Chapter 16

PV System Safety

Hazards and Avoidance • Personal Protective Equipment • Fall Protection • Electrical Safety
Overview

- Identifying the elements of the electrical safety system, and the codes and standards that help ensure the safety of PV installers and installations.

- Understanding the importance of a hazard assessment and safety training.

- Identifying the various safety hazards associated with PV systems and how to avoid them.

- Listing different types of personal protective equipment (PPE) commonly required for installing and maintaining PV systems.

- Identifying OSHA standards for electrical safety and for the use of ladders, stairways, guardrails, fall protection systems and power tools.
A safe PV system is installed according to applicable building codes and standards.

PV installer safety includes considerations for a safe work area, safe use of tools and equipment, safe practices for personnel protection, and awareness of safety hazards and how to avoid them.

The installation of PV systems involves a number of safety hazards, principally electrical and fall hazards.
The Electrical Safety System

- Safer Equipment & Systems
- Inspection, Code Compliance & Approval (AHJ & Utilities)
- Product Standards, Testing & Certification (ANSI, ISO/IEC & NRTLs)
- Worker Safety, Installation & Building Codes (NEC, ICC & OSHA)
Standards, Testing and Certification Bodies

- ANSI: American National Standards Institute
- ISO: International Organization for Standardization
- IEC: International Electrotechnical Commission
- NRTL: Nationally Recognized Testing Laboratory
Worker Safety, Installation and Building Codes

- OSHA: Occupational Safety and Health Administration
- NEC: National Electrical Code (NFPA 70)
- ICC: International Code Council
Inspection and Approval

- **AHJ: Authority Having Jurisdiction**
  - The local government agency charged with enforcing building codes.
  - The AHJ regulates, oversees and approves all construction activities, including plan review, permitting and inspection.

- **Electric utilities review and approve the interconnection of customer-owned power generation to their electrical distribution system.**
  - Dictated by public utility commissions and state laws.
  - Interconnection requires AHJ approval and usually includes provisions for size, fees, rates, metering and other requirements as applicable.
OSHA regulations applicable to PV installations are covered in the following standards:

- Part 1910 -- Occupational Safety and Health Standards
- Part 1926 -- Safety and Health Regulations for Construction

These standards address many safety categories, including:

- Hazard Assessment and Training
- Personal Protection Equipment
- Employer and Employee Responsibilities
- Electrical Hazards
- Fall Hazards
- Stairways and Ladders
- Scaffolding
- Power Tools
- Materials Handling
- Excavations
The employer must provide for frequent and regular inspections of the work areas, materials, and equipment to identify all safety hazards employees may be exposed to.

The employer shall instruct each employee in the recognition and avoidance of unsafe conditions and the regulations applicable to his work environment to control or eliminate any hazards or other exposure to illness or injury.
Use a hazard assessment checklist to document and describe the hazards and sources:

- Electrical, falls and falling objects, impacts, penetrations, heat, chemical, etc.

Select the appropriate personal protective equipment (PPE) when all engineering controls and work practices cannot eliminate the hazards.

- Protection for the head, eyes, face, hands, feet and other parts of the body.
- Fall arrest equipment
OSHA requires employers to record and report work-related fatalities, injuries and illnesses.

Unless exempt, employers with more than ten (10) employees must keep OSHA injury and illness records.

All employers must report to OSHA any workplace incident that results in a fatality or the hospitalization of three or more employees.
Personal Protective Equipment

- **PPE: Personal Protective Equipment**
  - Includes protective clothing, gloves, footwear, helmets, goggles, respirators, aprons or other garments designed to protect workers from injury to the body by impacts, electrical hazards, heat and chemicals, and other job-related safety hazards.

- **PPE is the last measure of control when worker exposure to the safety hazards cannot be totally eliminated by feasible work practices or engineering control.**
PPE Responsibilities

**Employer Responsibilities**
- Assess workplace for hazards, and define PPE requirements.
- Provide personal protective equipment (PPE).
- Determine when to use.
- Provide PPE training for employees and instruction in proper use.

**Employee Responsibilities**
- Use PPE in accordance with training received and other instructions.
  - Inspect daily and maintain in a clean and reliable condition.
Head Protection

- The employer shall ensure that each affected employee wears a protective helmet when working in areas where there is a potential for injury to the head from falling objects, or exposure to electrical hazards.

  - Type I hard hats provide protection from blows only to the top of the head.

  - Type II hard hats have a full brim and provide protection from blows to the top or sides of the head.
Hard Hat Classifications

- Class G (General)
- Class E (Electrical)
- Class C (Conductive)
Occupational Noise Exposure

- **OSHA Permissible Exposure Limit (PEL)**
  - Any eight-hour time-weighted-average (TWA) exceeding 90 decibels (dBA) requires the employer to implement control measures to reduce the exposure to 90 dBA or below.
  - Noise levels above 115 dBA require control measures for any duration.

- **Action Level**
  - OSHA also recognizes an 85 dBA TWA as an action level to monitor noise levels.
    - Noise levels likely exceed 85dBA if one has to raise their voice to converse with another person 3 feet away.
    - Requires baseline and annual audiometric testing programs for affected employees.
**Types of Hearing Protection**

- **Earmuffs**
  - Fit over the ear and seal against the side of the head.

- **Earplugs**
  - Inserted directly into the ear canal.

- **All approved hearing protectors have an assigned Noise Reduction Rating (NRR) in decibels.**
  - Reduces decibel exposure.
Eye and Face Protection

- The employer shall ensure that each affected employee uses appropriate eye or face protection when exposed to eye or face hazards from flying particles (side protection required), molten metal, liquid chemicals, acids or caustic liquids, chemical gases or vapors, or potentially injurious light radiation (filter lenses required).

- Types of eye and face protection include:
  - Safety glasses (required for most PV installation tasks)
  - Goggles
  - Face shields
Types of Eye and Face Protection

Vented and Indirect-Vent Goggles

Impact Splash-Resistant Goggles

Safety Glasses

Face Shield

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Respiratory Protection

- When employees are exposed to harmful atmospheres, dust or vapors, the employer shall provide respirators which are applicable and suitable for the purpose intended.

- Although not generally required, certain tasks related to a PV installation may require respiratory protection.
The employer shall ensure that each affected employee uses protective footwear when working in areas where there is a danger of foot injuries due to falling or rolling objects, or objects piercing the sole, and where such employee's feet are exposed to electrical hazards.
Types of Protective Footwear

Steel toe: ASTM F2413-05 I/75 C/75 EH
Impact and Compression-Resistant, Electrical Hazard Rated

Lab Safety Supply
Employers shall select and require employees to use appropriate hand protection when employees' hands are exposed to hazards such as those from skin absorption of harmful substances; severe cuts or lacerations; severe abrasions; punctures; chemical burns; thermal burns; and harmful temperature extremes.

Types of gloves vary widely in materials and application, including:
- Durable gloves made of mesh, leather or high-performance materials like Kevlar® to protect from cuts, burns and heat.
- Chemical-resistant rubber gloves to protect from burns and irritation
- Electrical insulating gloves for exposure to live voltage
Types of Gloves

Level 2 Cut-Resistant Kevlar® Gloves

Level 5 Cut-Resistant Leather Gloves

Chemical-Resistant Gloves

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Falls are the leading cause of deaths in the construction industry.

- Most fatalities occur when employees fall from open-sided floors and through floor openings.
- Many PV arrays are installed on rooftops or elevated structures.

Each employee on a walking/working surface with an unprotected side or edge 6 feet (1.8 m) or more above a lower level shall be protected from falling by the use of guardrail systems, safety net systems, or personal fall arrest systems.
Skylights must be protected from fall hazards by covers.

A PV installer fell to his death through this skylight.
Fall protection options:

- **Guardrails**
  - Minimum height, openings, and support strength required
- **Safety nets**
  - Installed no more than 30 feet below working level
- **PFAS: Personal Fall Arrest System**
  - Includes anchorage, lifeline and body harness
  - Required employee training on proper use and care

The employer shall provide a training program for each employee who might be exposed to fall hazards.
Roofing Work and Fall Protection

- **Low-slope roofs (≤ 4 in 12 pitch)**
  - Each employee engaged in roofing activities on low-slope roofs, with unprotected sides and edges 6 feet (1.8 m) or more above lower levels shall be protected from falling.
  - On roofs 50-feet or less in width, the use of a safety monitoring system alone [i.e. without the warning line system] is permitted.
  - Safety-monitoring system requires a competent person responsible for recognizing and warning employees of fall hazards.

- **Steep roofs (> 4 in 12 pitch)**
  - Each employee on a steep roof with unprotected sides and edges 6 feet (1.8 m) or more above lower levels shall be protected from falling by guardrail systems with toeboards, safety net systems, or personal fall arrest systems.
A warning line system is a barrier erected on a roof to warn employees that they are approaching an unprotected roof side or edge.

Designates an area in which roofing work may take place without the use of guardrail, body belt, or safety net systems.
Personal Fall Arrest Systems

Body Harnesses

Lanyard, Lifeline and Roof Anchors

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Personal Fall Arrest Systems

NREL/Rob Williamson

Alameda County JATC/Mel Switzer

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Anchorage Points

Removable/Reusable Roof Anchors

Concrete Dee-ring Anchor

Permanent Roof Anchor with Cap

Guardian Fall Protection
Protection from Falling Objects

- When an employee is exposed to falling objects, the employer shall have each employee wear a hard hat and shall implement one of the following measures:
  - Erect toeboards, screens, or guardrail systems to prevent objects from falling from higher levels; or,
  - Erect a canopy structure; or,
  - Barricade and prohibit employees from entering area to which objects could fall.
A stairway or ladder is required at points of access to a construction site where there is a break in elevation of 19 inches or more.

- At least one point of access must be kept clear.
Stairrails and Handrails

- Must be able to withstand 200 pound force.
- Stairways with four or more risers, or higher than 30 inches, must be equipped with at least one handrail, and a stairrail along each unprotected side or edge.
permanent or temporary stairways used on construction sites must meet the following requirements:

- Be installed between 30-50 degrees.
- Must have uniform riser height and tread depth, with less than 1/4-inch variation.
- Landings must be at least 30 inches deep and 22 inches wide at every 12 feet or less of vertical rise.
- Unprotected sides of landings must have standard 42 inch guardrail systems.
- Platforms must extend at least 20 inches beyond the outward swing of a door.
- Free of projections which may cause injuries or snag clothing.
Ladders

- Ladders must be kept in a safe condition and free from slipping hazards.
  - Area around the top and bottom of a ladder must be kept clear.

- Rungs, cleats, and steps must be level and uniformly spaced.
  - Rungs spaced 10 to 14 inches apart
  - Side rails 11-1/2 inches apart

- Use ladders only for designated purpose.
  - Do not use for scaffolding
  - Double-cleated ladders required for 25 or more employees or two-way traffic.
Portable Ladder Types

- Stepladders: Self-supporting portable ladder of fixed length, with flat steps and hinged back support.
  - Stepladders longer than 20 feet are prohibited.

- Straight ladders: Non self-supporting fixed-length single, consisting of one section.
  - Straight (single) ladders longer than 30 feet are prohibited.

- Extension ladders: Non self-supporting portable ladder adjustable in length.
  - Extension ladders longer than 60 feet are prohibited.

- Ladder construction materials
  - Wood, metal, reinforced plastic and fiberglass
Ladder Type and Duty Rating

- **Type IAA**
  - 375 lbs Super Heavy Duty

- **Type IA**
  - 300 lbs Extra Heavy Duty

- **Type I**
  - 250 lbs Heavy Duty Industrial

- **Type II**
  - 225 lbs Medium Duty Commercial

- **Type III**
  - 200 lbs Light Duty Household
Ladder Angle

- Position non-self-supporting ladders at an angle where the horizontal distance from the top support to the foot of the ladder is 1/4 the working length of the ladder.

- When using a portable ladder for access to an upper landing surface, the side rails must extend at least 3 feet above the upper landing surface.
Ladder Safety

Never
- Use ladders beyond their maximum rated load capacity.
- Use a ladder as a scaffold or for any purpose except what was intended.
- Tie ladders together to make longer sections or use single rail ladders.

Always
- Secure ladders and use on level and stable surfaces to prevent accidental movement.
- Carry tools in pockets, belt bag or raised and lowered by a rope.
- Keep areas around the top and bottom of ladder clear.
- Use only double-insulated or properly grounded electrical tools on a metal ladder.
- Use ladders with nonconductive siderails when exposed energized electrical equipment.
- Inspect ladders routinely for damage or defects.
- Train employees on the proper procedures to minimize ladder hazards.
Four main types of electrical injuries:
- Electrocution or death due to electrical shock
- Electrical shock
- Burns
- Falls (caused by shock)

Electrical accidents are caused by a combination of three factors:
- Unsafe equipment and/or installation,
- Workplaces made unsafe by the environment, and
- Unsafe work practices.
Preventing Electrical Hazards

- Wear nonconductive Class E hardhat.

- Wear electrical hazard (EH) rated foot protection.

- Use properly grounded or double-insulated power tools.
  - Tools with damage or worn power cords should be removed from service.

- Work on electrical equipment and circuits in a de-energized state using lockout and tagout procedures.
  - When working on energized equipment is unavoidable, use the appropriate PPE, including helmets, face shields, gloves and flame-resistant clothing.

- Beware of overhead power lines and buried electrical conductors.
Lockout & Tagout

- **Lockout**
  - The placement of a lockout device on an energy-isolating device, in accordance with an established procedure, ensuring that the energy-isolating device and the equipment being controlled cannot be operated until the lockout device is removed.

- **Tagout:**
  - The placement of a tagout device on an energy-isolating device, in accordance with an established procedure, to indicate that the energy-isolating device and the equipment being controlled may not be operated until the tagout device is removed.
Energy Control Program

- Employer must provide policies, procedures, documentation, equipment, training, inspection and maintenance for LOTO program and equipment to authorized employees.
All hand and power tools and similar equipment, whether furnished by the employer or the employee, shall be maintained in a safe condition.

Must be fitted with guards and safety switches. Hand-held power tools must be equipped with a constant pressure switch or on-off switch.

Power tools are extremely hazardous when used improperly. Eye protection is usually required.
Power Tool Precautions

- Disconnect tools when not in use, before servicing and cleaning, and when changing accessories.

- Secure work with clamps or a vise, freeing both hands to operate the tool.

- Keep tools sharp and clean.

- Do not wear loose clothing and jewelry that can get caught in moving parts.

- Do not use electric cords to carry, hoist or lower tools.

- Keep cords and hoses away from heat, oil, and sharp edges.

- Remove damaged electric tools & tag them: “Do Not Use.”
Fire Protection and Prevention

- The employer is responsible for developing a fire protection program.
  - Providing access to firefighting equipment at all times without delay.
  - All firefighting equipment shall be conspicuously located.
  - Periodically inspections and maintenance required.
  - Defective equipment shall be immediately replaced.
Fire Extinguisher Classifications

- **Class A:**
  - For fires involving ordinary combustible materials such as paper and wood.

- **Class B:**
  - For fires involving flammable or combustible liquids or gases, greases and similar materials.

- **Class C:**
  - For fires involving energized electrical equipment.

- **Class D:**
  - For fires involving combustible metals.
Only approved containers and portable tanks 5 gallons or less may be used for storage and handling of flammable and combustible liquids.

**Indoor storage requirements:**
- Never store in areas used for exits or stairways.
- Quantities in excess of 25 gallons must be stored in an approved storage cabinet.
- Cabinets shall be labeled "Flammable-Keep Fire Away."
- Not more than 60 gallons of flammable or 120 gallons of combustible liquids shall be stored in any one storage cabinet; no more than three such cabinets in a single storage area.
Signs, Signals and Barricades

- **Barricade** means an obstruction to deter the passage of persons or vehicles.

- **Signs** are the warnings of hazard, temporarily or permanently affixed or placed, at locations where hazards exist.

- **Signals** are moving signs, provided by workers, such as flaggers, or by devices, such as flashing lights, to warn of possible or existing hazards.

- **Tags** are temporary signs, usually attached to a piece of equipment or part of a structure, to warn of existing or immediate hazards.
Signs and Tags

- **Danger signs:**
  - Used only where an immediate hazard exists.

- **Caution signs:**
  - Used only to warn against potential hazards or to caution against unsafe practices.

- **Other common warning signs:**
  - Exit signs, safety instruction signs, directional signs, traffic signs, accident prevention tags.
First Aid Program

- First aid is emergency care provided for injury or sudden illness before emergency medical treatment is available. A workplace first-aid program includes:
  - Management Leadership and Employee Involvement
  - Worksite Analysis
  - Hazard Prevention and Control
  - Safety and Health Training
Medical and First Aid

- Provisions shall be made prior to commencement of the project for prompt medical attention in case of serious injury.

- In the absence of reasonably accessible emergency facilities, a person certified in first-aid, from recognized organizations such as the American Red Cross, shall be available at the worksite to render first aid.

- First aid supplies shall be easily accessible when required. Employers should determine the need for additional first aid kits at larger worksites.

- Certain OSHA standards for confined spaces, and electrical power transmission and distribution also require training in cardiopulmonary resuscitation (CPR).
OSHA 10-Hour Construction Industry Training Program

- Intended to provide entry level construction workers general awareness on recognizing and preventing hazards on a construction site.

- Workers must receive additional training on hazards specific to their job.

### 10-HOUR CONSTRUCTION INDUSTRY REQUIRED COURSE TOPICS

* OSHA subpart references are provided for informational purposes; training should emphasize hazard awareness.

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<th>Mandatory – 4 hours</th>
<th>Elective – 2 hours</th>
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<td>One Hour Introduction to OSHA, including:</td>
<td>Choose at least two of the following elective topics:</td>
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<tr>
<td>- OSH Act, General Duty Clause, Employer and Employee Rights and Responsibilities,</td>
<td>These topics must add up to at least two hours:</td>
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<td>Whistleblower Rights, Recordkeeping basics</td>
<td>- Minimum one-half hour each</td>
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<tr>
<td>- Inspections, Citations, and Penalties</td>
<td>Materials Handling, Storage, Use and Disposal, Subpart H</td>
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<tr>
<td>- General Safety and Health Provisions, Subpart C</td>
<td>Tools - Hand and Power, Subpart I</td>
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<td>- Competent Person, Subpart C</td>
<td>Scaffolds, Subpart L</td>
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<td>- Value of Safety and Health</td>
<td>Cranes, Derricks, Hoists, Elevators &amp; Conveyors, Subpart N</td>
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<tr>
<td>- OSHA Website and available resources</td>
<td>Excavations, Subpart P</td>
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<td>- OSHA 300 number</td>
<td>Stairways and Ladders, Subpart X</td>
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| Two Hours (minimum 15 minutes on each of four areas) OSHA Focus: Four Hazards:       | Optional – 4 hours |
| 30 Minutes Personal Protective and Lifesaving Equipment, Subpart E                   | For the remaining four class hours: |
| 30 Minutes Health Hazards in Construction (e.g., noise, hazard communication and crystalline silica) |

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The 30-hour Construction Outreach Training Program is intended to provide a variety of training to workers with some safety responsibility.

**30-HOUR MANDATORY COURSE TOPICS**

- Introduction to OSHA - at least Two Hours
  - OSH Act, General Duty Clause, Employer and Employee Rights and Responsibilities, Whistleblower Rights, Recordkeeping basics
  - Inspections, Citations, and Penalties
  - General Safety and Health Provisions, Competent Person, Subpart C
  - Value of Safety and Health
  - OSHA Website, OSHA 800 number and available resources
- OSHA Focus: Four Hazards - at least Five Hours (must cover all four areas – minimum 30 minutes on each)
  - Fall Protection, Subpart M (e.g., floors, platforms, roofs)
  - Electrical, Subpart K (e.g., overhead power lines, power tools and cords, temporary wiring, grounding)
  - Struck by (e.g., falling objects, machinery, constructing masonry walls)
  - Caught in-between (e.g., trench hazards, ungarded machinery, equipment)
- Personal Protective and Lifesaving Equipment, Subpart E - at least Two Hours
- Health Hazards in Construction (for example, noise, hazard com. and crystalline silica) - at least Two Hours
- Stairways and Ladders, Subpart X - at least One Hour

**30-HOUR ELECTIVE COURSE TOPICS**

Choose at least 6 of the following topics - Must add up to at least 12 hours

- Fire Protection and Prevention, Subpart F
- Materials Handling, Storage, Use and Disposal, Subpart H
- Tools - Hand and Power, Subpart I
- Welding and Cutting, Subpart J
- Scaffold, Subpart L
- Cranes, Derricks, Hoists, Elevators, and Conveyors, Subpart N
- Motor Vehicles, Mechanized Equipment and Marine Operations; Roll Off Protective Structures and Overhead Protection; and Signs, Signals and Barricades, Subparts O, W, and G
- Excavations, Subpart P
- Concrete and Masonry Construction, Subpart Q
- Steel Erection, Subpart R
- Safety and Health Program
- Confined Space Entry
- Powered Industrial Vehicles
- Ergonomics
PV safety involves the safety of the workers installing the system and the safety of all others who may come in contact with the system after it is installed.

- OSHA regulations help keep workers safe.
- NEC requirements and AHJ inspections help ensure a safe system is installed.
Questions and Discussion