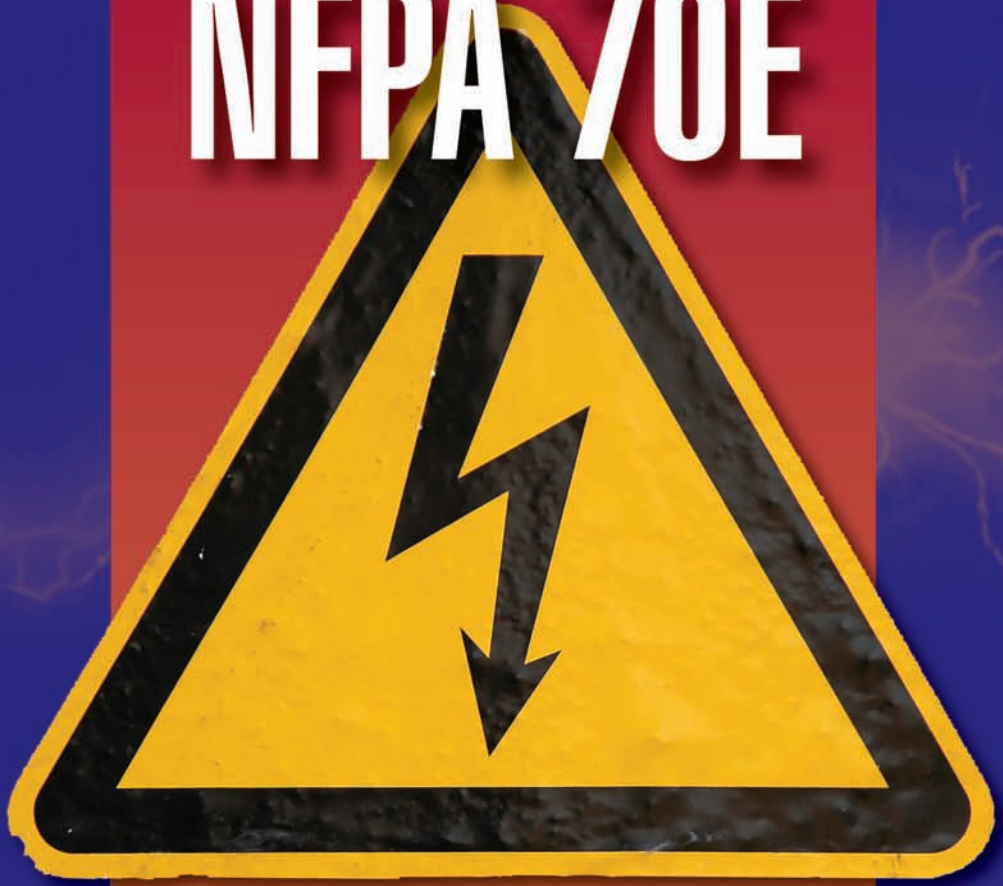
NFPA 70E



Standard for Electrical Safety in the Healthcare Workplace

Reprinted with permission, American Society for Healthcare Engineering (ASHE) of the American Hospital Association (AHA). For additional information contact ASHE at 312-422-2800 or E-mail ashe@aha.org.

The healthcare industry is continuously evolving, resulting in the remodeling and expansion of existing facilities. There will always be a push to work on or near energized equipment to avoid disruption of the critical environment during maintenance and construction. Anytime energized equipment is accessible, there is a danger to those in the vicinity, and whether it is a routine inspection or taking a load reading to determine a panel's capacity for future expansion, electrical safety should be foremost in the mind of all healthcare engineers.

Many facility engineers are finding that electrical contractors are unwilling to work on or near energized equipment. It is often the electrical contractor's policy, due to their insurance, that energized work never be undertaken. However, there are many instances where work must be done in energized panels, and it often falls to the facility engineers and electricians to do all the hot work because the contractor is unwilling to do so. This increases the importance of healthcare facility managers, engineers, and electricians being trained to understand how to determine and mitigate electrical hazards in the healthcare workplace.

The NFPA 70E Electrical Safety in the Workplace standard was created to bridge the gap between the National Electric Code (NEC) and the Occupational Safety and Health Act (OSHA). This paper will interpret and summarize the requirements of training and protecting of electrical workers who install and service electrical distribution equipment and components in a healthcare environment and is not meant to be a substitution for the actual standard or the safety training required by the standard.

The department of labor estimates an average of 9,600 serious electrical shock and burn injuries each year, with one fatality per day due to electrocution. It is estimated that direct and indirect costs of a major electrical injury event can be $23 million and that 91% of electrical related accidents are the result of poor safe work practices. A National Institute for Occupational Safety and Health (NIOSH) Report estimates that 5 to 10 injuries involving arc flash explosions occur every day in the United States. NFPA 70E provides instruction and tools to alleviate workplace risk due to electrocution and arc flash.

About NFPA 70E

NFPA 70E is intended for use by employers, employees, and OSHA to protect electrical workers from the inherent dangers of working near and with energized equipment. The NEC, by contrast, is intended to be used by those who design, install, and inspect electrical installations. The NEC instructs you on how to install it, OSHA requires you to be safe while installing it, and NFPA 70E gives you the tools, knowledge and practices to safely do so.

The technical nature of the NEC is extremely difficult for the average employee and employer to understand, and there is a good portion of the text that is not directly related to employee safety or OSHA's needs. There are also requirements for electrical safety that are not included in the NEC that OSHA must consider. NFPA 70E was developed to solve these problems.

NFPA 70E addresses these electrical safe work practices, and covers the installation of power, signaling and communications wiring and equipment. It sets training requirements, outlines safety programs, details the process for achieving electrically safe work conditions, and defines safety-related maintenance requirements for many situations that arise in the healthcare environment.

NFPA 70E is split into 4 chapters:

- **Chapter 1,** Safety-Related Work Practices;
- **Chapter 2,** Safety-Related Maintenance Requirements;
- **Chapter 3,** Safety Requirements for Special Equipment; and
- **Chapter 4,** Installation Safety Requirements.

Chapter 1, *Safety-Related Work Practices* gives general requirements for electrical safety-related work practices, processes for establishing an electrically safe work condition, and requirements for working on or near live parts. This chapter includes requirements for training, electrical safety programs, lockout/tagout procedures, flash hazard analysis, boundaries for live parts, determining the hazard/risk category for various tasks, and personal protective equipment requirements for each hazard category.

Chapter 2, *Safety-Related Maintenance Requirements* covers practical safety-related maintenance requirements for various electrical equipment and installations in the workplace. However, it does not prescribe specific maintenance methods or testing procedures, only maintenance directly associated with employee safety. The methods and procedures can be found in NFPA70B *Recommended Practice for Electrical Equipment Maintenance*. Some equipment included in Chapter 2 consist of substations, switchboards, panelboards, motor control centers, wiring, rotating equipment, batteries, and hazardous location equipment.

Chapter 3, *Safety Requirements* for Special Equipment covers electrical safety installation requirements and safety-related work practices and procedures for employees who work on or near special electrical equipment, including electrolytic cells, batteries, lasers, and power electronic equipment, which includes arc welding equipment, motor drives, UPS systems, and lighting controllers.

Chapter 4, *Installation Safety Requirements* consists of aspects of NFPA 70 *National Electric Code* that deal directly with electrical safety in the work place.

Application of NFPA 70E

NFPA 70E is a standard, not a code, and therefore not directly enforceable. However, both the NEC and OSHA have requirements that make understanding and applying NFPA 70E a must. OSHA enforces NFPA 70E under the "General Duty Clause" in the 29 CFR 1910 Code of Federal Regulations, which requires the employer to assess the workplace for hazards, furnish a workplace that is free from recognized hazards, and enforce the use of protective equipment when working where a potential electrical hazard exists. OSHA also requires that energized parts greater than 50 volts to ground be de-energized unless the employer can demonstrate that the NEC requires arc flash warning labels to raise the level of awareness of flash hazards.

What has everyone interested in NFPA 70E is that it offers a quantitative way to analyze shock and arc flash/blast hazard, and defines personal protection equipment necessary for specifically defined situations. Arc-flash labeling has been required by the NEC since 2002, and it requires that electrical equipment that is likely to require examination or maintenance while energized shall be field marked to warn qualified persons of potential electric arc flash hazards. NFPA 70E provides the assistance needed in determining the severity of potential exposure, planning of safe work practices, and selection of personal protective equipment.

What has everyone interested in NFPA 70E is that it offers a quantitative way to analyze shock and arc flash/blast hazard, and defines personal protection equipment necessary for specifically defined situations.

Establish an Electrically Safe Work Condition

The best practice is to establish an electrically safe work condition for every task, which is achieved by performing the following:

- Determine all possible sources of electrical supply
- De-energize by opening disconnecting device for each source
- Visually verify that all blades of the disconnecting device is fully open or that drawouttype breakers are withdrawn fully where possible
- Apply proper lockout/tagout procedures
- Check for voltages between phases and between phase and ground
- Where the possibility of induced voltages or stored electrical energy exists, ground the phase conductors or circuit parts.

Work on Energized Equipment

Requirements for working on energized equipment make up a large part of NFPA 70E. Ideally, no work would be done on energized equipment, but often that is just not feasible.

To work on or near energized equipment, the following should be considered or provided:

- **Justification of Work** – the employer must demonstrate that deenergizing introduces additional or increased hazards or is infeasible due to equipment design or operational limitations. Such examples are interruption of life-support equipment, deactivation of emergency alarm systems, and shutdown of hazardous location ventilation equipment.
- **Energized Electrical Work Permit** – a work permit should be provided that includes a description, justification of work, safe work practices, shock hazard analysis, shock protection boundaries, flash hazard analysis, flash hazard boundaries, personal protective equipment (PPE) requirements, access restrictions for unqualified persons and energized work approval.
- **Shock Hazard Analysis and Approach Boundary** – a shock hazard analysis that will determine the approach boundary should be performed.
- **Flash Hazard Analysis and Determination of Hazard/Risk Category** – a flash hazard analysis should be performed to determine the hazard/risk category (HRC).
- **Personal Protective Equipment** – PPE should be determined given the results of the flash and shock hazard analysis.

Hazard Analysis

The NEC requires new installations to be labeled for arc flash, but does not require facilities to label existing equipment. For best safe work practices, a thorough arc flash analysis of a facility's electrical system should be performed, evaluating the arc and shock hazard of all equipment, and recommending proper safety procedures and PPE for work near the equipment.

Not only will this create a much safer workplace, but at older facilities, a comprehensive review of an electrical system that has been remodeled many times can be accomplished, enabling a more accurate and complete understanding of the facility's electrical system.

An arc flash hazard analysis is based on mathematical formulas (IEEE Standard 1584) that yield a distance from a possible arc flash source for a second-degree burn and the incident energy exposure, given the available short circuit current, voltage, and breaker clearing times for the equipment.

A thorough hazard analysis is not required. NFPA 70E provides the following tables that can be used in lieu of analysis to determine the hazard and required PPE, as long as all of the short circuit and clearing time assumptions are met:

- *Approach Boundaries to Live Parts for Shock Protection,* Table 130.2(C) (See NFPA 70E), should be used to determine the Limited, Restricted, and Prohibited approach boundaries as they relate to shock hazard.
- *Hazard/Risk Category Classifications,* Table 130.7(C)(9)(a) (See NFPA 70E), should be used to determine the HRC for common tasks as they relate to arc flash and blast hazards.
- *Protective Clothing and Personal Protective Equipment Matrix,* Table 130.7(C)(10) (See NFPA 70E) should be used to determine the required PPE for the different hazard/risk categories. This includes clothing as well as protective equipment such as flash suits, hard hats, and eye, face, head, hand, and foot protection.

It is very important to recognize that these tables have limits placed on them, and that they do not apply to many situations. If the task is not exactly what is in the table, or if the panel short circuit rating or breaker clearing times do not match the assumptions, the table should not be utilized.

Below are the Limited, Restricted, and Prohibited Boundary Distances (from Table 130.2(C) (See NFPA 70E)) for equipment from 50V up to 750V. This does not represent the entire table, but gives an idea of the information included.

Limited Approach – Exposed Movable Conductor	10'-0"
Limited Approach – Exposed Fixed Circuit Part	3'-6"
Restricted Approach	1'-0"
Prohibited Approach	0'-1"

The Limited Approach boundary is the limit at a distance from an exposed live part within which a shock hazard exists. The Restricted Approach Boundary is the 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. The Prohibited Approach Boundary is the limit at a distance from an exposed live part within which work is considered the same as making contact with the live part.

Below are some examples of some common tasks and their HRCs, as detailed on Table 130.7(C)(9)(a) (See NFPA 70E). This does not represent the entire table, but gives an idea of the information included.

- **Category 0 Examples**
  - Breaker Operation, Cover On
- **Category 1 Examples**
  - Breaker Operation, Cover Off – 480V Panel
  - Removal of Bolted Covers – 208V Panel
  - Work on Energized Parts, Install Breaker, Voltage test – 208V Panel
- **Category 2 Examples**
  - Work on Energized Parts, Install Breaker, Voltage test – 480V Panel or Switchboard, MCC, Switchgear
  - Racking Breakers with Cubicle Door Closed – 480 V Switchgear
- **Category 3 Examples**
  - Removal of Individual MCC Starter Bucket
  - Racking Breakers with Cubicle Door Open – 480 V Switchgear
  - Removal of Bolted Covers to Expose Live Parts
  - 480 V Switchgear
- **Category 4 Examples**
  - Breaker Operation with Door Open – Metal Clad Switchgear, 1kV and Above
  - Work on Energized Parts, Voltage Testing – Metal Clad Switchgear, 1kV and Above

Below are some examples of protective clothing for specific HRCs per Table 130.7(C)(10) (See NFPA 70E). This does not represent the entire table, but gives an idea of the information included.

Category	Personal Protective Equipment Repuirements
0	Non-melting, flammable materials
1	Flame retardant shirt and pants or coverall
2	Cotton underwear (conventional short sleeve and brief/shorts) PLUS flame retardant shirt and pants
3	Cotton Underwear PLUS Flame Retardant shirt and pants PLUS Flame Retardant coverall, OR cotton underwear PLUS two flame retardant
4	Cotton underwear PLUS Flame Retardant shirt and pants PLUS multilayer flash suit

How to Limit Arc Exposure

It is very important to understand how different short circuit ratings and different breaker types and sizes can affect the severity of the hazard. Incident energy of an arc will increase with fault current and time. Through system design and operating procedure, one can reduce the incident energy level.

The following tips may help reduce the incident energy:

- Place close/open control switches for breakers with electric close and trip control on a remote or non-breaker panel
- Use a remote or longer operating arm when racking in or opening/closing breakers
- Confirm that protective devices are set at their lowest possible trip and pick-up times
- Open an incoming or tie breaker to reduce available fault current on double-ended load centers or substations
- Confirm that fuses are sized correctly, as smaller fuses reduce exposure time
- Lower relay settings when working on live equipment to decrease clearing time

Conclusions

Electrical safety is important to all those who work around electrical equipment; all individuals should leave their workplace in the same condition as when they arrived. NFPA 70E gives healthcare facility management and engineers the tools, knowledge, and practices they need for a safe workplace. The hospital engineer should be familiar with the requirements of NFPA 70E, and have methods in place for training, analysis, and determination of PPE. ASHE

Andrew Meyers, PE, LEED® AP, Associate Electrical Engineer, Mazzetti & Associates - Consultants & Engineers, San Francisco, CA. Andrew can be reached by e-mail at andrewm@mazzetti.com.