

## I. Introduction

An increasing number of organizations are actively promoting electrical safety for employees. The National Fire Protection Association's *NFPA 70E, Standard for Electrical Safety in the Workplace*, an American National Standard, is updated on a three-year cycle. The Institute of Electrical and Electronics Engineers (IEEE) publishes the Yellow Book, the *IEEE Guide for Maintenance, Operation, and Safety of Industrial and Commercial Power Systems*, and IEEE 1584™, the "IEEE Guide for Performing Arc-flash Hazard Calculations." Cooper Bussmann makes available an "Arc-flash Calculator Guide," see Annex G and an arc-flash calculator on its website ([www.bussmann.com](http://www.bussmann.com)). The University of Chicago Trauma Center has a unit that specializes in electrical burns and related injuries. Its interests are not only on improving treatment methods but also in providing insight into electrical injuries and awareness of how to avoid electrical hazards. Major manufacturers and entire industries are seeing benefits of becoming more involved in promoting employee safety awareness programs.

The purpose of this Safety BASICS™ handbook is to do the following:

- Increase awareness of safety issues for individuals who work on or near electrical equipment as well as system operators and equipment designers/specifiers.
- Provide safety principles to be used for protecting individuals from potential injuries and even death caused by electrical hazards.
- Provide some means to perform flash hazard analysis.
- Provide some design, system upgrades and work practice suggestions that enhance electrical safety in the workplace.

This material is designed to provide the reader with an overview of hazards associated with exposure to electrical energy. It highlights standards and standard organizations, and offers guidance on safety procedures and a number of key principles that can help to minimize exposure to electrical hazards. Knowing how to minimize the exposure to electrical hazards or reducing the hazard itself can help to reduce future injuries and even deaths.

The Safety BASICS program is for the supervisor, manager, electrician, engineer, and the designer/specifier of equipment used in the electrical system. The IEEE makes it very clear that, "Engineers engaged in the design and operation of electrical systems protection should familiarize themselves with the most recent OSHA regulations and all other applicable regulations related to human safety." To the IEEE, providing adequate safety means going beyond the minimum requirements of consensus standards.

Perhaps a statement in the IEEE "Buff Book" says it best: "Safety has priority over service continuity, equipment damage or economics."

## II. Consensus Standards

Consensus standards are seen as generally accepted engineering practices and can be used for litigation purposes when entered as evidence in a legal proceeding. In case of an incident where litigation is involved, the design and safety practices used are compared with these standards. In some cases, this type of enforcement is more critical than if the government were the enforcing agent.

In the United States, consensus standards are normally written by volunteers and published by standards-developing organizations (SDOs). The content of consensus standards is the result of work done by a blue-ribbon panel of experts and defines the industry's best generally available knowledge. Consensus standards fall into several different classes. Some consensus standards are product oriented; others define testing requirements, cover installation or design issues, or are people oriented. Many become legally mandated by governmental organizations.

Whether a national consensus standard is mandated and enforced by governmental action or not, the judicial system tends to use these standards as generally recognized and accepted engineering practices for litigation purposes. To understand the significance of this point, consider the text used in the OSH Act: "the (Labor) Secretary shall...by rule promulgate as an occupational safety or health standard any national consensus standard..." The legal profession uses relevant national consensus standards in court cases, where the standard is entered into evidence.

Each SDO and standard has a principle objective. To correctly apply any individual consensus standard, both the SDO objective and the standard objective should be clearly understood. The standard then should be applied with this understanding in mind. For instance, the National Fire Protection Association (NFPA) is primarily concerned with fire protection and personal safety. Therefore, NFPA standards should be embraced when these objectives are considered important. Some NFPA standards are product oriented; others are installation oriented. These standards should be applied as discussed in the scope of the document.

The NFPA publishes two critical standards. One is *NFPA 70*, otherwise known as the *National Electrical Code® (NEC®)*, and the other is the *Standard for Electrical Safety in the Workplace (NFPA 70E)*. The NFPA has many other standards, but these are two of the most important electrical standards. The premier standards publishing organization in the U.S. is the

American National Standards Institute (ANSI). ANSI is authorized by the U.S. government as the organization with the authority to identify American National Standards (ANS). No standard is written by ANSI; instead, ANSI identifies requirements for both the SDO and the standard. Among these is a requirement that each standard be produced by people knowledgeable in the area being addressed. Each ANSI standard, then, is ensured to have had broad, knowledgeable input as well as a "consensus" by the community covered by the standard.

Most consensus standards define minimum requirements necessary to accomplish the prime objective under normal operating or functioning conditions. Of course, in most cases, a standard tends to define some protective measures. However, defined protective measures are intended to protect the equipment from destruction in case of a failure. Generally, consideration for the "people factor" is missing from the standards puzzle, even though actions of people account for more than 75 percent of all incidents that result in injury.

### **A. Types of standards**

At this point in time, more than 22,000 national consensus standards exist in the U.S. Standards developing organizations (SDOs) that address electrical safety include the:

- American National Standards Institute (ANSI)
- National Fire Protection Association (NFPA)
- Institute of Electrical and Electronic Engineers (IEEE)
- Underwriters Laboratories (UL)
- U.S. Occupational Safety and Health Administration (OSHA)
- National Electrical Contractors Association (NECA)
- National Electrical Manufacturers Association (NEMA)

Note that these SDOs mostly are based in the U.S. and primarily have a U.S. focus.

Each of these SDOs writes and publishes standards that address various electrical safety issues. As stated earlier, some standards are intended for adoption by governmental organizations. However, national SDO-developed consensus standards not adopted by governmental organizations can still be used in a court of law.

### **B. NFPA 70 (the National Electrical Code® — NEC®)**

NFPA 70 commonly is called the *National Electrical Code*, or the *NEC*. The *NEC* is currently adopted by more than 1,800 different governmental organizations in the U.S. and by several Latin American countries. These organizations include city, county, or state governments. Some adopt the *NEC* as it is published by NFPA; others add or subtract requirements.

The *NEC* is the document related to installation of "premises" wiring. Premises wiring involves interior and exterior wiring, including power, lighting, control and signal circuits, along with all associated hardware. This wiring extends from the service point from the utility or separately derived system to the outlet(s).

The focus of the *NEC* is to identify requirements used to control the probability of electrical fires and provide safe installation when the system or equipment is operating normally. By itself, the *NEC* is a standard with advisory information offered for use in law and for regulatory purposes. The *NEC* is reviewed and revised on a three-year cycle.

Keep in mind, however, that the *NEC* is offered as a "minimum" standard and, therefore, its requirements sometimes must be exceeded to meet functional necessities, sound engineering judgment, and improved safety.

### **C. OSHA standards**

The U.S. Occupational Safety and Health Administration was authorized by the Williams-Steiger act of 1970. The OSHA Act passed both Houses of Congress. Signed into public law, it became known as "The Act." The Act provides for several very important elements:

- Establishes OSHA as an arm of the U.S. Department of Labor
- Mandates that an employer provide a safe workplace for employees
- Defines national consensus standards as the starting point for a safe workplace
- Provides for an inspection and enforcement process
- Provides for a due process
- Provides for specific standards related to personal safety requirements
- Provides for public input to the process

OSHA standards are published in the U.S. Federal Register and made available to the general public online at [www.osha.gov](http://www.osha.gov) and in hard copy from the U.S. Government Printing Office.

The U.S. Department of Labor has written the OSHA regulations under Title 29 of the Code of Federal Regulations (CFR), establishing them as requirements for electrical installations and electrically safe practices. In the Standard 29 CFR, Part 1910 covers general industry, while Part 1926 covers the construction industry (see Table II(C)). Each Part is subdivided into Subparts. Each Subpart is further subdivided into Paragraphs.

**Table II(C). OSHA Standards for Electrical Work**

OSHA Standard	Title	Addresses
1910.7	Nationally Recognized Testing Laboratories	NRTLs
1910.137	Electrical Personal Protective Equipment	Voltage-rated protective products
1910.147 1910.333(b)(2)	Control of Hazardous Energy	Lockout/tagout
1910.269	Power Generation, Transmission and Distribution	Overhead and underground distribution
1910.300-399	Electrical Safety Requirements	General Industry
1926.400-449	Electrical Safety Requirements	Construction

General industry tasks (for electrical energy) are covered in 29 CFR 1910.7, 1910.137, 1910.147, 1910.269, and 1910.300-399. Construction tasks are located in section 1926.400-449. OSHA standards (rules) and requirements also contain definitions. These definitions generally are related to tasks rather than employers or even industries. Employers should therefore pay close attention to the type of tasks being performed.

It is important to note that OSHA law enforcement includes fines. While many fines may be small, it is not unusual for fines of up to \$70,000 to be assessed per instance, per exposed employee. OSHA fines easily can escalate to more than a million dollars. In addition to fines, OSHA violations can result in criminal indictment. It is also becoming more common for an employer to be held personally accountable. In some situations, the employer, or even the plant manager, can be held criminally liable and sent to jail.

**D. NFPA 70E**

NFPA 70E is the *Standard for Electrical Safety Requirements in the Workplace*. This standard focuses on protecting people and identifies requirements that are considered necessary to provide a workplace that is generally free from electrical hazards. NFPA 70E is intended to address conditions that exist, or might exist, and abnormal conditions where people can become involved.

NFPA 70E suggests the following:

- Electrical hazards include shock, arc-flash, and arc-blast.
- The best way to avoid injury or incident is to establish an electrically safe work condition before beginning the work.
- Procedures and training are extremely important if injury is to be avoided.

When OSHA's electrical standards were first developed, they were based on the *National Electrical Code*. As OSHA focused more on all aspects of electrical safety, OSHA recognized the need for a consensus document of electrical safety requirements to protect individuals working on, or near, electrical equipment.

The first edition of NFPA 70E was published in 1979. Although NFPA 70E may not yet have the same extensive recognition as the NEC, it provides the latest thinking on the subject of electrical safety, particularly in the area of safe work practices. Many parts of the current OSHA regulations 29 CFR 1910 Subpart S were derived from NFPA 70E.

NFPA 70E identifies the requirements for enhanced personal safety. It is growing in recognition as an extremely important national consensus standard that defines the requirements for an overall electrical safety program. It is being adopted widely by organizations across the U.S. National consensus standards, like NFPA 70E, may be entered into evidence in a court of law.

**E. OSHA and NFPA 70E**

For electrical safety in the workplace, some people describe the relationship between the OSHA regulations and NFPA 70E as OSHA is the "shall" and NFPA 70E is the "how." OSHA regulations, which are Federal law and shall be followed, are often written in performance-oriented language (does not state how to comply). NFPA 70E is recognized as the tool that illustrates how an employer might accomplish the objective defined by the OSHA performance-oriented language.

For electrical citations, OSHA commonly uses the general duty clause and then as an alternative (means to comply) OSHA uses NFPA 70E.

*General Duty Clause: Section 5(a)(1) of the Occupational Safety and Health Act requires an employer to furnish to its employees: "employment and a place of employment which are free from recognized hazards that are causing or are likely to cause death or serious physical harm to his employees ..."*

The following is an excerpt from an OSHA Letter of Interpretation dated July 25, 2003 signed by Russell B. Swanson, Director, Directorate of Construction:

*Industry Consensus Standard NFPA 70E*  
With respect to the General Duty Clause, industry consensus standards may be evidence that a hazard is "recognized" and that there is a feasible means of correcting such a hazard. ...

*Industry consensus standards, such as NFPA 70E, can be used by employers as guides to making the assessments and equipment selections required by the standard. Similarly, in OSHA enforcement actions, they can be used as evidence of whether the employer acted reasonably.*

The following is another excerpt from the OSHA Letter of Interpretation dated July 25, 2003 signed by Russell B. Swanson, Director, Directorate of Construction:

*Question (2): I note that OSHA has not incorporated the personal protective equipment portions of NFPA 70E by reference in §1910.132 (personal protective equipment, general requirements) or §1910.335 (safeguards for personal protection). Does an employer have an obligation under the General Duty Clause to ensure that its own employees comply with personal protective equipment requirements in NFPA 70E?*

*Answer (partially reprinted)*

*These provisions are written in general terms, requiring, for example, that personal protective equipment be provided "where necessary by reason of hazards..." (§1910.132(a)), and requiring the employer to select equipment "that will protect the affected employee from the hazards..." (§1910.132(d)(1)). Also, §1910.132(c) requires the equipment to "be of safe design and construction for the work performed."*

*Similarly, §1910.335 contains requirements such as the provision and use of electrical protective equipment that is appropriate for the specific parts of the body to be protected and the work to be performed (§1910.335(a)(1)).*

*Industry consensus standards, such as NFPA 70E, can be used by employers as guides to making the assessments and equipment selections required by the standard. Similarly, in OSHA enforcement actions, they can be used as evidence of whether the employer acted reasonably.*

Another approach by OSHA is to investigate whether electrical work meets 1910.333(a)(1) which requires workers not to work on or near exposed live parts except for two demonstrable reasons (see Section IX (A) in this book). If the work can be justified for a worker to work on or near while energized, then OSHA will use NFPA 70E as an alternative or means to comply. That is OSHA uses NFPA 70E as the "how."

As an example of progressive safety initiatives, the National Electrical Contractors Association (NECA) Central Ohio Chapter in partnership with the International Brotherhood of Electrical Workers

(IBEW) Locals 683 and 1105 and with OSHA Region V Columbus Area Office have an agreement to work as partners to achieve improvements in electrical worker safety. As part of the agreement there is a standard checklist that must be used when working energized circuits; this is based on NFPA 70E.

In 2000, a major industrial was cited by OSHA for alleged serious and repeated safety violations including "failing to de-energize live electrical parts before working on or near them," "failing to require employees to wear protective clothing, gloves, and face protection when working on or near electrical parts," and "failing to certify that a hazard assessment had been conducted." In the settlement between the company and OSHA, it was agreed the company develop hazard analyses in accordance with specific NFPA 70E requirements.

### **F. Other standards and resources**

The *National Electrical Safety Code (NESC)* is an ANSI standard that is written and published by the IEEE. This standard is intended to identify requirements that apply to outdoor electrical transmission, distribution, and communication systems, equipment, and associated work practices, as opposed to premises wiring, which is addressed in the *NEC*. The *NESC* is the base standard that provided the starting point for OSHA when 29 CFR 1910.269 was being written.

*NFPA 70B, Recommended Practices for Electrical Equipment Maintenance*, is a document whose purpose is to reduce hazards to life and property that can result from failure or malfunction of industrial and commercial electrical systems and equipment. Along with its maintenance guidance, it also addresses electrical safety.

The National Electrical Manufacturers Association (NEMA) has many standards on electrical products and systems. NEMA standards often have served as a basis for Underwriter Laboratories® (UL) safety standards. Both NEMA and UL standards are designed as consensus standards and are considered as minimal requirements.

The Color Book Series by the Institute of Electrical and Electronic Engineers (IEEE) provides recommended practices and guidelines that go beyond the minimum requirements of the *NEC*, *NEMA*, and *UL* standards. When designing electrical power systems for industrial and commercial facilities, consideration should be given to the design and safety requirements of the IEEE color books listed in Annex D.

The need for unified international standards was identified many years ago. The U.S. standards system is essentially voluntary. In some parts of the world, governments essentially mandate adherence to the standards system that is in place. The International

Electrotechnical Commission (IEC) standards are an attempt within international communities to reach a consensus on standard requirements. Significant progress is being achieved with this objective. Many of the European governments have mandated standards systems. The European Union (EU) encourages further consensus among affected nations.

In many instances, protection schemes embraced in the IEC differ from those in the U.S. For example, in the U.S., nationally recognized testing laboratories are used to perform standardized "third party" product testing. Products meeting the testing standard are marked, identifying the testing laboratory. Many products meeting international safety requirements for installation in Europe require certification to testing standards and must bear a CE mark. The CE mark applies to certain "directives" within European Union countries. The intent is to provide a "safe" product that is acceptable to all of the EU countries.

With regard to personnel safety, the IEC standards address protection from electrical shock more directly than U.S. standards. For instance, IEC standards generally recognize that degrees of exposure vary. This idea will be discussed further in the section on IP finger-safe ratings.

### III. Establishing an Electrical Safety Program

Reducing and even eliminating exposure to electrical hazards requires continuous attention. An overall electrical safety program must be implemented that emphasizes specific areas of concern. The program must be well thought out. People who are well versed in safety standards and procedures must write the program. Program authors should include safety professionals, technical professionals, and practitioners. And the program must be published and readily available to all employees. The following are three good reasons for practicing electrical safety:

- Personal reasons, which affect us as caring individuals and employers
- Business reasons, because safety makes good business sense
- Regulatory and legal reasons, because violations can result in fines and/or imprisonment

An essential element in an effective electrical safety program is training. From both a legal and effective point of view, training records are important. Training should be based on the program and procedures in place within an organization. The training should focus first on increasing knowledge and understanding of electrical hazards and second on how to avoid exposure to these hazards. As a person completes a specific segment of training, a record should be

established and maintained.

An electrical safety program should accomplish the following objectives:

- Make personnel aware of the rules, responsibilities, and procedures for working safely in an electrical environment.
- Demonstrate the employer's intention to comply fully with federal law.
- Document general requirements and guidelines to provide workplace facilities free from unauthorized exposure to electrical hazards.
- Document general requirements and guidelines to direct the activities of personnel, who could be either deliberately or accidentally exposed to electrical hazards.
- Encourage and make it easier for each employee to be responsible for his or her own electrical safety self-discipline.

### IV. Electrical Safety Program

An electrical safety program is vital in establishing an electrically safe work place and is required:

*NFPA 70E 110.7 Electrical Safety Program.*

*(A) General. The employer shall implement an overall electrical safety program that directs activity appropriate for the voltage, energy level, and circuit conditions.*

*FPN: Safety-related work practices are just one component of an overall electrical safety program.*

To reduce electrical hazards, each hazard must be addressed, as the work is being assigned and planned. An overview of electrical safety requirements can be found in OSHA 29 CFR 1910.331—1910.335, "Safety-Related Work Practices." These requirements contain information on qualified vs. unqualified persons, training requirements, work practice selection, use of electrical equipment, and safeguards for personnel protection. In addition, *NFPA 70E* addresses all the key aspects of electrical safety and electrical safe work practices. If these requirements are followed completely, injuries and deaths can be prevented.

#### A. Electrical safety program principles

The following principles, when implemented, can help ensure safer work places:

1. **Identify and minimize the hazards in electrical systems.** For new systems, designers should address minimizing hazards in the electrical system design stage. For existing systems, implement upgrades or retrofits that reduce the hazards.
2. **Plan every job.** Most incidents occur when something unexpected happens. Take time to prepare a