Introduction to Arc Flash

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PDH: 2

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Module 1: Introduction

Learning Objectives

By the end of this section, you will be able to:

- **Evaluate** the statistical impact of electrical hazards on workplace safety.
- **Identify** the specific OSHA standards governing electrical design and safety-related work practices.
- **Explain** how OSHA standards are applied to minimize electrical dangers through equipment design and testing.

Executive Summary: Electricity is a familiar but lethal workplace hazard that requires strict adherence to design and work practice standards. OSHA regulations, grounded in National Fire Protection Association (NFPA) codes, provide a comprehensive framework to protect employees from shock, electrocution, and arc flash incidents through rigorous equipment certification and installation requirements.

The Prevalence of Electrical Hazards

Electricity is essential to modern life, yet its familiarity often leads to a lack of respect for the hazards it poses. While some employees, such as **engineers and technicians**, work with it directly, many others interact with it indirectly.

Why you should be concerned

- **Severity of Risk:** Electricity exposes employees to electric shock, electrocution, burns, fires, and explosions.
- **Fatality Statistics:** In 1999, 278 workers died from electrocutions, accounting for nearly **5 percent** of all on-the-job fatalities that year.
- **Preventability:** Most of these fatalities could have been easily avoided through proper safety protocols.

Regulatory Framework: OSHA Standards

OSHA maintains extensive standards covering electrical hazards across various industries. These standards are primarily based on **NFPA 70** (National Electric Code) and **NFPA 70E** (Electrical Safety Requirements for Employee Workplaces).

General Industry Standards (29 CFR 1910)

- **Design Safety Standards:** 1910.302 through 1910.308 cover the design of electrical systems.
- **Work Practice Standards:** 1910.331 through 1910.335 detail safety-related work practices.

Other Industry Applications

- **Construction:** Regulated by 29 CFR 1926, Subpart K.
- **Marine Terminals and Longshoring:** Reference General Industry Subpart S.
- **Shipyards:** Covered under 29 CFR 1915.181.

⚠️ **Safety Constraint:** In states operating their own OSHA-approved programs (24 states and 2 territories), procedures may not be identical to federal requirements, but they must be **at least as effective** as federal standards.

Hazard Minimization through Design

OSHA standards focus on the **design and use** of electrical installations to minimize danger.

- **Installation Requirements:** Elements such as lighting, motors, machines, and switches must be constructed to minimize workplace dangers.
- **Certification:** Certain approved testing organizations must **test and certify** electrical equipment before it is permitted for use in the workplace.

💡 **Design Tip:** Professional Engineers should verify that all specified equipment bears a mark from a **nationally recognized testing laboratory** to ensure compliance with OSHA's certification requirements.

Checkpoint Quiz

1. **Which consensus standards serve as the primary basis for OSHA's electrical safety regulations?**
   a) ANSI Z244.1 and ASME B30.2
   b) NFPA 70 (NEC) and NFPA 70E
   c) ASTM D3176 and IEEE C2
   d) OSHA 3075 and 29 CFR 1911

Answer: (b). OSHA standards are specifically based on these National Fire Protection Association standards.

2. **If an electrical installation is located in a shipyard, which specific regulation covers limited electrical safety work practices?**
   a) 29 CFR 1926 Subpart K
   b) 29 CFR 1910 Subpart S
   c) 29 CFR 1915.181
   d) 29 CFR 1917

Answer: (c). This is the specific standard cited for shipyard electrical work practices.

3. **What is a mandatory requirement for electrical equipment before it can be used in a workplace under OSHA standards?**
   a) It must be painted a specific color based on voltage.
   b) It must be tested and certified by approved testing organizations.
   c) It must be designed by a licensed electrician only.
   d) It must be replaced every five years regardless of condition.

Answer: (b). OSHA requires certification to ensure equipment is safe for the workplace environment.

Module 2: Electricity: The Basics

Learning Objectives

By the end of this section, you will be able to:

- **Evaluate** how material properties, such as resistance and the presence of impurities, influence electrical flow.
- **Analyze** the physiological reactions of the human body to varying levels of electric current.
- **Determine** appropriate safety actions for managing "freezing" incidents and identifying serious internal injuries.

Executive Summary: Electrical safety is dictated by the relationship between conductors and insulators. Because the human body is an efficient conductor, completing a circuit path results in shocks that can range from minor tingles to fatal cardiac arrest depending on amperage and duration.

What Affects the Flow of Electricity?

Electricity travels more easily through some materials than others based on their resistance.

- **Conductors:** Substances like metals offer very little resistance. The surface and subsurface of the earth are common, often overlooked conductors.
- **Insulators:** Materials such as glass, plastic, porcelain, clay, pottery, and dry wood generally slow or stop the flow.
- **Air:** Normally an insulator, air can become a conductor during an arc or lightning stroke.

How Does Water Affect the Flow of Electricity?

While pure water is a poor conductor, impurities significantly alter its properties.

- **Impurities:** Small amounts of salt, acid, or solvents turn water into a conductor.
- **Material Changes:** Dry wood is an insulator, but when saturated with water, it becomes a conductor.
- **Human Skin:** Dry skin has high resistance, but moist or wet skin acts as a conductor.

⚠️ **Safety Constraint:** Working in damp or wet environments requires extra caution to prevent electrical hazards.

What Causes Shocks?

Electricity travels in closed circuits. A shock occurs when the human body completes the current path with:

- Both wires of an electric circuit.

- One wire of an energized circuit and the ground.
- A metal part that accidentally becomes energized due to a break in insulation.
- Another conductor carrying a current.

What Effect Do Shocks Have on the Body?

The severity of a shock depends on the amount of current, its path through the body, duration of exposure, and frequency.

Table: Effects of Electric Current in the Human Body

Current	Reaction
Below 1 milliampere	Generally not perceptible
1 milliampere	Faint tingle
5 milliamperes	Slight shock felt; not painful but disturbing. Average individual can let go. Strong involuntary reactions can lead to other injuries.
6–25 milliamperes (women)	Painful shock, loss of muscular control*
9–30 milliamperes (men)	The freezing current or "let-go" range. * Individual cannot let go, but can be thrown away from the circuit if extensor muscles are stimulated.
50–150 milliamperes	Extreme pain, respiratory arrest, severe muscular contractions. Death is possible.
1,000–4,300 milliamperes	Rhythmic pumping action of the heart ceases. Muscular contraction and nerve damage occur; death likely.
10,000 milliamperes	Cardiac arrest, severe burns; death probable

* If the extensor muscles are excited by the shock, the person may be thrown away from the power source.

What Kind of Burns Can a Shock Cause?

Burns are the most common shock-related injury and require immediate medical attention.

- **Electrical Burns:** Current flows through tissue or bone, generating heat damage.
- **Arc or Flash Burns:** Result from high temperatures caused by an electric arc or explosion near the body.
- **Thermal Contact Burns:** Skin touches hot surfaces of conductors or energized equipment, or clothing catches fire.