

Cutler-Hammer

Printed in USA
Publication No. RE02701002E / Z4112
January 2006