Safety Basics

IN THIS CHAPTER YOU will examine PV safety in detail. You will first review general safety hazards. Next, you will read about OSHA standards. Then you will read about safety practices related to electricity, falls, stairways and ladders, tools, modules, electric spaces, and batteries. This chapter concludes with a survey of personal protective equipment.

Topics & Concepts

This chapter covers the following topics and concepts:

- Safety hazards
- OSHA regulations
- Basic electrical safety
- Fall protection
- Stairways and ladders
- Hand and power tools
- Working space for electrical systems
- Photovoltaic modules
- Battery safety
- Personal protective equipment (PPE)

Goals

When you complete this chapter, you will be able to:

- Identify the various safety hazards associated with both operating and nonoperating PV systems and components
- List different types of personal protective equipment (PPE) commonly required for installing and maintaining PV systems
- List different methods and indentify safe practices for hoisting and rigging; for the use of ladders, stairways, and guardrails; for the use of protective gear for the head, feet, face, and hearing; for the use of power tools; and for the use of appropriate fall protection, including the requirements for personal fall arrest and safety-monitoring systems, according to OSHA standards
- Recognize the principal electrical safety hazards associated with PV systems, including electrical shock and arc flash

Safety Hazards

You must take several safety concerns into consideration when installing either operational or nonoperational PV systems. In order to work safely with PV systems, you must have a good understanding of electrical systems and common sense. Here are a few commonsense points to keep in mind:

This photo provides an example of the type of unsafe site conditions that you may face on the job site.
Courtesy of Perfect Power

- Workplace clutter increases your risk of tripping.
- Clutter around you when you are working on a sloped roof increases your risk of falling off the roof.
- Tools left lying out on a roof are likely to fall off it and injure someone below.
- If you are working on a rooftop in bright sunshine, your chance of sunburn increases, so be sure to put on a good layer of sunscreen.

Additional commonsense practices to follow when installing PV systems include wearing gloves to protect against getting cuts or burns.

Take care not to drop tools on yourself or anyone else. The risk of shock, fire hazards, or electrical short circuits is present anytime a PV system is being assembled. Be sure to follow proper procedure during installation to reduce and, ideally, eliminate hazards to yourself or others.

OSHA Regulations

If you are servicing or installing PV systems, you need to be familiar with the standards established by the **Occupational Safety and Health Administration (OSHA)**. OSHA regulations apply to all US states and territories and are enforced on a federal and local level. OSHA regulations include health standards, electrical safety, fall protection systems, stairways and ladders, hand and power tools, cranes and lifts, excavations, scaffolding, and other potential sources of hazards likely to be encountered in construction practice and PV installations. OSHA regulations require that a safe and healthy workplace be free of hazards and follow the appropriate OSHA standards.

According to the regulations set by OSHA, all *employers* are responsible for:

- Providing training concerning safety hazards and OSHA regulations
- Maintaining records of occupational injuries and illnesses
- Displaying the OSHA poster in the workplace
- Reporting to OSHA within 8 hours if any accident results in fatality or in-patient hospitalization of three or more employees

According to the regulation set by OSHA, all *employees* are responsible for:

- Following the employer's safety and health rules
- Wearing and using all required safety gear and equipment
- Reporting hazardous conditions to OSHA if employers do not correct them
- Cooperating with OSHA inspectors

In all cases of maintenance or installation of PV systems, you should understand and follow OSHA regulations. The OSHA regulations most relevant to PV installation include Chapter 29, part 1926, subparts D, E, I, K, and X. Do not ignore the safety precautions set by OSHA. Safe workplace practices lead to a hazard-free job.

Basic Electrical Safety

OSHA describes electrical regulations under Chapter 29, Part 1926, subpart K. About five workers are electrocuted each week in the United States. These electrocutions cause 12 percent of all workplace deaths. It does not take much electrical charge to cause injury. Electrical hazards also pose a great deal of fire danger. This leads to further risks related to life and property.

Electrical accidents are usually caused by a combination of three factors:

- Unsafe equipment and/or installation
- Workplaces that are made unsafe by the environment
- Unsafe workplace practices

Four major types of electrical injuries can occur. Types of direct electrical injuries include electrocution (death by electricity), electrical shock, and burns from electrical shock. Indirect electrical injuries include falls in reaction to an electrical shock. Additional electrical injuries include concussions from arcing explosions, and eye damage because of arc flash.

You must follow safety procedures to reduce the risk of electrical injury. Working near conductors or any kind of electrical equipment requires special personal protective equipment. A list of **personal protective equipment (PPE)** will be provided later in the chapter.

There are other things you should do to ensure electrical safety, in addition to wearing PPE. Many electrical safety measures are common sense. Some are not. When working on any kind of electrical system always:

- Be aware of the work environment.
- Keep walkways and working space clear of cords or other potential tripping hazards.
- Use the safety equipment appropriate for where you are working (e.g., in an attic, wear a breathing mask to keep from breathing in insulation).
- Test GFCIs (ground fault circuit interrupters) regularly as well as switches and insulation to help ensure that the electrical wiring is up to code and free from risk of fire or shock.
- Use flexible extension cords of the 3-wire type (with a ground), designed for extra-hard use.
- Physically lock the power source disconnect with a padlock in the off position. This is referred to as **lockout** and keeps workers from energizing electrical circuits while they are working.
- Label deactivated controls and de-energized equipment and circuits wherever they can be energized. Identifying the equipment and circuits being worked on is called **tagging** and allows the workers to see exactly what electrical equipment is being worked on and what circuits are off or on.

Electrical safety requires awareness of the working environment, appropriate protective gear, and a little bit of planning. Working with electrical systems can be dangerous, even life threatening. Take the time to understand and apply these basic electrical safety measures.

Fall Protection

Falls are the leading cause of death in the construction industry. Most of the time, installing or working on PV systems will involve climbing ladders and working on roofs. It is important to understand OSHA fall protection regulations. Usually falls happen when an employee falls through floor openings. Because of this, OSHA requires that fall protection be used in any place where a worker can fall 6 feet or more. Employers must train employees on how to reduce the number of fall hazards in the workplace. Employees also receive training on how to use fall protection systems and devices.

Fall protection options include:

- **Personal Fall Arrest Systems (PFAS)** such as anchorages, lifelines, and body harnesses
- Guardrails to protect open-sided floors
- Platforms that have top rails between 39 and 45 inches tall, a mid-rail, and toe boards that are at least 3.5 inches high
- Safety nets that are no farther than 30 feet below the work space and preferably closer

The best fall protection practice is to do as much work as possible on the ground level. In many cases, you can do work such as pre-assembly of the PV panels and arrays on the ground.

Stairways and Ladders

Stairways

OSHA describes stairway and ladder regulations under Chapter 29, Part 1926, subpart X. OSHA regulations require that you use a stairway or ladder at the points of entrances where there is an elevation break of 19 inches or more on a job site. Stairways that have four or more risers or that are more than 30 inches high must have a handrail. The handrail must be able to handle at least 200 pounds of force. Stairs must be installed between 30 and 50 degrees. The tread on the stairs must be the same size with less than a 25 percent variation. Stairway landings must be at least 30 inches deep and 22 inches wide at a distance of every 12 feet of rise. You must install a 42-inch guardrail if the landing has unprotected sides.

Ladders

You'll be using ladders regularly when working on PV systems. There are several safety guidelines to follow every time you use a ladder on the job. You should

always inspect a ladder before using it. Use only ladders that are in good condition. Always keep the space around a set-up ladder clear of tripping hazards.

Ladder safety list:

- Rungs and cleats should be evenly spaced at 10 to 14 inches apart.
- Ladders should be used only for their intended purpose.
- Never use a ladder to create a walkway.
- Do not tie together ladders to make longer sections.
- Missing or broken rungs create a serious safety hazard. If you find a defect, you must label the ladder "Do Not Use."
- Always set up a ladder on a stable and level surface.
- Secure the ladder to prevent accidents.
- Do not put more weight on a ladder than it can handle.
- If the ground is wet, do not use a ladder unless it has slip-resistant feet
- If you support a ladder by leaning it against a wall, position the ladder at an angle that is at a safe and stable distance from the building.
- Do not use the top step of a stepladder.
- If you use a ladder around electrical equipment, make sure it has nonconductive side rails like wood or fiberglass.
- Use at least one hand to hold on to the ladder when climbing up or down.
- Do not carry anything that could make you lose your balance.

TECH TIPS

Tall, fixed ladders 24 feet or longer must be equipped with one of the following: a ladder safety device, self-retracting lifelines with rest platforms every 150 feet or less, and multiple ladder sections that do not exceed 50 feet.

Hand and Power Tools

OSHA describes hand and power tool regulations under Chapter 29, Part 1926, subpart I. As a worker, you will use a variety of hand and power tools on the job. Although tools make the job easier, they also introduce hazards. These hazards include falling and flying objects, harmful dust and vapors, and electrical safety issues. Hazards created by hand and power tools are often caused by incorrect use of the tool and improper maintenance. There are simple safety rules that you can follow to reduce these hazards.

Basic tool safety rules:

- Practice regular and correct maintenance of the tool.
- Use the right tool for the job.
- Inspect the tool for problems or damage before using it.
- Follow the manufacturer's instructions on how to use the tool.
- Wear the proper personal protective equipment (PPE).

- Use the tool's safety guard and/or safety switches.
- Understand that hazards caused by power tools may be different depending on the power source used.

Working Space for Electrical Spaces

The National Electrical Code (NEC) is extremely detailed about how electrical working spaces must be set up to keep workers safe. It forms the basis for the national electrical wiring rules. Maintaining a safe environment for electrical spaces is essential, as is understanding the requirements for proper working spaces. A proper working space creates a safe and accessible electrical space.

Clearance

Proper clearance is the first step when determining the balance of the system hardware for the PV system. The clearance needed for the PV system hardware is usually 3 feet. Sometimes aspects of the site change the amount of clearance space needed. Voltages that are from 150 to 600 VDC will need bigger clearance if live parts are on one side and grounded parts on the other, or if there are live parts on both sides of the working space. The width of working spaces has to be at least the width of the equipment or no smaller than 30 inches. If the equipment is not 30 inches wide, the width still needs to be a minimum of 30 inches. For DC voltages that are less than 60V, a smaller working space may be allowed through the authority having jurisdiction (AHJ). You must get this permission before you mount any equipment.

Attic Spaces

PV installation sometimes requires you to work in an attic. There are a few safety precautions to follow when working in an attic. Wearing a breathing mask, eye protection, and clothes that protect the skin from insulation will keep you safe from injury. You should know where the supports are located to prevent falling through the ceiling. You should also know where the entrance and exits are located. Before working in an attic, you should drink plenty of fluids and use proper lighting.

TECH TIPS

Consult the NEC code for more detailed information on working space in electrical spaces.

Photovoltaic Modules

You must know how to work safely with PV modules. This allows you to avoid electrical shock and injury. You should always handle PV modules carefully. Take care not to drop the modules. Because one module is rarely used alone, you will typically work with others to handle and connect several modules to create a string for an array.

You should always pay attention to the open wire ends. Open wire ends must be protected from shorting each other. A short circuit may not blow any fuses or breakers, but it can produce a very intense DC arc between the wires. An arc can reach temperatures of 10,000 degrees C over just a half an inch. This arc can create a fire hazard, a burn hazard, or an ultraviolet eye hazard. Sometimes the sheer surprise of an arc is enough to knock someone over.

You should know how to carefully handle and connect PV modules. If possible, do as much work in a well-lit ground-level area before transporting the PV modules to the anchoring site.

Battery Safety

Many batteries can produce a large amount of hydrogen within the area where they are located. Sometimes, the hydrogen will build up at the top of the battery container or in a closed area. If the concentration of hydrogen gets too high, the mixture can be explosive. A battery container should be vented on the top to let the hydrogen escape. The NEC says that all battery locations must provide ventilation. The NEC does not, however, provide guidelines on how to vent the battery.

Typical battery containers have a vent at the bottom because acid containment is different from hydrogen containment. Hydrogen venting is very different from providing combustion air for appliances. If a vented lead battery type is used, you should never put it beneath electronic machinery. Vapors from the battery can corrode the electronic equipment and cause problems. Batteries should always be kept in a place that can contain the contents of the battery in case of a spill.

If an acidic battery spill does occur, baking soda neutralizes the battery acid. You should always keep baking soda on hand when working with this type of battery in case of an accident.

A nickel-cadmium battery has a strong electrolyte base. If you use a nickel-cadmium battery, keep vinegar nearby to neutralize a spill of the electrolyte.

You should always wear proper protective equipment when working with batteries. This equipment includes eye, face, and hand protection. You can use an apron to protect clothing.

There must be enough working clearance in order to maintain the battery. Because batteries are dangerous, ample room is necessary.

You should always use the appropriate tools when working with batteries. Insulated tools will help prevent shorts. A shorted battery can create a current of 10,000 amps or more. This can flow through the circuit, which will damage the tool, explode the battery, and harm the worker.

Lastly, if a battery is being used in a cold outdoor climate, the electrolyte freezing temperature increases as the batteries discharge. If the electrolyte freezes, *do not charge the battery*. Allow it to thaw on its own. Also, do not try to thaw the

battery with anything that might set the battery on fire. Battery gases can be very flammable.

Personal Protective Equipment (PPE)

OSHA describes PPE regulations under Chapter 29, Part 1926, subpart E. You should always wear the appropriate protective gear when working with electrical systems. Employers must protect their employees from possible injuries. You can prevent injuries from falling objects, noxious substances, and noise damage by using proper PPE. There are several pieces of PPE that you should own. Wear the PPE to work every day in order to reduce the risk of personal injury.

Employers should also provide instruction on using PPE effectively. An employer is responsible for providing a safe work environment as well as the appropriate equipment and training related to safety measures.

Employees are responsible for using PPE and understanding possible safety hazards and prevention. Employees are also responsible for the daily inspection of their PPE and surroundings. You can cut down on workplace injuries by maintaining a clean and predictable working environment.

A basic list of personal protective equipment (PPE) includes:

- **Safety glasses**—Protection for the eyes can keep dust and other particles, fragments, shards, and metal shavings in the air from getting into the eyes.

These workers are utilizing just a few of the many types of PPE available to PV installers.
Courtesy of Perfect Power

Glasses must not interfere with the work process and should be comfortable as well as easy to see through.

- **Goggles and face shield for eye and face protection**—a face shield should allow the worker to see clearly and move freely.
- **Hardhats for head protection**—there are three classes of hardhats. Class A hardhats are appropriate for general construction, but do not have much voltage protection. Class B hardhats are made for electrical and utility work and protect against shock and burns. Class C hardhats are made to be comfortable and offer some protection from falling objects as well as shock and burns.
- **Safety shoes for foot protection**—Wear protective footwear when there is the possibility of objects falling or rolling onto your feet and when you are working around materials that could splash on your feet or cause high temperatures around them.
- **Gloves for hand and arm protection**—Gloves protect the hands and arms from obvious hazards. Wear gloves when you use your hands to perform a task that involves sharp objects or chemicals. Your gloves need to allow you to move your hands freely and easily.
- **Earplugs and earmuffs for hearing protection**—Use earplugs and earmuffs when there is high frequency noise in the workspace. Protecting the eardrums from loud noises helps prevent hearing damage.

STUDY TIP

Avoid careless mistakes when taking the Entry Level exam. Many response options will be intentionally designed to trick you. Pace yourself on the test and do not rush. Read each question and answer carefully to avoid the traps.

Chapter 2 Summary

Safety is the first step to performing a job well. Many considerations are involved when working with electrical systems. You need to be familiar with OSHA regulations as well as NEC code before beginning a job. Electrical systems can pose multiple hazards, such as shock, burns, and falls. You should always be aware of the job environment and take care to protect yourself from injury.

Utilizing PPE and proper electrical safety procedures reduces the risk of injury to a minimum. Procedures like tagging and lockout allow you to do electrical jobs safely. Daily inspection of tools and job equipment is also necessary. Choosing to use a broken tool or ladder can pose a serious threat to the worker. An overall knowledge of safety basics combined with common sense goes a long way in protecting you from injury or even death.

Key Concepts and Terms

Lockout
National Electrical Code (NEC)
Occupational Safety and Health Administration (OSHA)
Personal fall arrest systems (PFAS)
Personal protective equipment (PPE)
Tagging

Chapter 2 Assessment

Safety Basics

1. OSHA regulations should be followed when working on any job.
   - ❑ **A.** True
   - ❑ **B.** False
2. Which answer is *not* a responsibility of the employee according to OSHA regulations?
   - ❑ **A.** Following the employer's safety and health rules
   - ❑ **B.** Wearing and using all required safety gear and equipment
   - ❑ **C.** Providing training concerning safety hazards and OSHA regulations
   - ❑ **D.** Reporting hazardous conditions to OSHA if employers do not fix them
3. Which of the following are examples of PPE? (Select all that apply.)
   - ❑ **A.** Jeans
   - ❑ **B.** Hardhat
   - ❑ **C.** Safety goggles
   - ❑ **D.** Leather belt
4. Which of the following are components of a PFAS? (Select three.)
   - ❑ **A.** Harnesses
   - ❑ **B.** Anchorages
   - ❑ **C.** Nets
   - ❑ **D.** Ladders
   - ❑ **E.** Earplugs

5. NEC stands for National Electrician Code.
   - ❑ **A.** True
   - ❑ **B.** False
6. Which of the following are hazards posed by working with electricity?
   - ❑ **A.** Shock
   - ❑ **B.** Hearing loss
   - ❑ **C.** Burn
   - ❑ **D.** A and C only
   - ❑ **E.** None of the above
7. Physically locking the power source disconnect with a padlock in the "off" position is referred to as
   - ❑ **A.** lockout.
   - ❑ **B.** tagging.
   - ❑ **C.** PFAS.
   - ❑ **D.** arc.
8. Labeling all electrical circuits and cords to be worked on before starting the job is referred to as
   - ❑ **A.** PPE.
   - ❑ **B.** tagging.
   - ❑ **C.** lockout.
   - ❑ **D.** regulations.
9. When working with PV modules, the worker should take care to protect the open-ended circuit.
   - ❑ **A.** True
   - ❑ **B.** False
10. An acidic battery spill can be neutralized by the use of which of the following?
    - ❑ **A.** Vinegar
    - ❑ **B.** Baking powder
    - ❑ **C.** Flour
    - ❑ **D.** Baking soda
11. 11. A battery box or container that is not vented can lead to a build up and explosion of what type of gas?
    - ❑ **A.** Oxygen
    - ❑ **B.** Helium
    - ❑ **C.** Hydrogen
    - ❑ **D.** Electrolyte
12. A worker does not need to be familiar with the NEC before beginning a job.
    - ❑ **A.** True
    - ❑ **B.** False