Focus

How Did We Get Here?

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The history of arc flash and electrical safety

It seems like the more you attempt to learn about arc flash and electrical safety, the more confusing it becomes. A mixture of -letters such as OSHA, NFPA 70E, NEC, IEEE 1584, ASTM F1506 seem to be the secret language used by the electrical safety industry. Who created this alphabet soup of standards, and how did we get here?

Electrical safety practices, codes and standards were not created overnight. In fact, they have evolved over a very long period of time and continue to change. As confusing as it may appear, most people just want to know two main things:

• Which standard applies to me?

• What am I supposed to do to be in compliance?

Answering these two questions is not as easy at it sounds. Because many of the standards are intertwined, the requirements of one standard often rely on information found in another. Just sifting through it all can be quite daunting. To get a better understanding of each standard and its requirements, I thought it would be best to start at the beginning.

A few million years ago, a tremendous bolt of lightning shot out of the sky and hit the earth with a thunderous crash. The energy destroyed a tree and ignited a fire, and the shock wave caused a roar that echoed throughout the land. A caveman trembled in horror at the awesome power unleashed by this mighty force. Skip ahead to Benjamin Franklin's 1752 stormy-night kite flight, which helped him understand the strength and danger of electricity.

1882—Edison and Pearl Street

Fast forward: With the flip of a switch at 3 p.m. on Sept. 4, 1882, Thomas Edison's Pearl Street generating station ushered in the age of commercial electrical power systems. Illuminating more than 50 incandescent lamps. This was a historic moment that changed the world forever. Edison's generator, or dynamo as it was called at the time, was the largest in its day, producing an astounding 100 kilowatts (kW) of power, which would be enough to power around 1,200 lamps. Pearl Street generated direct current (DC) electricity. Just a few years later, Nicola Tesla and George Westinghouse would prove that their alternating current system (AC) was technically superior, since it could transmit power over much greater distances.

Shortly after the Pearl Street station was brought online, the next historic event took place—the first electric shock from a commercial power system. This event led to the necessity of developing modern-day electrical safety practices.

1897—The National Electrical Code

People quickly learned that electrical shock was not the only hazard and that, if wires and equipment were not properly installed, electricity could start a fire. In the late 1800s, people had very limited knowledge about proper electrical installations, some form of guidance was needed.

By 1895, five different electrical installation codes had been developed, and it was becoming a bit confusing as to which one to use. In 1896, a committee was formed to develop a single uniform electrical code. This was the birth of what we know today as the National Electrical Code (NEC), first published the following year, in 1897. In 1911, the National Fire Protection Association (NFPA) became the sponsor of the NEC, which is used today for the practical safeguarding of persons and property from hazards arising from the use of electricity.

1956—Dalziel and electric shock research

By the 1950s, it was widely understood that injury and death could result from an electric shock. Yet, there was little research and data at the time to define exactly what happens and what threshold of current causes certain physical responses. Exactly how much current could stop a heart? How much current could stop a person's breathing? To answer these questions and more, Charles Dalziel performed experiments on animals and humans to study the effects of electric shock. Through his extensive research, he published the book, "The Effects of Electric Shock on Man." His work has advanced the causes of electrical safety and is still used today.

1969—Burn research—Stoll Curve

In the late 1950s and early 1960s, Alice Stoll and Maria Chianta studied the effect of heat related to burn injury. Their research determined the level of heat energy that would produce the onset of a second-degree burn. This is where the skin blisters as the outer layer (epidermis) separates from the inner layer (dermis). Their research led to the development of what is known as the "Stoll Curve," which is used to predict burn injury. The Stoll Curve is used as the benchmark for determining the level of flame-retardant (FR) clothing and associated personal protective equipment (PPE) that should be worn for protection against the thermal effects of an arc flash.

1970—OSHA

In 1970, The United States Congress passed the Occupational Safety and Health Act in order to reduce the number of job related injuries and deaths. The Occupational Safety and Health Administration (OSHA) is the agency responsible for federal regulations and their enforcement.

Initially, OSHA selected language from the NEC as a basis for the electrical regulations. Several years later, however, procedures dictated by Section 6(b) of the act made this practice complicated. Section 6(b) requires OSHA to provide public notice, an opportunity for public comment and public hearings as part of adopting or modifying a standard. Using these procedures every time OSHA needed to adopt language from the latest NEC would make the process almost impossible. To solve this dilemma, OSHA turned to the NFPA for assistance.

1976—NFPA 70E

In 1976, the NFPA formed a new electrical standards development committee at the request of OSHA to develop an electrical safety standard. The purpose of this consensus standard is to provide a practical safe working area for employees relative to the hazards arising from the use of electricity. The NFPA 70E Standard for Electrical Safety Requirements for Employee Workplaces was first published in 1979.

Today, NFPA 70E is at the heart of electrical safety practices. Although OSHA is federal law, its language often is more general; therefore, NFPA 70E is frequently used to define specific details for protection against electrical hazards, such as electric shock and arc flash.

1982—Arc flash and Ralph Lee

When a conductor touches another conductor or a grounded surface, anything from a few sparks to a violent and often deadly electrical explosion could occur. In 1982, Ralph Lee presented “The Other Electrical Hazard: Electrical Arc Blast Burns.” Many consider this paper as the beginning of modern electrical arc flash theory. Lee quantified the potential burn hazards and raised awareness about the safety concerns. His work established a method to estimate the amount of incident energy produced by electrical arcs and the energy threshold to produce a “just curable burn” of the human body. Much of today’s arc flash protection practices are based on Lee’s earlier efforts.

1995—NFPA 70E first references arc flash

The arc flash hazard was first mentioned in the 1995 edition of NFPA 70E. This was the beginning of standards formally addressing this additional electrical hazard.

2000—NFPA 70E PPE requirements and hazard risk tables

The 2000 edition of NFPA 70E introduced the Hazard Risk Category Classification system. Tables were developed that could be used to select FR fabric and PPE for protection against the thermal effects of arc flash. The tables relied on grouping the hazard and risk into five categories (0–4) and then selecting the protection based on the category number.

2000—Incident energy calculations

The severity of an arc flash is defined by the amount of incident energy, expressed in calories/centimeter2 (cal/cm2) that could reach a worker if an arc flash occurs. In 2000, Richard L. Doughty, Thomas E. Neal and H. Landis Floyd II published “Predicting Incident Energy to Better Manage the Electric Arc Hazard on 600V Power Distribution Systems.” It provided detailed calculation methods that enabled predicting the prospective incident energy and became the cornerstone of today’s arc flash calculation methods.

2002—IEEE 1584 is published

In 2002, IEEE 1584—IEEE Guide for Performing Arc Flash Calculations was published. This guide refined previous calculation methods and developed methods to estimate the actual arcing current that could flow during an arc flash. IEEE 1584 has become the predominant method in the industry for performing arc flash calculation studies.

Many of today's electrical safety practices for arc flash protection are based on determining the prospective incident energy for a given piece of equipment and selecting FR clothing and related PPE that would protect the worker from the energy level.

2002—NEC and arc flash warning labels

The 2002 NEC first acknowledged the arc flash hazard and introduced Article 110.16 Flash Protection. This article requires field marking of certain electrical equipment to warn qualified people of the potential electric arc flash hazard.

2007—NESC—Arc flash and electric utilities

The 2007 edition of the National Electrical Safety Code (NESC) requires that, effective Jan. 1, 2009, electric utility systems that fall under this standard must perform an arc flash assessment.

2009—NFPA 70E additional label requirements

The 2009 edition of NFPA 70E added an additional requirement for arc flash warning labels. The latest edition now requires that either the calculated incident energy or the level of PPE must be listed on the label. This requirement is intended to make PPE selection easier for qualified people working on or near live energized systems.

2009—Where do we go from here?

It took a long time for electrical safety practices to evolve to where they are today. With so many different documents and methods, what are the actual electrical safety requirements? What do terms such as "electrically safe," "approach limit," "arc flash protection boundary" and "incident energy" really mean? Beginning in the July issue of ELECTRICAL CONTRACTOR, I will begin the journey of helping unravel the mystery of electrical safety standards and their requirements.

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