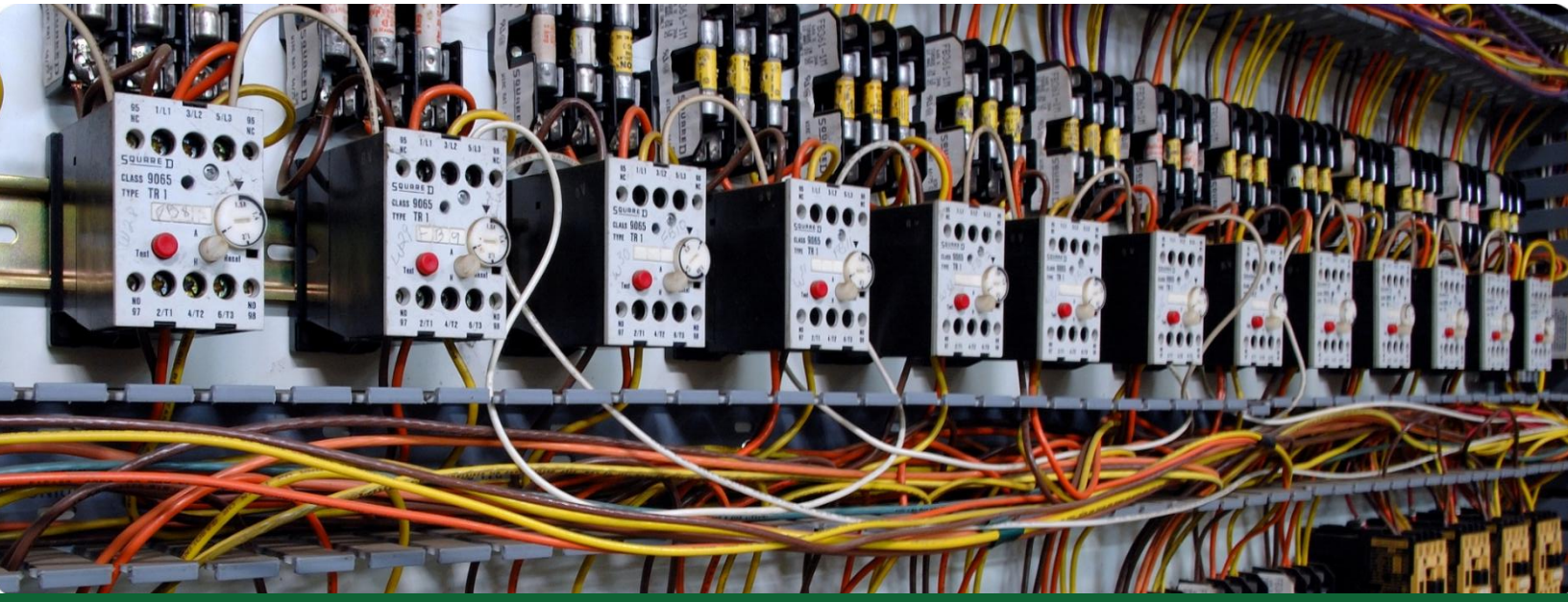
Transit Core Competencies Curriculum

Participant Resource Guide

Electrical Foundations

May 2026



Course Outline

- Module 1: Introduction to Electricity
- Module 2: Basic Electrical Principles
- Module 3: AC and DC Electricity
- Module 4: Circuit Components & Architecture
- Module 5: Magnetism and Electromagnetism
- Module 6: Electrical Tools
- **Module 7: Safety and PPE**

TWC TRANSIT WORKFORCE CENTER

U.S. Department of Transportation
Federal Transit Administration

A program of the Federal Transit Administration administered by the International Transportation Learning Center

Course: Electrical Foundations
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Module 7 – Safety and PPE

Objectives

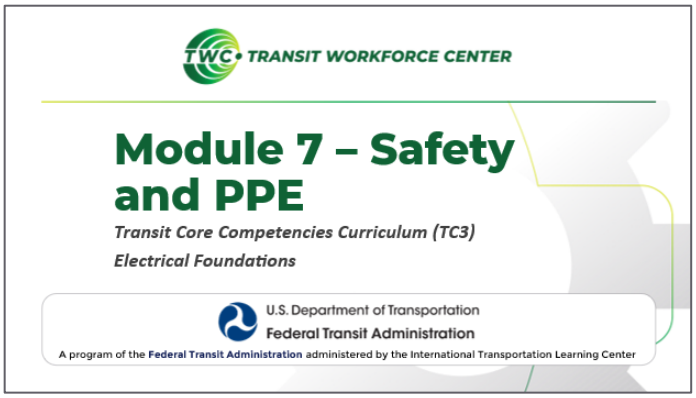
- Identify and assess electrical hazards in the workplace.
- Select and utilize appropriate PPE for high voltage, low voltage, and arc flash environments.
- Apply workplace safety policies and procedures to mitigate electrical hazards.

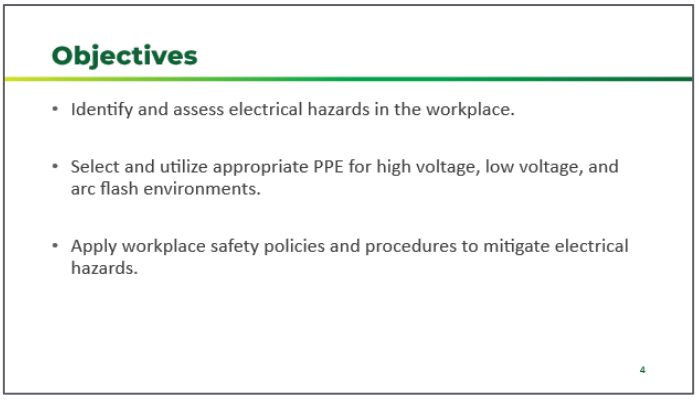
Key Terms

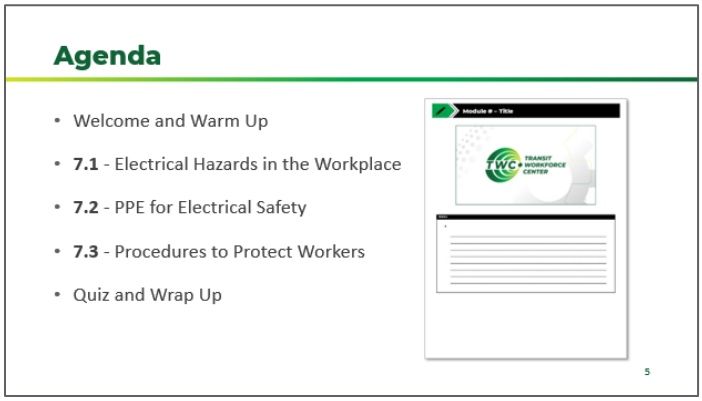
- Affected Employee
- Arcing (Electrical Arcing)
- Arc Flash Boundary
- Arc Rating
- Authorized Employee
- Electric Shock
- Electrocution
- Grounding
- Hierarchy of Controls
- High Voltage
- Insulation
- Intermediate Voltage
- Limited Approach Boundary
- Lockout/Tagout (LOTO)
- Low Voltage
- NFPA 70E
- OSHA 29 CFR 1910.335 – Safeguards for Personnel Protection
- OSHA 29 CFR 1910.333 – Selection and Use of Work Practices
- Primary Electrical Risks
- Resistance
- Restricted Approach Boundary
- Secondary Electrical Risks

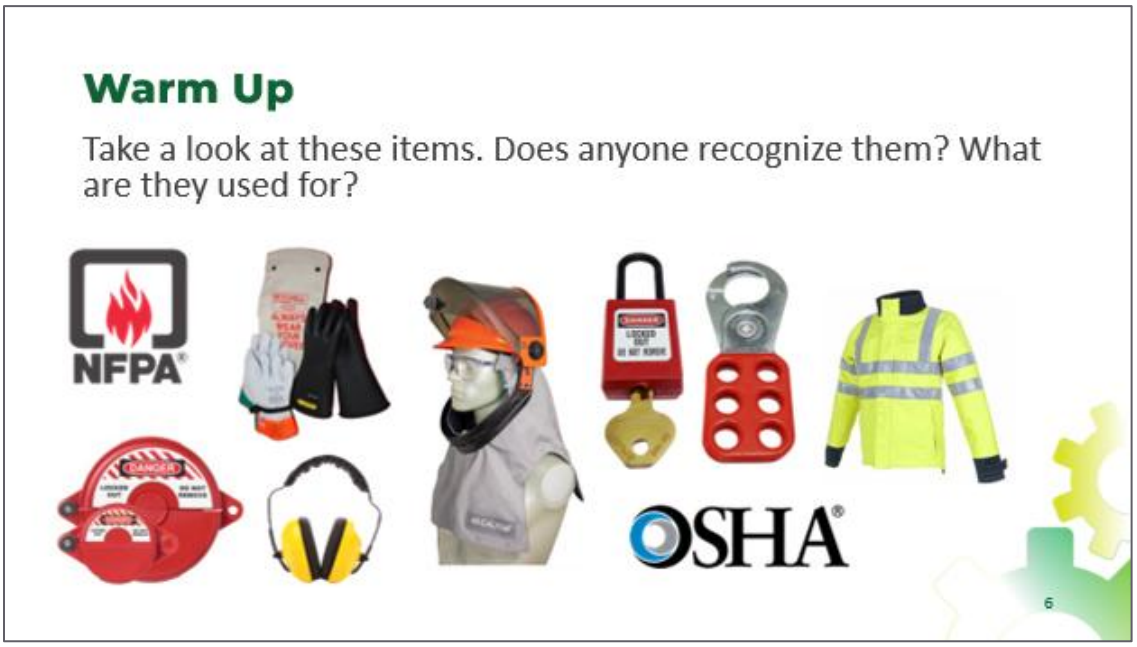
Participant Resource Guide

Safety and PPE



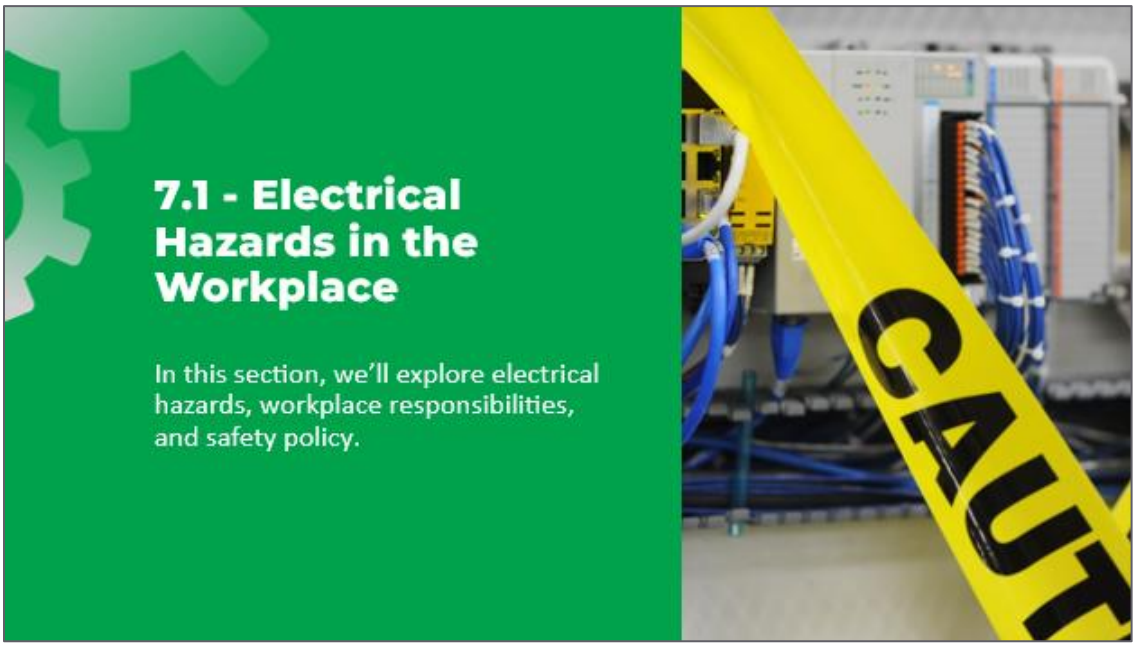






Notes:

- The images on this slide all have something to do with the topics you'll learn about in today's lesson.
- Take a look at these items.
- Do yourecognize them? What are they used for?


7.1 - Electrical Hazards in the Workplace
In this section, we'll explore electrical hazards, workplace responsibilities, and safety policy.
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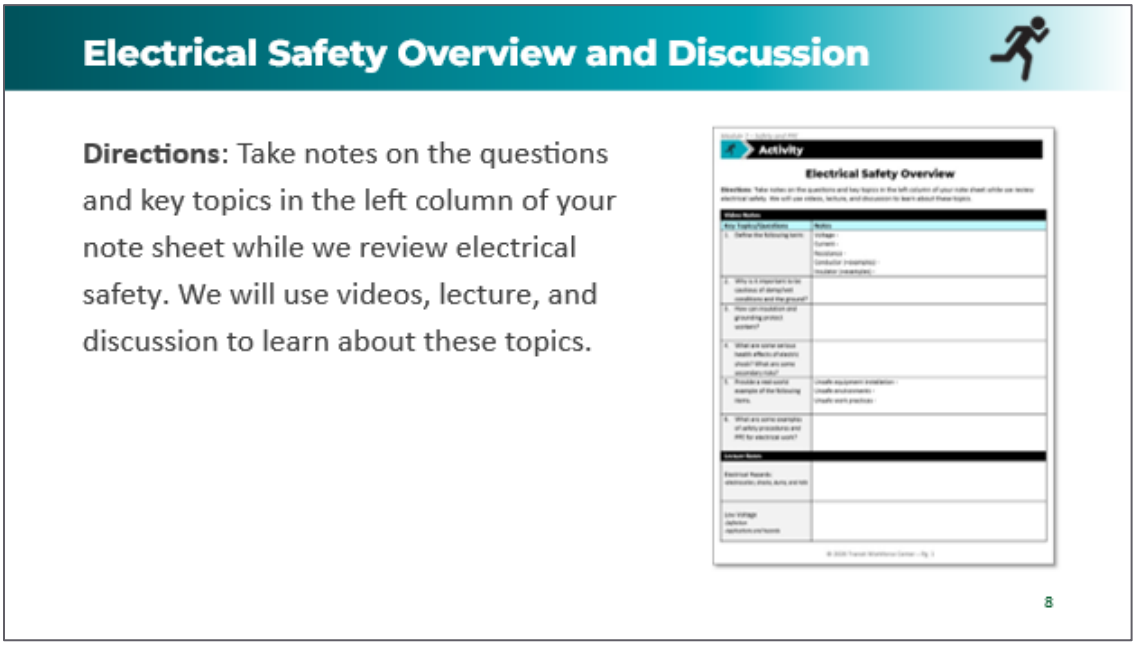


Notes:

- You'll start with a video, lecture, and discussion activity.
- Take a look at the **"Electrical Safety Overview and Discussion" handout** embedded in the Participant Resource Guide. Then you'll start with a video that provides a solid overview of electrical safety.
- As you watch, take notes on the questions and key topics in the left column of your note sheet while we review electrical safety.
- You'll complete the remainder of the activity with a lecture.

Activity

Electrical Safety Overview

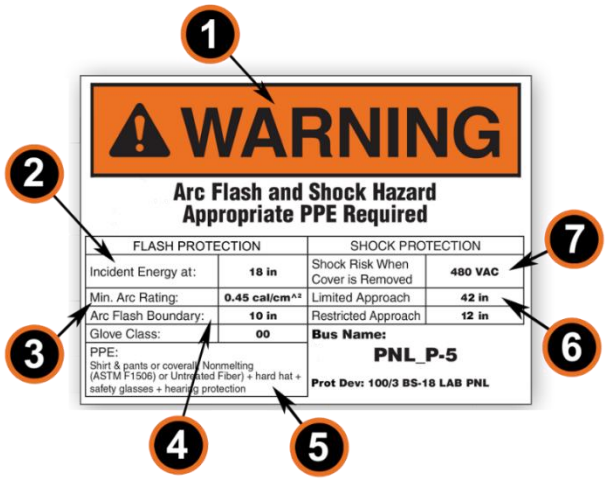
Directions: Take notes on the questions and key topics in the left column of your note sheet while we review electrical safety. We will use videos, lectures, and discussions to explore these topics.

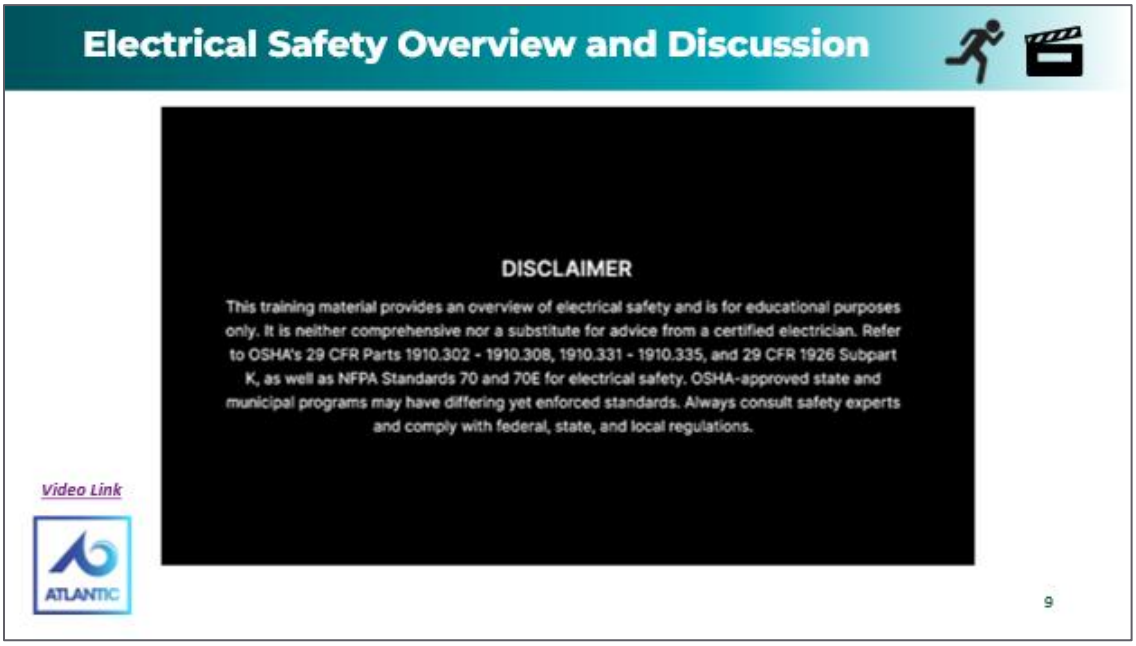
Video Notes	
Key Topics/Questions	**Notes**
1. Define the following term:	Voltage - Current - Resistance - Conductor (+examples) - Insulator (+examples) -
2. Why is it important to be cautious of damp/wet conditions and the ground?	
3. How can insulation and grounding protect workers?	
4. What are some serious health effects of electric shock? What are some secondary risks?	
5. Provide a real-world example of the following items.	Unsafe equipment installation - Unsafe environments - Unsafe work practices -
6. What are some examples of safety procedures and PPE for electrical work?	
Lecture Notes	
Electrical Hazards: *-Electrocution, Shocks, Burns, and Falls*	
Low Voltage *-Definition* *-Applications and hazards*	

High Voltage *-Definition* *-Applications and hazards*	
Arc Flash *-Definition* *-Dangers*	
PPE *- Hierarchy of controls* *- Employer/Employee responsibilities*	
OSHA *-1910*	
NFP *-70E* *-Arc flash boundary* *-Arc flash rating* *- Arc flash labels (*See image below)*	
Safety Policies at our Agency *-PPE location and storage procedures*	

***Arc Flash Label** - Note the seven essential information items on the arc flash label below.*

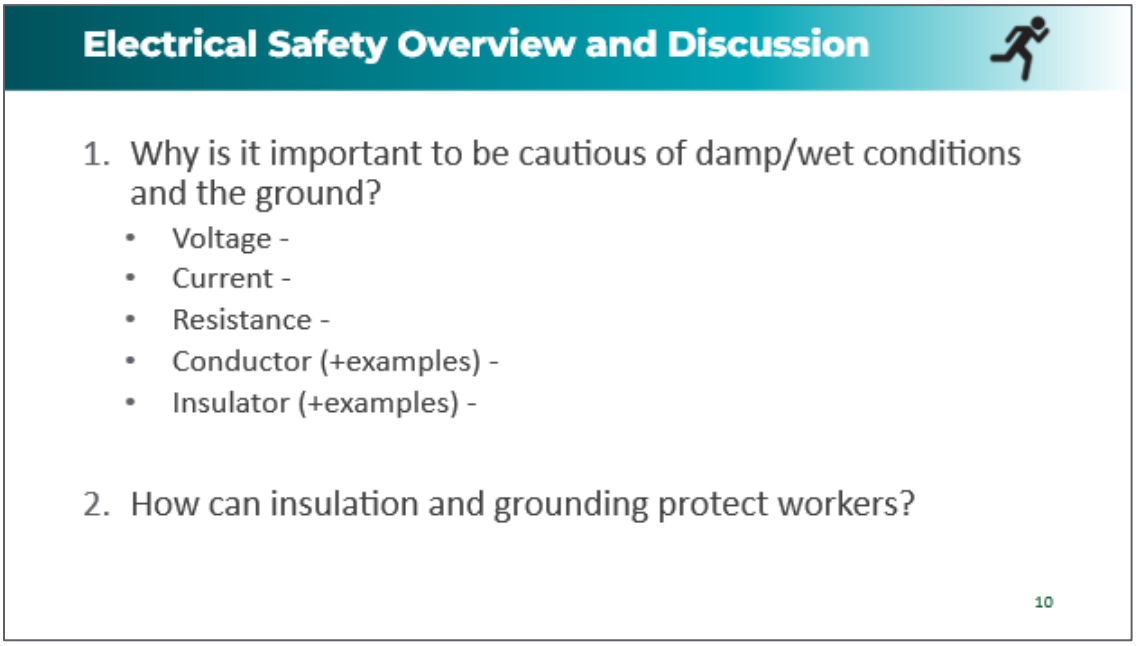
Image Source: (Brady Corporation, 2024)

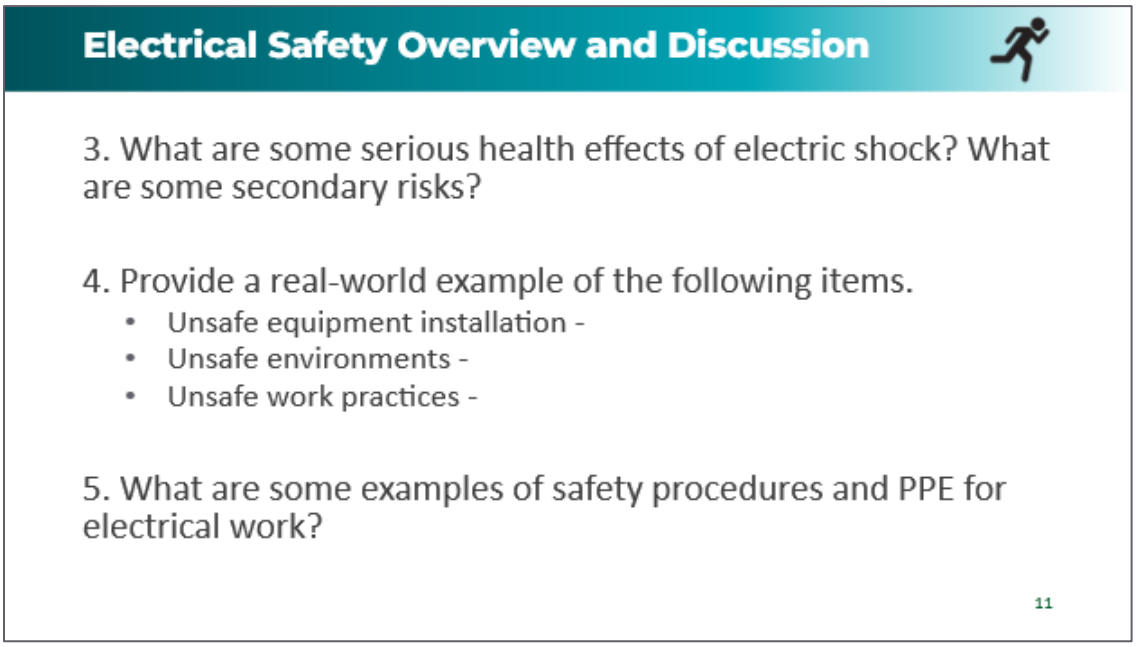


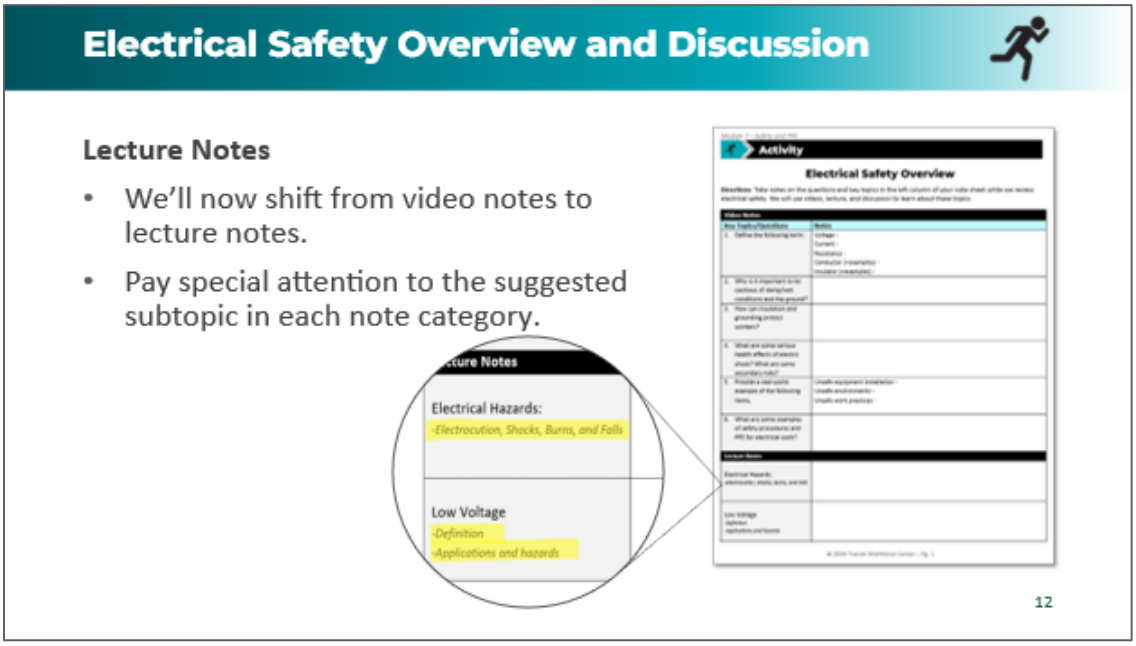


Notes:

- **Video Link**: https://www.youtube.com/watch?v=WoJBg6oEA3k

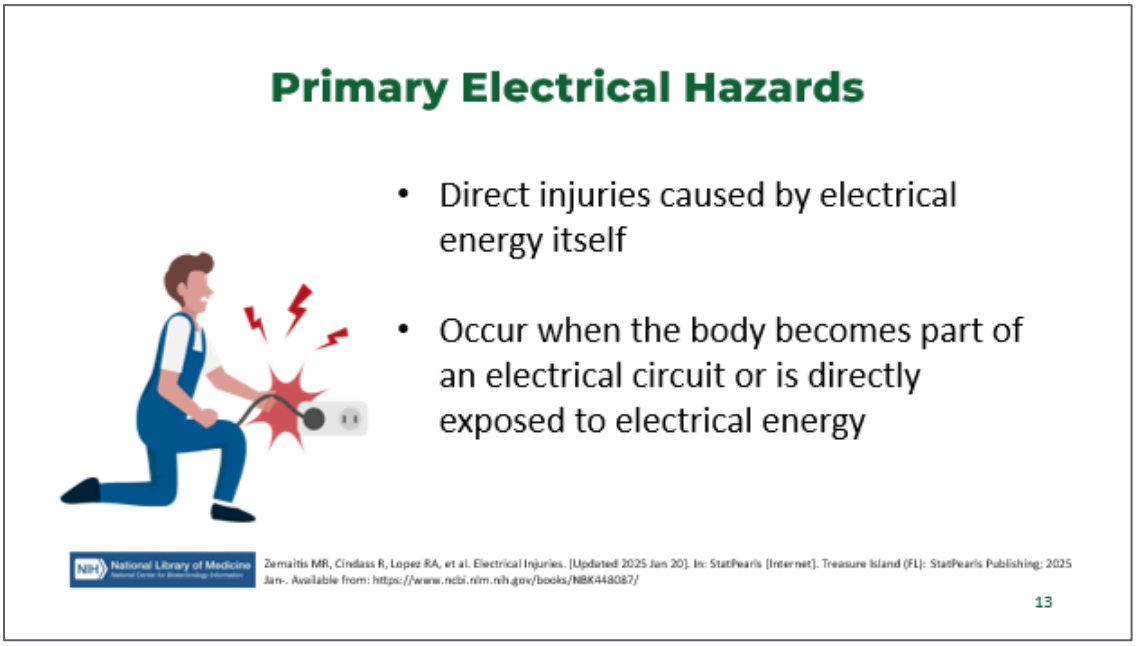

Electrical Safety Overview and Discussion
1. Why is it important to be cautious of damp/wet conditions and the ground?
• Voltage -
• Current -
• Resistance -
• Conductor (+examples) -
• Insulator (+examples) -
2. How can insulation and grounding protect workers?
10


Electrical Safety Overview and Discussion
3. What are some serious health effects of electric shock? What are some secondary risks?
4. Provide a real-world example of the following items.
• Unsafe equipment installation -
• Unsafe environments -
• Unsafe work practices -
5. What are some examples of safety procedures and PPE for electrical work?
11



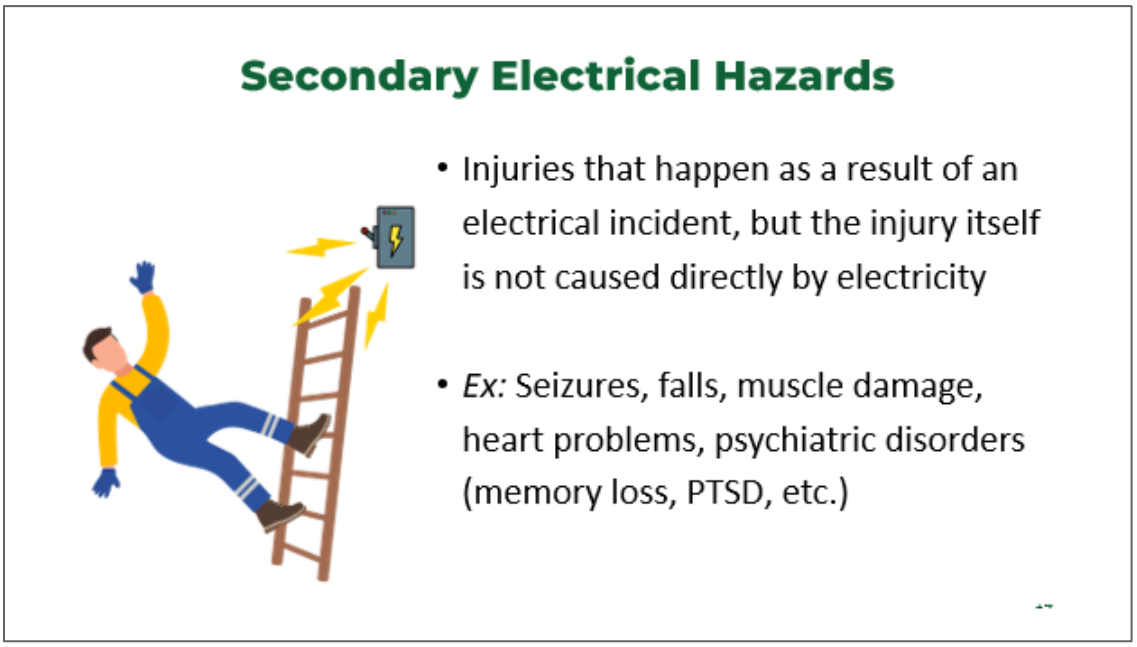
Notes:

- You'll now shift from video notes to lecture notes.
- Pay special attention to the suggested subtopic in each note category.



Notes:

- Electrical hazards are often placed in two categories: primary hazards and secondary hazards.
- **Primary hazards** are direct injuries caused by electrical energy itself. These occur when the body becomes part of an electrical circuit or is directly exposed to electrical energy.
- Primary electrical hazards include things like shocks, electrocution, and burns and they are are more common and more dangerous than many people realize.
- Every year, over 1,000 people in the U.S. die from electrocution (across the board, not just the workplace), and around 30,000 more suffer non-fatal electric shocks that can still cause serious injuries.
- Electrical burns are another major concern, accounting for 5% of all burn unit admissions in the country.
- These risks highlight why electrical safety isn't optional — it's essential.

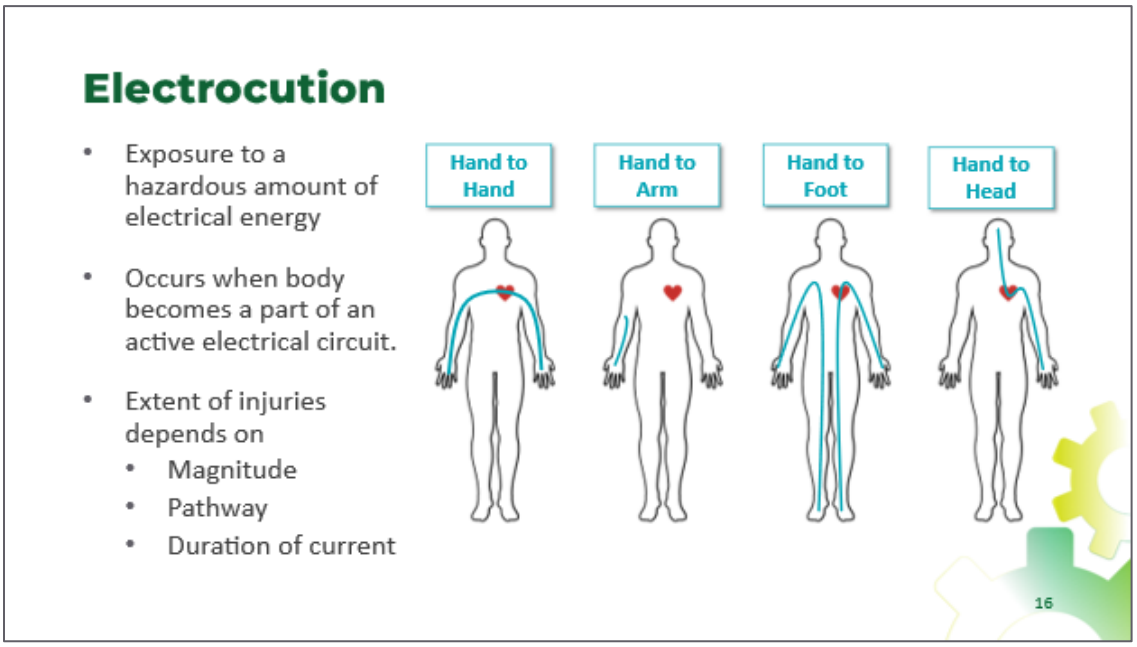


Notes:

- Primary hazards can lead to **secondary hazards**, which are injuries that happen as a result of an electrical incident, but the injury itself is not caused directly by electricity.
- In other words, electricity triggers *another* dangerous event.
- Electrical incidents can lead to long-term or delayed health issues like seizures, memory loss, PTSD, and heart problems.
- Victims may also experience muscle or eye damage, and many are seriously hurt by falls that happen during or after a shock.
- These secondary risks make prevention and immediate medical attention just as important as avoiding the shock itself.

Notes:

- Electrical injuries can take several forms, and each one comes with serious consequences.
- These injuries can happen instantly and often without warning.
- Let's take a deeper look at the most common types of electrical injuries - electrocution, electric shock, burns, and falls caused by contact with electrical energy.



Notes:

- Electrocution results when a human is exposed to a lethal amount of electrical energy and is subsequently killed.
- For death to occur, the human body must become part of an active electrical circuit having a current capable of over stimulating the nervous system or causing damage to internal organs.
- The extent of injuries received depends on the current's magnitude, the pathway of the current through the body, and the duration of current flow through the body.

Notes:

- **Video Link:** https://tinyurl.com/ycx7dua8

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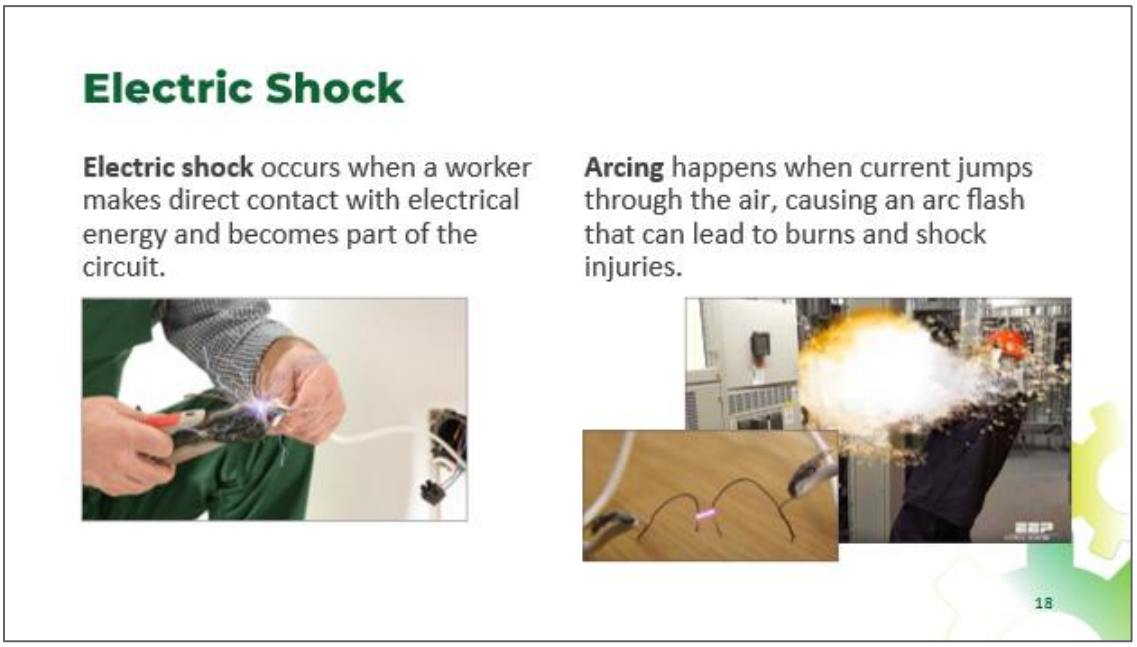
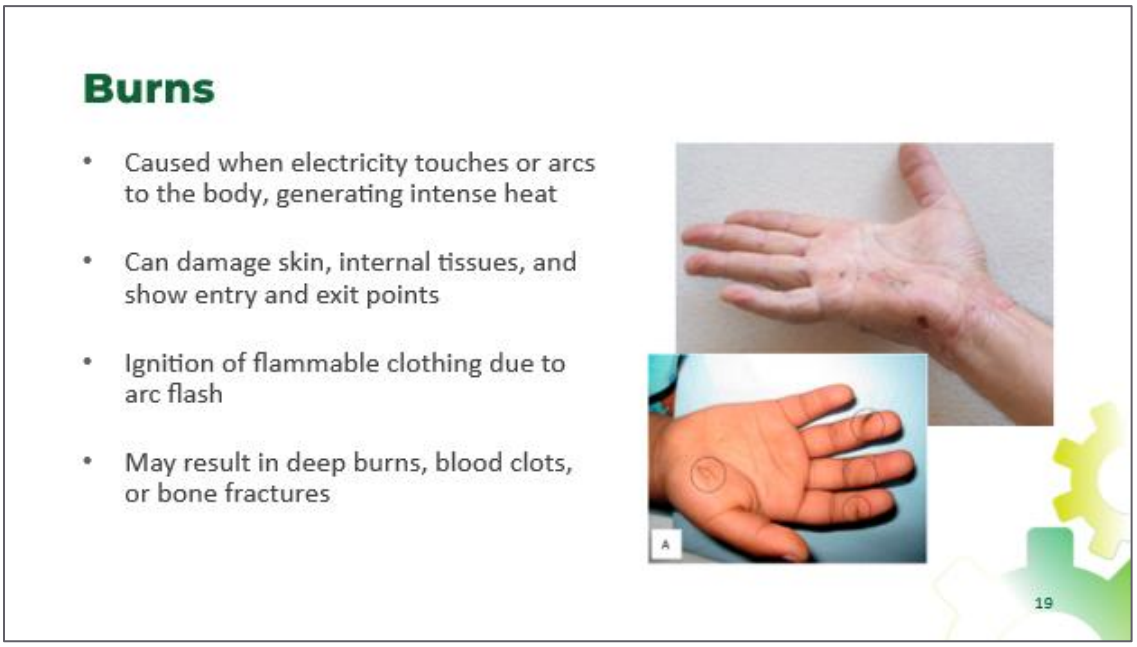


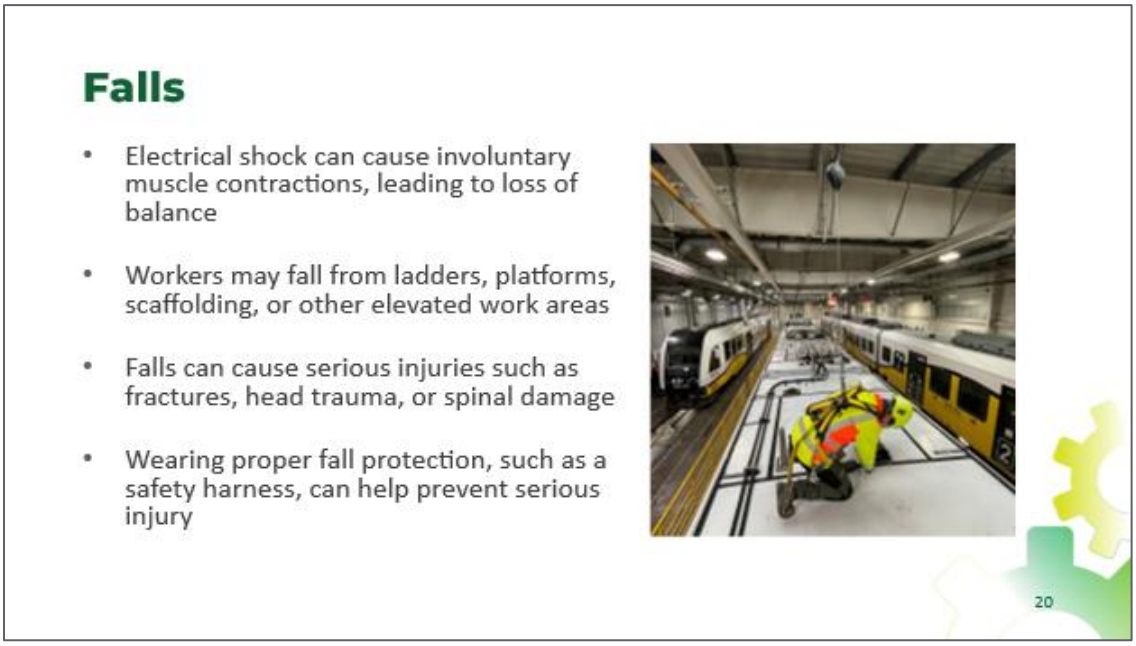
Notes:

- **Electric shock** happens when a worker touches live electrical parts and becomes part of the circuit, allowing current to pass through the body. This can cause serious internal injuries, even if there's no visible damage.
- **Arcing**, on the other hand, occurs when electricity jumps through the air causing what's known as an arc flash. Arc flashes are extremely dangerous and can result in both severe burns and electric shock injuries.



Notes:

- **Electrical burns** happen when electricity makes contact with your body or arcs close enough to create heat at the point of contact. These burns can affect not just the skin, but also deep tissues, muscles, and organs which makes them especially dangerous.
- With high-voltage incidents, you might see an entry and exit wound, showing where the current traveled through the body.
- The damage isn't always visible on the surface. Internally, electricity can cause clotting, nerve damage, and even break bones, especially if there's violent muscle contraction or a fall during the shock.
- That's why any electrical burn, no matter how small it looks, should be treated seriously and evaluated by a medical professional.

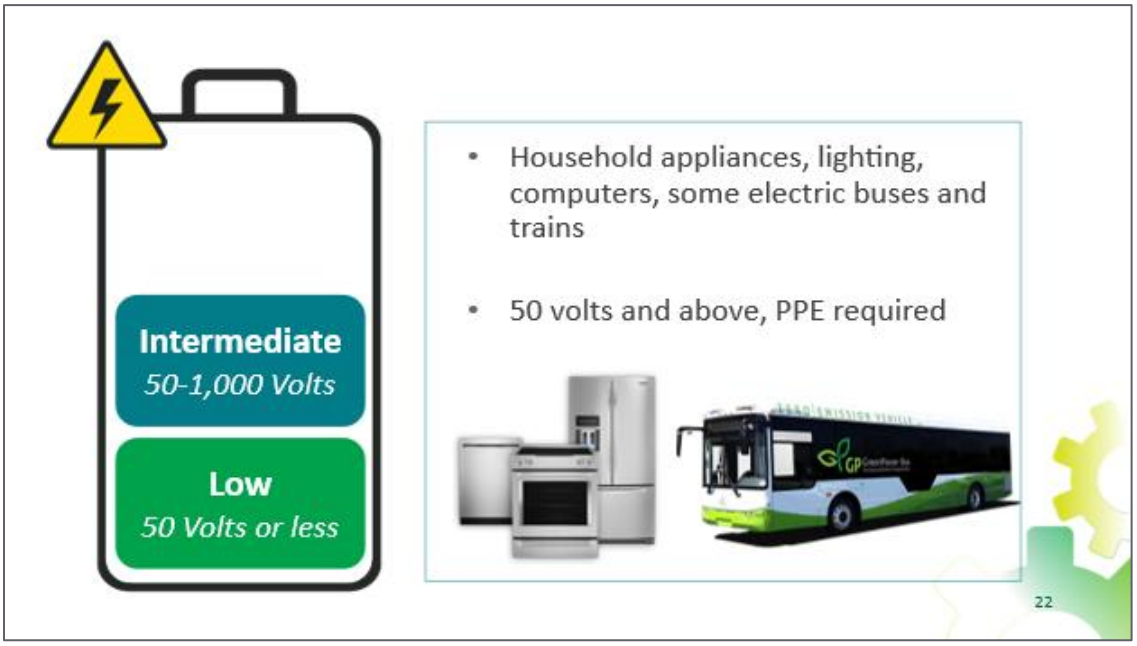


Notes:

- When we talk about electrical hazards, we often focus on shock or electrocution. However, **falls** are one of the most serious secondary hazards associated with electricity.
- An electric shock can cause sudden, involuntary muscle contractions. This can cause a worker to lose their grip, balance, or control of tools.
- If a worker is on a ladder, lift, or elevated platform, even a relatively small shock can lead to a dangerous fall.
    - These falls can cause serious injuries such as broken bones, head trauma, or spinal injuries. In some cases, the fall may be more dangerous than the electrical shock itself.
    - That's why it's important to think about the entire work environment, not just the electrical source.
- When working at height, workers should always use the appropriate fall protection, such as a properly fitted safety harness.
- PPE should also be inspected every time it is used. Workers should check harnesses and other fall protection equipment for tears, worn straps, damaged stitching, or weak connection points.
- Regular inspection and maintenance of PPE is just as important as wearing the PPE itself.

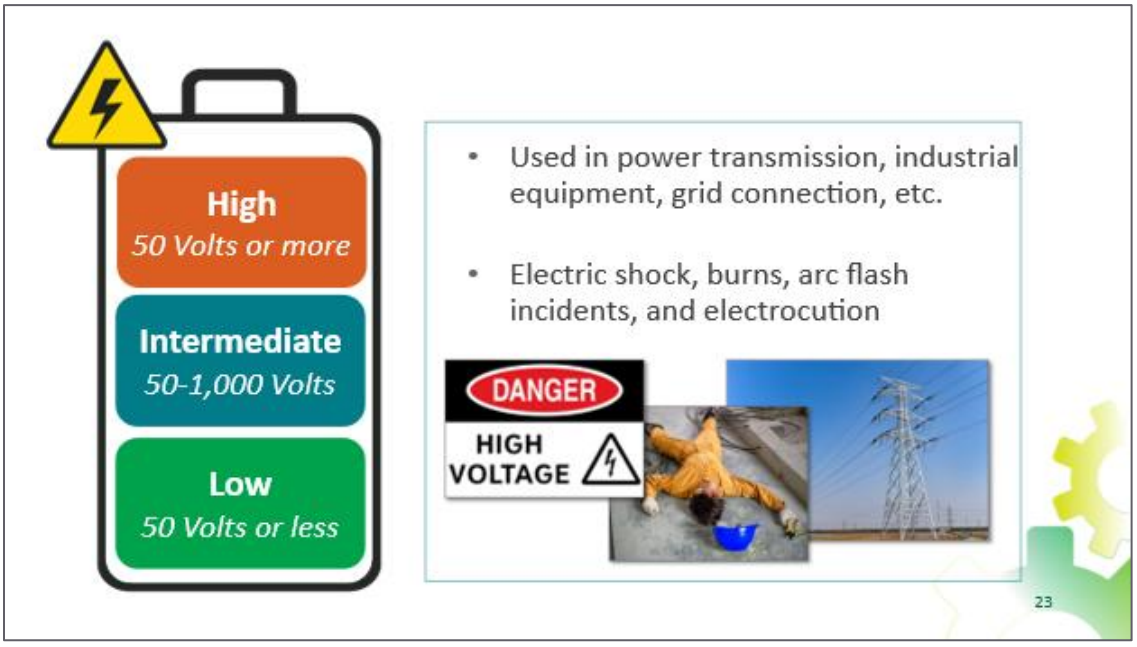
Notes:

- Low voltage refers to electrical systems operating at **50 volts or less**, either AC or DC.
- Many of the systems workers interact with every day fall into this category.
    - Examples include car and bus batteries, communication systems, and some lighting systems.
    - Bus mechanics often work around 12-volt DC battery systems, which are considered low voltage.
- Even though these systems operate at lower voltages, **low voltage does not mean low danger**. Under the right conditions, electrical current can still cause serious injury.
- When working around batteries or other low-voltage systems, workers should avoid creating sparks and should wear appropriate PPE such as gloves and safety goggles. Batteries can release explosive gases, and a spark could cause a battery to explode.
- Workers should also watch for hazards such as short circuits to ground, burning insulation, or overheating wires, which can lead to fires.
- This course provides foundational electrical safety training, and many of the examples we discuss will focus on low-voltage DC systems commonly found in transportation equipment and facilities.



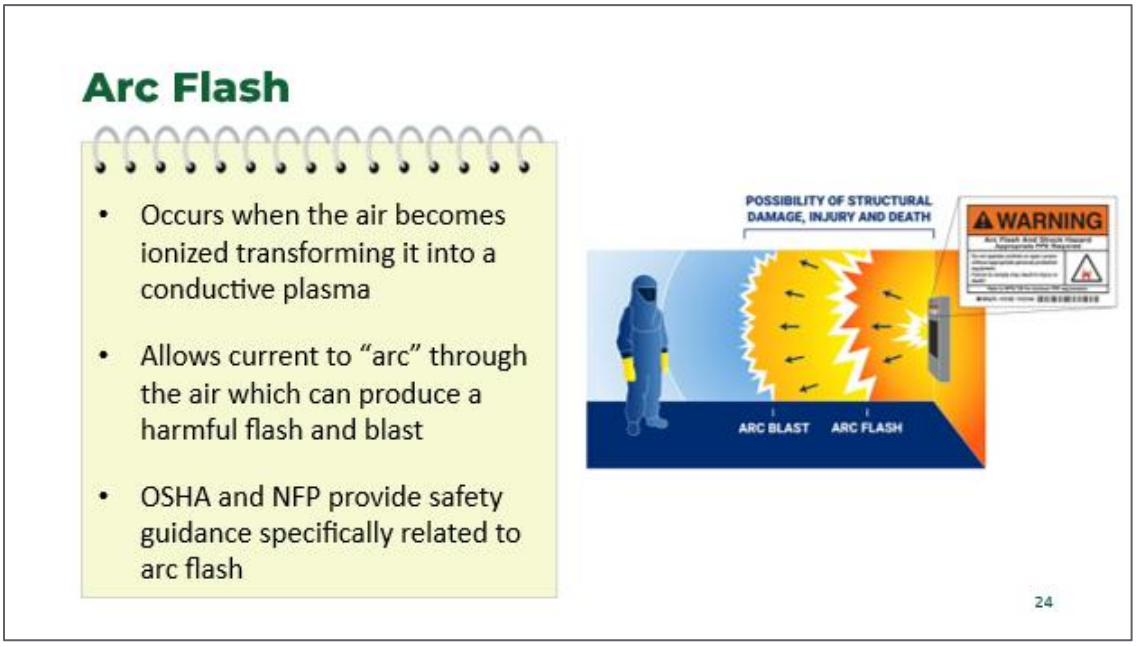
Notes:

- Intermediate voltage refers to electrical systems that operate **above 50 volts and below 1,000 volts**, either AC or DC.
- At this voltage level, electricity presents a significant shock hazard, so appropriate PPE and safety procedures are required when working on or near energized equipment.
- Many transportation systems operate within this range. For example, trains and battery-electric buses often use electrical systems under 1,000 volts.
- Because of this, rail mechanics and transit technicians frequently work around intermediate-voltage equipment, which makes understanding electrical safety especially important.
- Even though these systems are not considered high voltage, they still have enough electrical energy to cause serious injury if proper safety practices are not followed.



Notes:

- High voltage refers to systems above 1,000 volts (1 kV).
- It is used in power transmission, industrial equipment, grid connection, etc.
- Hazards include electric shock, burns, arc flash, and electrocution.
- At this point in training, high voltage training will be minimized. Much more training will happen if you work around high voltage equipment.
- For example, someone in a rail agency's substation department would be common to work with voltage above 1000 volts.

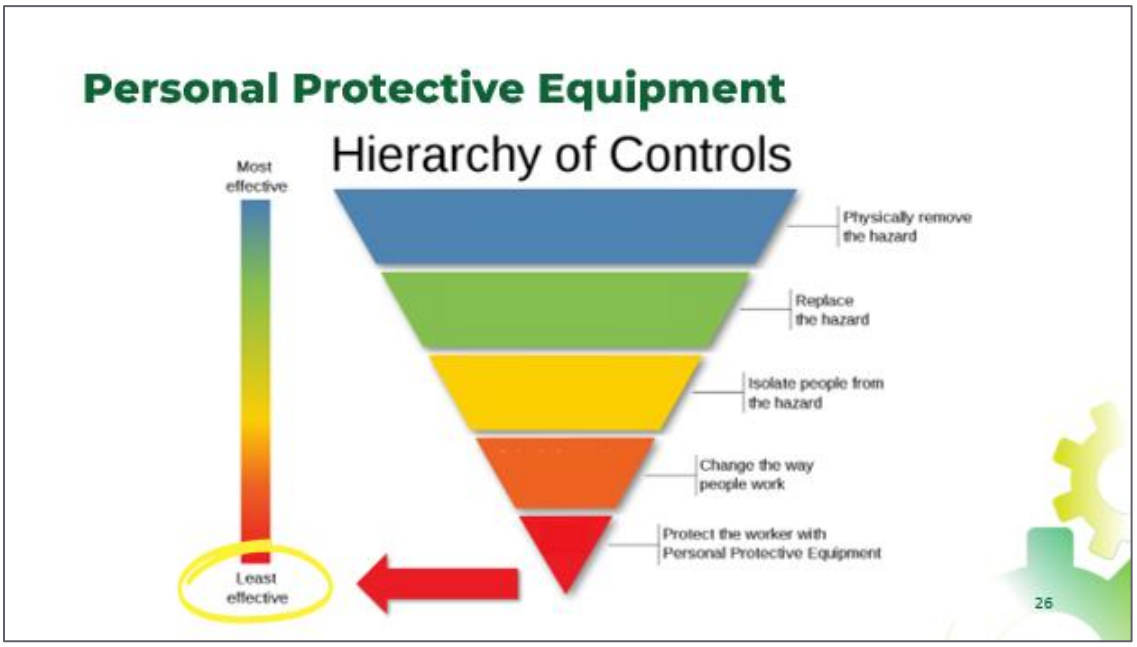


Notes:

- An arc flash is the result of a phenomenon known as electric arcing.
- An **electric arc** forms when electrical current leaves its intended conductive path and travels through the air.
- Normally, air acts as an insulator. However, when the air becomes ionized, its particles gain and lose electrons and it turns into a conductive gas called plasma. Electricity can then flow through this plasma, creating a powerful flash of heat and light.
- Electric arcs can occur for several reasons, including high voltage or current, moisture, damaged insulation, or degraded electrical equipment.
- Arc flashes can produce extreme heat, bright light, and pressure waves, which can cause serious burns and other injuries.
- For this course, it is important to understand that arc flash hazards can occur in intermediate or high-voltage systems.
- Workers who operate around these systems receive additional training and protective equipment to ensure their safety.

Notes:

- This video shows the dangers of arc flashes. Let's take a look.
- **Video Link**: https://www.youtube.com/watch?v=DbqLDjXTsOM



Notes:

- Working with electricity can be dangerous, which is why workplaces use multiple layers of protection to keep workers safe.
- One important safety concept used across many industries is called the **Hierarchy of Controls**.
    - This framework helps us think about the most effective ways to reduce hazards in the workplace.
- As we move down the hierarchy, the controls become less effective, which is why the goal is always to use the highest level of control possible.
- At the top of the hierarchy is **Elimination**, which means physically removing the hazard entirely. If the hazard no longer exists, the risk is removed.
    - One example of elimination is the use of **automation**. Some railway networks are beginning to use robotic systems that can detect defects and perform repairs such as welding or grinding. By automating these tasks, workers are removed from direct exposure to the hazard.
- The next level is **Substitution**, which means replacing the hazard with a safer alternative.
    - For example, replacing manual track switches with power-operated switch machines allows workers to control the switch remotely. The task still needs to be completed, but the worker can perform it from a safer location away from the tracks.
- Next is **Engineering Controls**, which isolate people from the hazard through equipment or system design.
    - An example of an engineering control is insulated tools. These tools are coated with rubber, nylon, or another insulating material that helps prevent electrical current from reaching the worker. The hazard still exists, but the design of the tool provides a layer of protection.

- The next level is **Administrative Controls**, which change how people work through policies, procedures, training, or scheduling.
    - A common example is a Lockout/Tagout procedure, often called LOTO. Before working on electrical equipment, workers must follow specific steps to ensure the equipment is properly shut off and cannot be accidentally re-energized.
- At the bottom of the hierarchy is **Personal Protective Equipment,** or **PPE**.
    - PPE includes items such as arc-rated clothing, insulated gloves, and protective face shields. PPE does not eliminate the hazard, but it helps reduce the severity of injury if an incident occurs.
- This is why PPE is considered the last line of defense, used after other safety controls have been applied.
- PPT is the least effective because it is *subject to human* error and *only effective if used*

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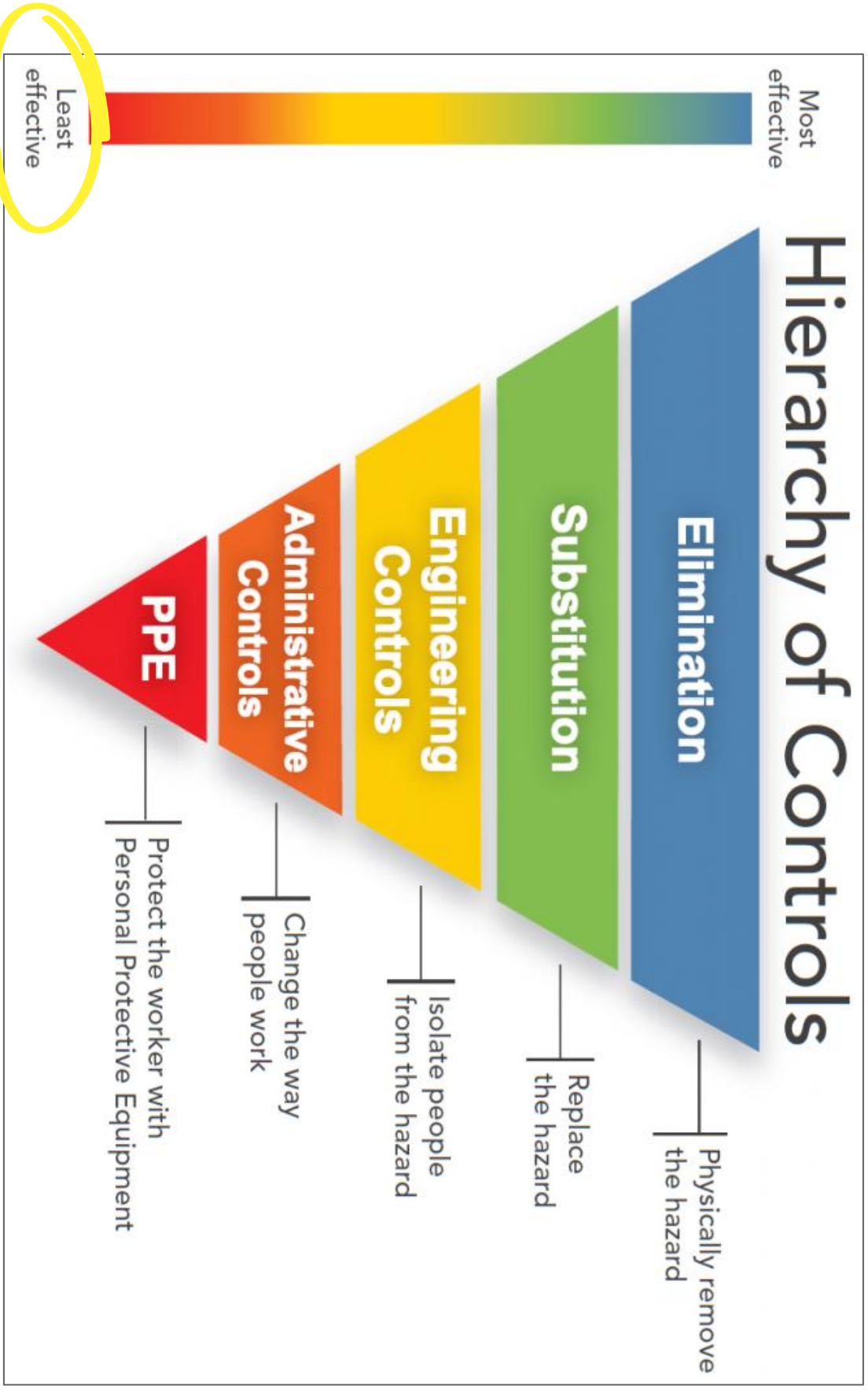
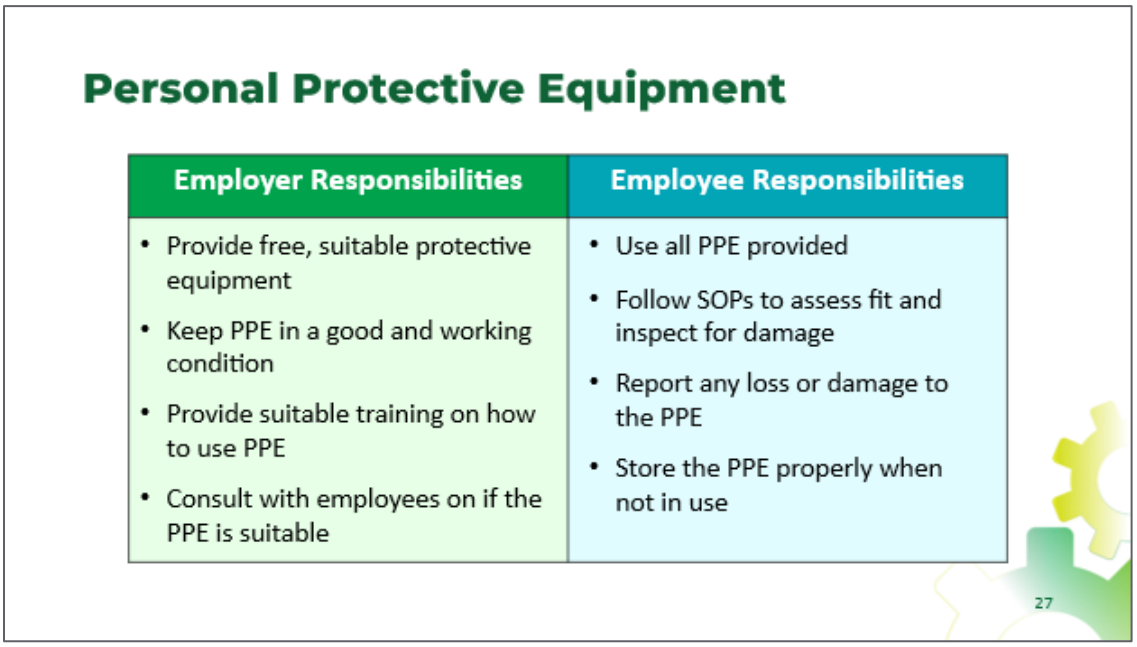

Hierarchy of Controls
Most effective
Least effective
Elimination
Physically remove the hazard
Substitution
Replace the hazard
Engineering Controls
Isolate people from the hazard
Administrative Controls
Change the way people work
PPE
Protect the worker with Personal Protective Equipment

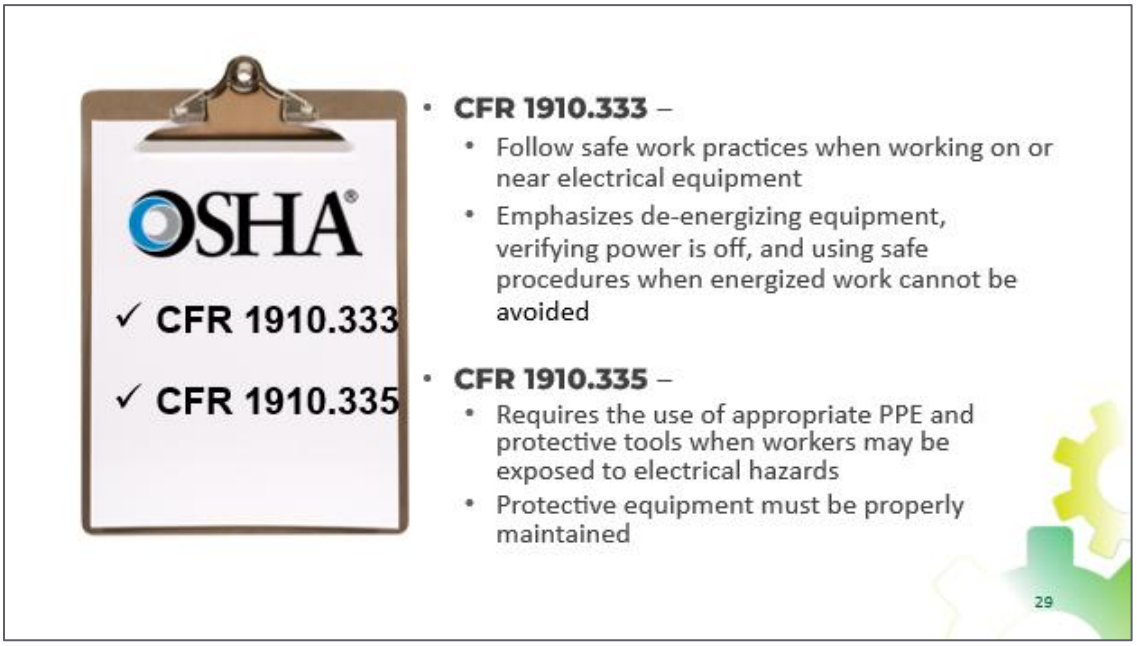


Notes:

- For PPE to be effective, it requires both employer and employee responsibilities to be fulfilled.
- Employer responsibilities
    - You'll be provided with the right PPE for the job at hand. It's our job to keep it in good condition so you can count on it.
    - You'll also be trained on how to use it properly, and your feedback matters—if the gear doesn't work for you, let them know.
- Employee responsibilities
    - Always use the PPE you're given and follow the steps to check that it fits and isn't damaged before each use.
    - If something's missing or broken, report it right away—and make sure to store your gear properly so it stays in good condition.

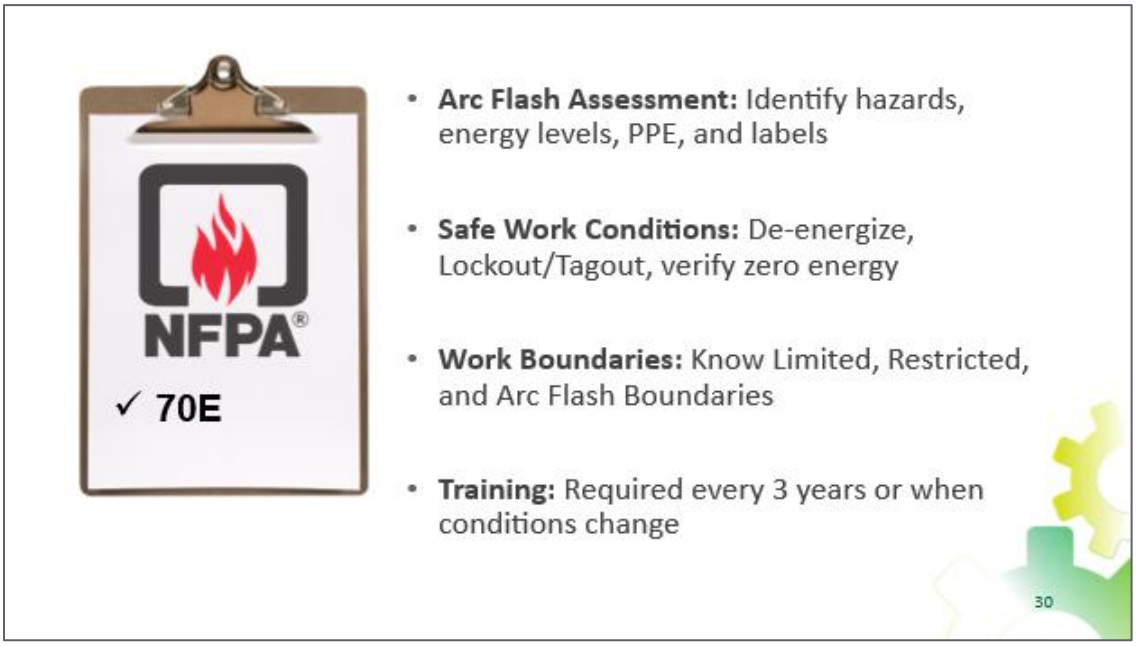
Notes:

- Industry standards from OSHA and NFPA also protect workers from injuries related to electrical work.
- OSHA developed 1910.333 and 1910.335 which is mandatory for all.
- NFPA developed 70E which, while not mandatory, provides guidance on how to meet OSHA requirements.



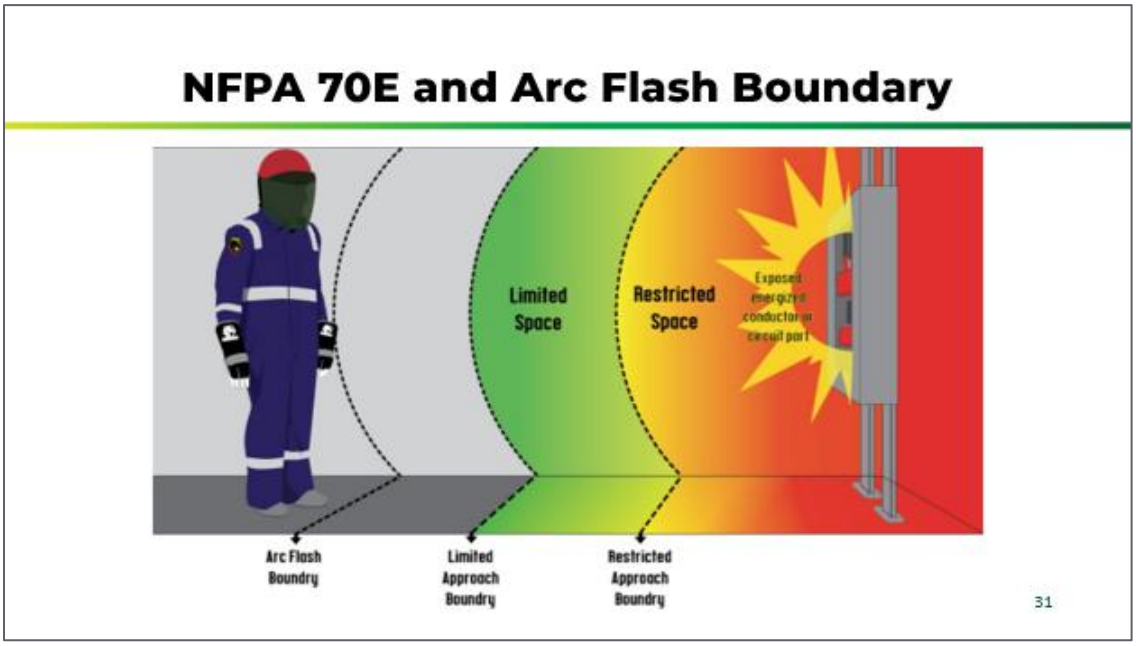
Notes:

- **OSHA 29 CFR 1910.333 – Selection and Use of Work Practices**
  - This standard requires workers to follow safe work practices when working on or near electrical equipment. It emphasizes de-energizing equipment whenever possible, verifying power is off, and using safe procedures when energized work cannot be avoided.
- **OSHA 29 CFR 1910.335 – Safeguards for Personnel Protection**
  - This standard requires the use of appropriate personal protective equipment and protective tools when workers may be exposed to electrical hazards. It also requires that protective equipment be properly maintained and used to reduce the risk of injury.



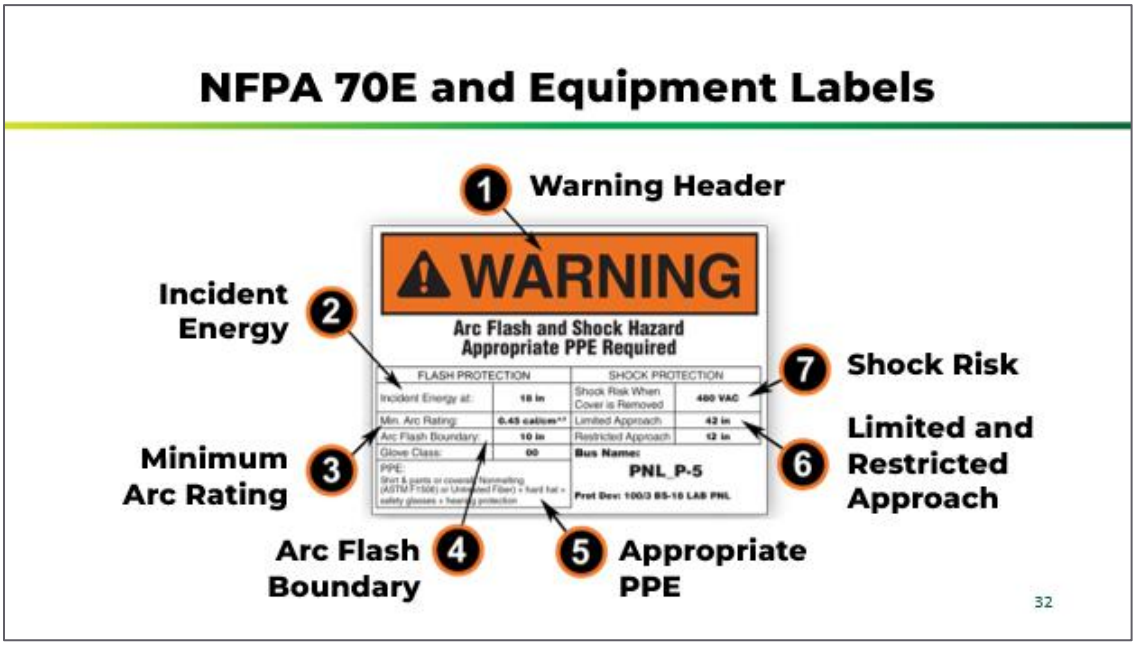
Notes:

- **Requires arc flash risk assessments** to identify hazards, determine energy levels, and set safety boundaries with appropriate PPE and labeling.
- **Outlines electrically safe work conditions** including de-energizing equipment, Lockout/Tagout procedures, and verifying de-energization to protect workers.
- **Defines boundaries for safe electrical work:** Limited Approach (unqualified), Restricted Approach (qualified with PPE), and Arc Flash Boundary (risk of second-degree burns).
- **Mandates training on safe practices**, hazard identification, and PPE, updated every three years or when conditions change.



Notes:

- **Arc Flash Boundary**: The distance from energized equipment where arc flash burns may occur; anyone crossing must wear arc-rated PPE matching the incident energy level.
- **Limited Approach Boundary:** The minimum distance an unqualified person can approach energized equipment without supervision, unless escorted by a qualified worker and additional precautions are taken.
- **Restricted Approach Boundary:** A shock protection zone closer to live parts that only qualified workers may enter using shock-rated PPE and insulated tools.



Notes:

- Arc flash protection also includes labels to help workers better understand the hazards and risks they are working with.
- Labels may vary somewhat, but they generally contain the following:
  1. Warning header when the voltage is over 600 or when the incident energy is over 40 cal/cm2.
  2. Incident Energy: the amount of energy that a worker could be exposed to in the event of an arc flash.
  3. Minimum Arc Rating refers to the minimum arc rating of the required PPE.
  4. Arc Flash Boundary: The minimum safe distance from the electrical equipment where a person could potentially receive a second-degree burn if arc flash occurs.
  5. Appropriate PPE: Specific types of protective gear required to protect workers from the identified electrical hazards.
  6. Limited and Restricted Approach: The minimum distance an unqualified person can approach energized equipment without supervision, unless escorted by a qualified worker and additional precautions are taken.
  7. Shock Risk: The voltage of the equipment.

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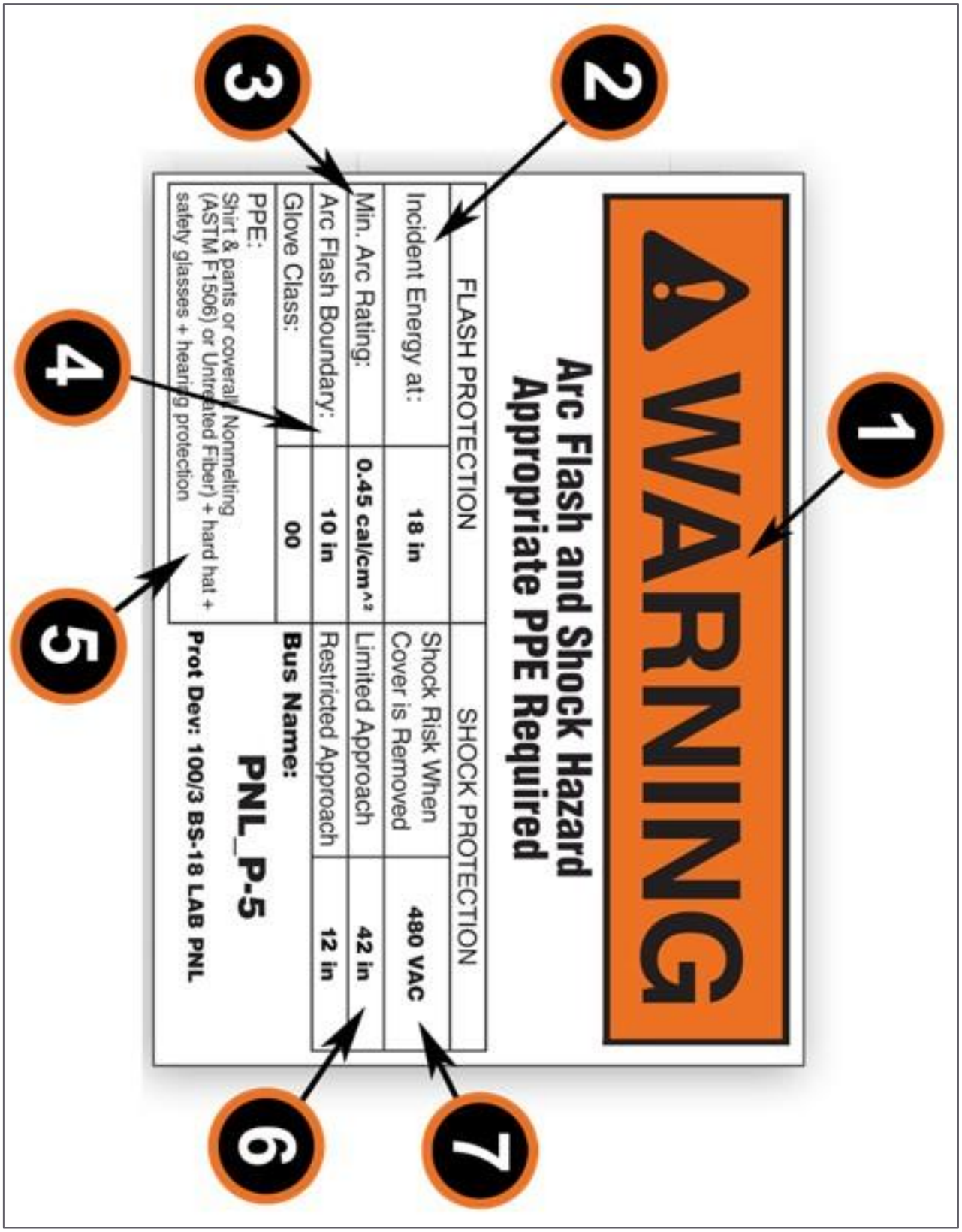
WARNING
Arc Flash and Shock Hazard
Appropriate PPE Required
FLASH PROTECTION
Incident Energy at: 18 in
Min. Arc Rating: 0.45 cal/cm^2
Arc Flash Boundary: 10 in
Glove Class: 00
PPE:
Shirt & pants or coverall (Nonmelting (ASTM F1506) or Untreated Fiber) + hard hat + safety glasses + hearing protection
SHOCK PROTECTION
Shock Risk When Cover is Removed 480 VAC
Limited Approach 42 in
Restricted Approach 12 in
Bus Name:
PNL_P-5
Prot Dev: 100/3 BS-18 LAB PNL
1
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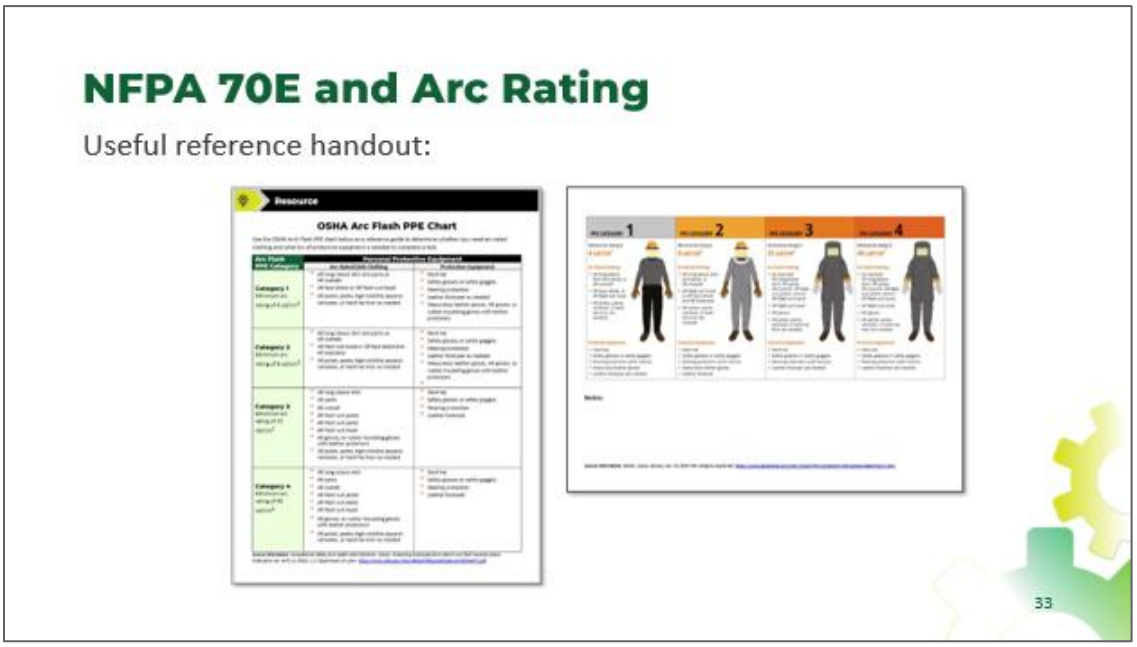


Notes:

- There is a lot to remember when it comes to arc flash PPE.
- In your Participant Resource Guide, you will find a handout titled OSHA Arc Flash PPE Chart.
- This handout outlines each arc flash PPE category and the arc-rather clothing and protective equipment associated with each.
- You'll briefly go through each category next.

Resource

OSHA Arc Flash PPE Chart

Use the OSHA Arc Flash PPE chart below as a reference guide to determine whether you need arc-rated clothing and what kind of protective equipment is needed to complete a task.

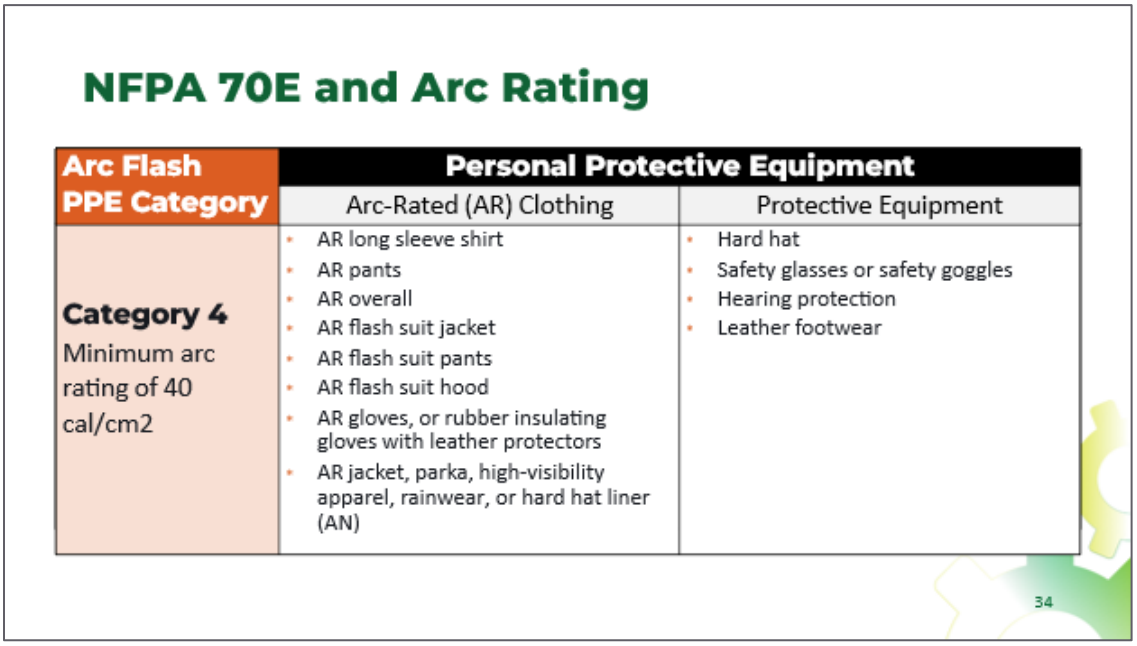
Arc Flash PPE Category	Personal Protective Equipment	
	Arc-Rated (AR) Clothing	**Protective Equipment**
Category 1 Minimum arc rating of 4 cal/cm^2	* AR long-sleeve shirt and pants or AR overalls * AR face shield or AR flash suit hood * AR jacket, parka, high-visibility apparel, rainwear, or hard hat liner as needed	* Hard hat * Safety glasses or safety goggles * Hearing protection * Leather footwear as needed * Heavy-duty leather gloves, AR gloves, or rubber insulating gloves with leather protectors
Category 2 Minimum arc rating of 8 cal/cm^2	* AR long-sleeve shirt and pants or AR overalls * AR flash suit hood or AR face shield and AR balaclava * AR jacket, parka, high-visibility apparel, rainwear, or hard hat liner as needed	* Hard hat * Safety glasses or safety goggles * Hearing protection * Leather footwear as needed * Heavy-duty leather gloves, AR gloves, or rubber insulating gloves with leather protectors
Category 3 Minimum arc rating of 25 cal/cm^2	* AR long sleeve shirt * AR pants * AR overall * AR flash suit jacket * AR flash suit pants * AR flash suit hood * AR gloves, or rubber insulating gloves with leather protectors * AR jacket, parka, high-visibility apparel, rainwear, or hard hat liner as needed	* Hard hat * Safety glasses or safety goggles * Hearing protection * Leather footwear
Category 4 Minimum arc rating of 40 cal/cm^2	* AR long sleeve shirt * AR pants * AR overall * AR flash suit jacket * AR flash suit pants * AR flash suit hood * AR gloves, or rubber insulating gloves with leather protectors * AR jacket, parka, high-visibility apparel, rainwear, or hard hat liner as needed	* Hard hat * Safety glasses or safety goggles * Hearing protection * Leather footwear

PPE CATEGORY 1	PPE CATEGORY 2	PPE CATEGORY 3	PPE CATEGORY 4
Minimum Arc Rating of **4 cal/cm²**	Minimum Arc Rating of **8 cal/cm²**	Minimum Arc Rating of **25 cal/cm²**	Minimum Arc Rating of **40 cal/cm²**
Arc Rated Clothing: • AR long-sleeve shirt and pants, or AR coverall • AR face shield, or AR flash suit hood • AR jacket, parka, rainwear, or hard hat liner (as needed)	**Arc Rated Clothing:** • AR long-sleeve shirt and pants, or AR coverall • AR flash suit hood, or AR face shield and AR balaclava • AR jacket, parka, rainwear, or hard hat liner (as needed)	**Arc Rated Clothing:** • As required: AR long-sleeve shirt, AR pants, AR coverall, AR flash suit jacket, and/or AR flash suit pants • AR flash suit hood • AR gloves • AR jacket, parka, rainwear, or hard hat liner (as needed)	**Arc Rated Clothing:** • As required: AR long-sleeve shirt, AR pants, AR coverall, AR flash suit jacket, and/or AR flash suit pants • AR flash suit hood • AR gloves • AR jacket, parka, rainwear, or hard hat liner (as needed)
Protective Equipment: • Hard hat • Safety glasses or safety goggles • Hearing protection (with inserts) • Heavy-duty leather gloves • Leather footwear (as needed)	**Protective Equipment:** • Hard hat • Safety glasses or safety goggles • Hearing protection (with inserts) • Heavy-duty leather gloves • Leather footwear	**Protective Equipment:** • Hard hat • Safety glasses or safety goggles • Hearing protection (with inserts) • Leather footwear (as needed)	**Protective Equipment:** • Hard hat • Safety glasses or safety goggles • Hearing protection (with inserts) • Leather footwear (as needed)

Notes:

Source Information:

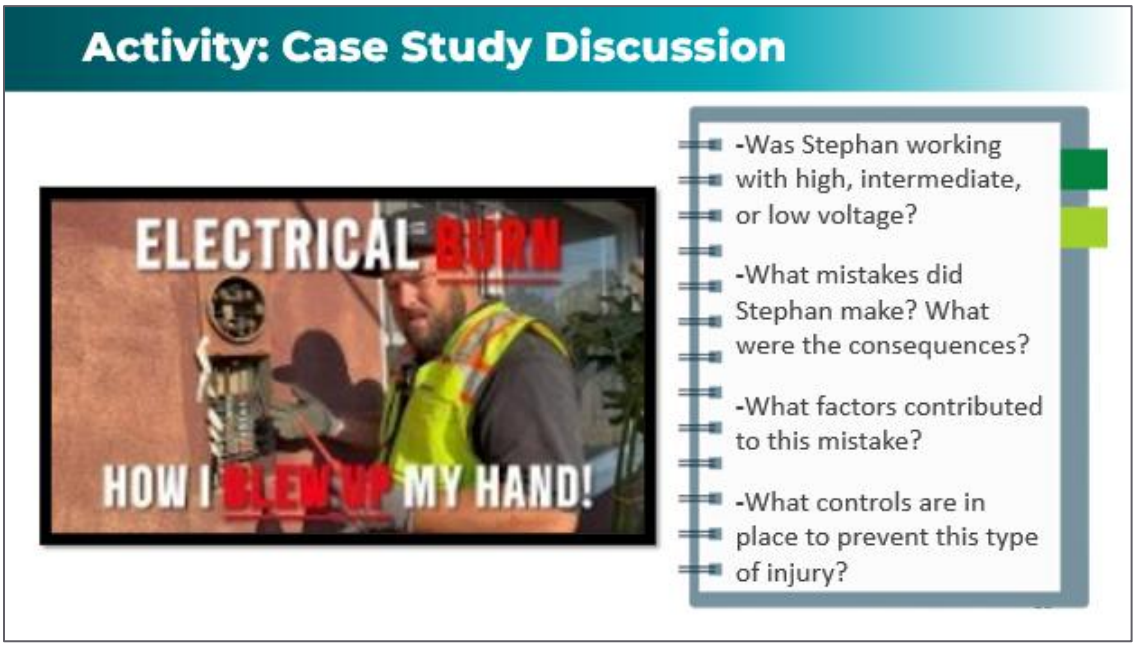
- Gintex. (2023, January 16). *Arc flash PPE category explained*. https://www.gintextiles.com/ARC-FLASH-PPE-CATEGORY-EXPLAINED-id48375347.html
- Occupational Safety and Health Administration. (2024). *Protecting employees from electric-arc flash hazards* (OSHA Publication No. 4472-11 2024). U.S. Department of Labor. https://www.osha.gov/sites/default/files/publications/OSHA4472.pdf



NFPA 70E and Arc Rating

Arc Flash PPE Category	Personal Protective Equipment	
	Arc-Rated (AR) Clothing	Protective Equipment
Category 4 Minimum arc rating of 40 cal/cm2	• AR long sleeve shirt • AR pants • AR overall • AR flash suit jacket • AR flash suit pants • AR flash suit hood • AR gloves, or rubber insulating gloves with leather protectors • AR jacket, parka, high-visibility apparel, rainwear, or hard hat liner (AN)	• Hard hat • Safety glasses or safety goggles • Hearing protection • Leather footwear

34


Activity: Case Study Discussion
ELECTRICAL BURN
HOW I BLEW UP MY HAND!
-Was Stephan working with high, intermediate, or low voltage?
-What mistakes did Stephan make? What were the consequences?
-What factors contributed to this mistake?
-What controls are in place to prevent this type of injury?

Knowledge Check

1. Why is PPE the least effective item on the Hierarchy of Controls?

   PPT is the least effective because it is subject to human error and only effective if used

2. Name two administrative controls we have discussed today.

   Policies, procedures, training, etc.

36

Knowledge Check

3. A technician needs to access electrical equipment while standing on a ladder. Which type of ladder should they choose to reduce the risk of electric shock?

(A). Metal

(B). Aluminum

(C). Wooden

(D). Extension

37

Knowledge Check

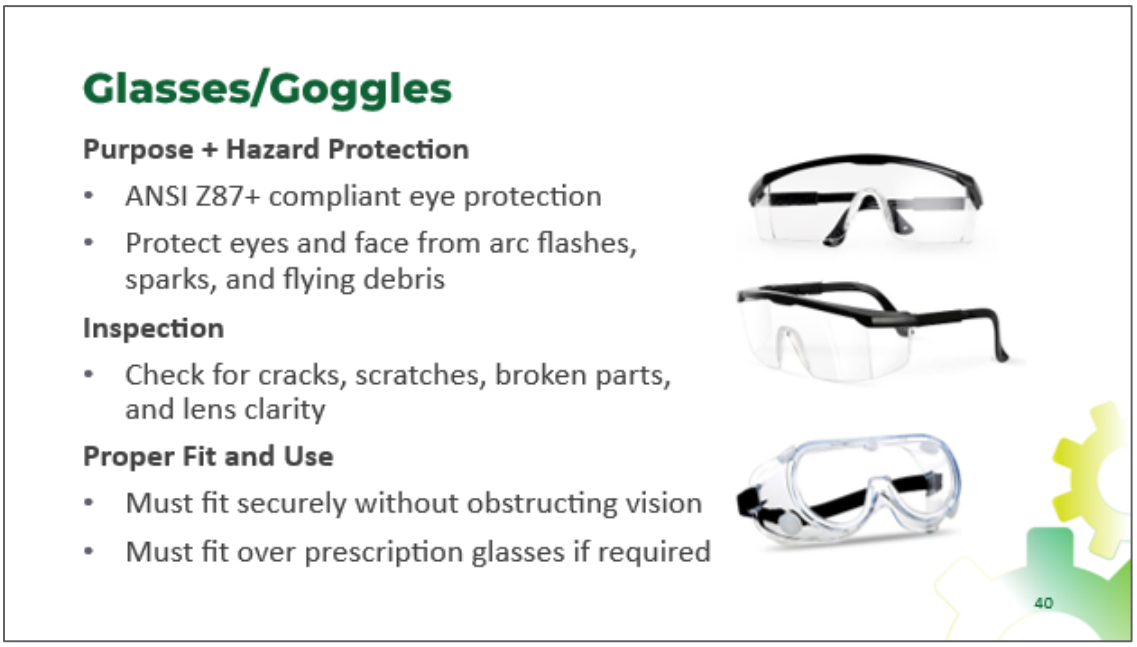
4. What kind of PPE is required when working on a device with this warning label?

Category 1 arc-rated clothing and protective equipment

38

Notes:

- In this section you'll review types of PPE used in electrical work.
- Important note before we begin – All PPE is used at intermediate and high voltages, not just select pieces.



Notes:

- **Purpose and Hazard Protection:**
  - Safety glasses and goggles help protect the eyes from hazards such as sparks, flying debris, and flashes of intense light that may occur during electrical work.
  - Many safety glasses are marked Z87+, which refers to the ANSI Z87.1 standard for eye protection. When glasses carry the Z87+ marking, it means they are impact-rated and tested to withstand high-energy impacts, not just minor hazards.
  - Workers can usually find the Z87+ marking on the lens, the frame, or the temple of the glasses.
- **Inspection**
  - Before using eye protection, it is important to inspect the equipment. Workers should check for cracked lenses, scratches, broken parts, or anything that reduces visibility or protection.
- **Proper Fit and Use**
  - Proper fit is also important. Safety glasses or goggles should fit securely and allow clear vision while staying comfortably in place.
  - If a worker wears prescription glasses, the safety glasses or goggles should fit properly over them without interfering with vision or protection.
  - For example, mechanics or technicians performing maintenance on electrical cabinets, battery systems, or equipment that may produce sparks or debris should wear approved eye protection to reduce the risk of eye injury.
  - Proper inspection, fit, and use of eye protection helps ensure the equipment provides the protection it was designed to deliver.

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Notes:

- Hearing protection such as earmuffs helps protect workers from high-decibel noise in the workplace, including loud equipment or the sudden pressure wave created by an arc blast.
- Exposure to very loud noise can damage hearing, sometimes permanently, so proper hearing protection is important in high-noise environments.
- Before using earmuffs, workers should inspect them for damage, such as missing parts, cracks, or worn padding that could reduce protection.
- When wearing earmuffs, they must fully cover the ears and form a tight seal around them to provide effective noise reduction.

Notes:

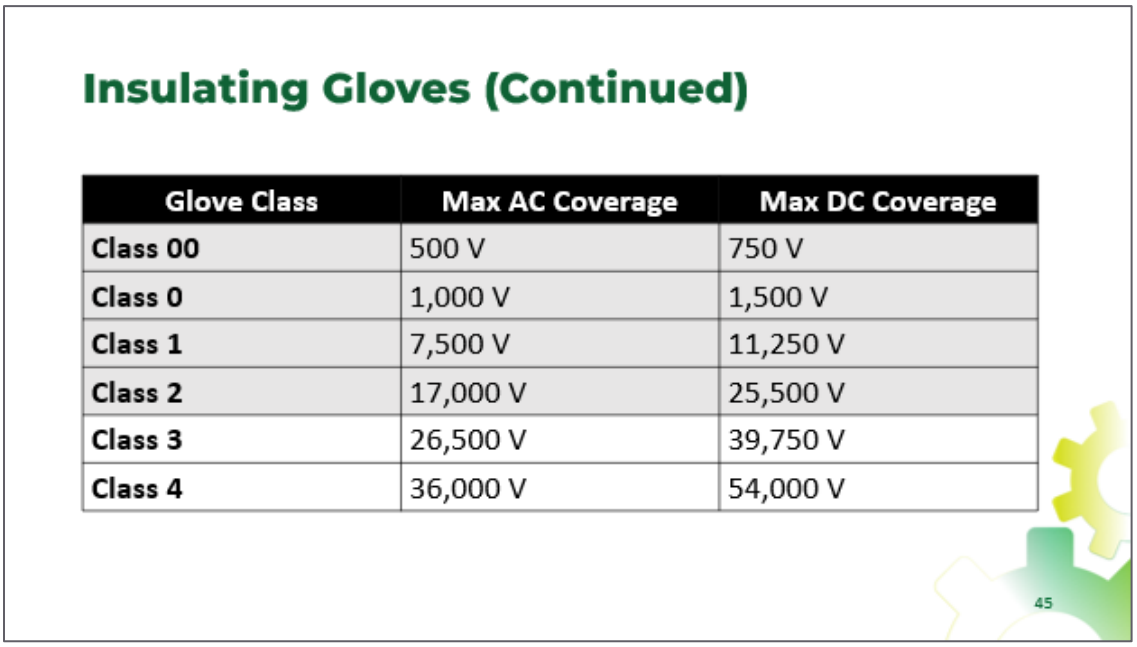
- Leather safety boots that are EH-rated are designed to provide secondary protection against electrical shock.
- EH stands for Electrical Hazard. These boots are constructed with insulating materials that help reduce the amount of electricity that can pass through the body to the ground during an electrical fault.
    - For example, if a worker accidentally steps on or touches something energized, EH-rated boots can help reduce the chance of electricity traveling through the feet to the ground.
- However, it is important to remember that EH-rated footwear does not make a worker shock-proof. It provides an added layer of protection but must be used along with other safety controls and PPE.
- Before use, workers should inspect their boots for damage, especially to the sole or leather. Cracks, holes, or excessive wear can reduce the protective qualities of the footwear.
- Boots should also fit properly and be securely laced. A proper fit helps maintain stability, prevents slips or trips, and ensures the footwear provides the protection it was designed to deliver.

Notes:

- Insulating gloves are designed to protect workers' hands from electrical shock when working on or near energized electrical equipment. These gloves are typically made from specialized rubber materials that resist the flow of electricity, helping prevent electrical current from passing through the hands.
- Before use, insulating gloves must be carefully inspected. Workers should check the rubber for cracks, holes, pinholes, or other signs of damage that could reduce protection.
- It is also important to check for contamination from grease, oil, or petroleum products, which can degrade the rubber and weaken the insulating properties.
- Workers should also verify the inspection or test date stamp on the gloves. In many workplaces, insulating gloves are approved for six months of service after testing, and they must be retested or replaced after that period.
- Because sunlight and ultraviolet light can degrade rubber, gloves should be stored properly and not left exposed to direct sunlight for long periods.

Notes:

- Insulating gloves must also be properly sized for the worker. A correct fit allows workers to safely handle tools while maintaining the protection the gloves are designed to provide.
- Another important consideration is the voltage class of the glove. Insulating gloves are manufactured in different classes, and each class is rated to protect against a specific voltage range. Workers must always select gloves that match the voltage level of the task.
- When using rubber insulating gloves, workers should also wear leather protector gloves over them. These protect the rubber from cuts, punctures, and abrasion that could damage the insulating material.
- When the gloves are not in use, they should be stored in an approved glove bag or protective container. Proper storage helps prevent damage and keeps the gloves clean and ready for use.



Notes:

- Insulating gloves are manufactured in different classes, and each class is rated to protect against a specific voltage level.
- The class number tells you the maximum voltage the glove can safely protect against. As the class number increases, the glove is designed to protect against higher voltages.
- These voltage ratings come from the ASTM D120 standard, which sets requirements for rubber insulating gloves used in electrical work.
- In most transit environments, workers will typically use Class 00, Class 0, or sometimes Class 1 or Class 2 gloves, depending on the voltage of the system they are working on.
- Choosing the correct glove class is important because the glove must be rated for the voltage level of the task.
    - If you're not sure what voltage you're working on, what should you do before selecting your gloves?
    - What might happen if someone chooses gloves that are rated for a much higher voltage than necessary?
- The **key takeaway** is that workers should always select gloves that match the voltage level of the job while still allowing them to work safely and effectively.

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Glove Class	Max AC Coverage	Max DC Coverage
Class 00	500 V	750 V
Class 0	1,000 V	1,500 V
Class 1	7,500 V	11,250 V
Class 2	17,000 V	25,500 V
Class 3	26,500 V	39,750 V
Class 4	36,000 V	54,000 V

Notes:

- This video provides an overview of the purpose, use, and inspection of insulated gloves.
- **Video link**: https://www.youtube.com/watch?v=4mpksxHgCAA

Notes:

- This video dives a little deeper into inspection.
- **Video link**: https://www.youtube.com/watch?v=AnfTcccmFS4

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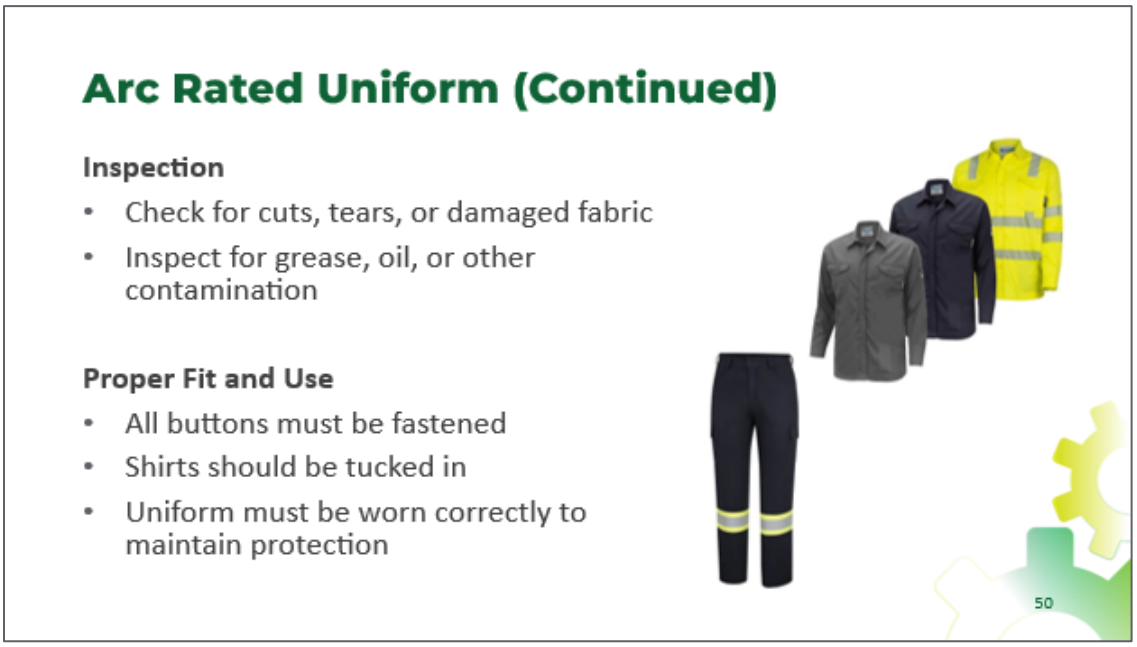
Instructor Demo: Insulating Gloves
Glove Inspection
Glove Inflation Test
48

Notes:

- Arc-rated uniforms are designed to protect the body from the intense heat and flames produced during an arc flash event.
- These garments are made from arc-rated materials that are tested to resist ignition and prevent the fabric from melting or continuing to burn when exposed to an electrical arc.
- It is important to avoid wearing synthetic or man-made materials, such as polyester or nylon, when working around intermediate or high voltage. These materials can melt onto the skin when exposed to extreme heat, which can significantly worsen burn injuries.
- Workers should also remember that arc-rated protection works as a system. Wearing only one piece of the uniform does not provide full protection.
- For example, wearing only an arc-rated shirt while leaving other areas exposed may still allow serious burns during an arc flash event.

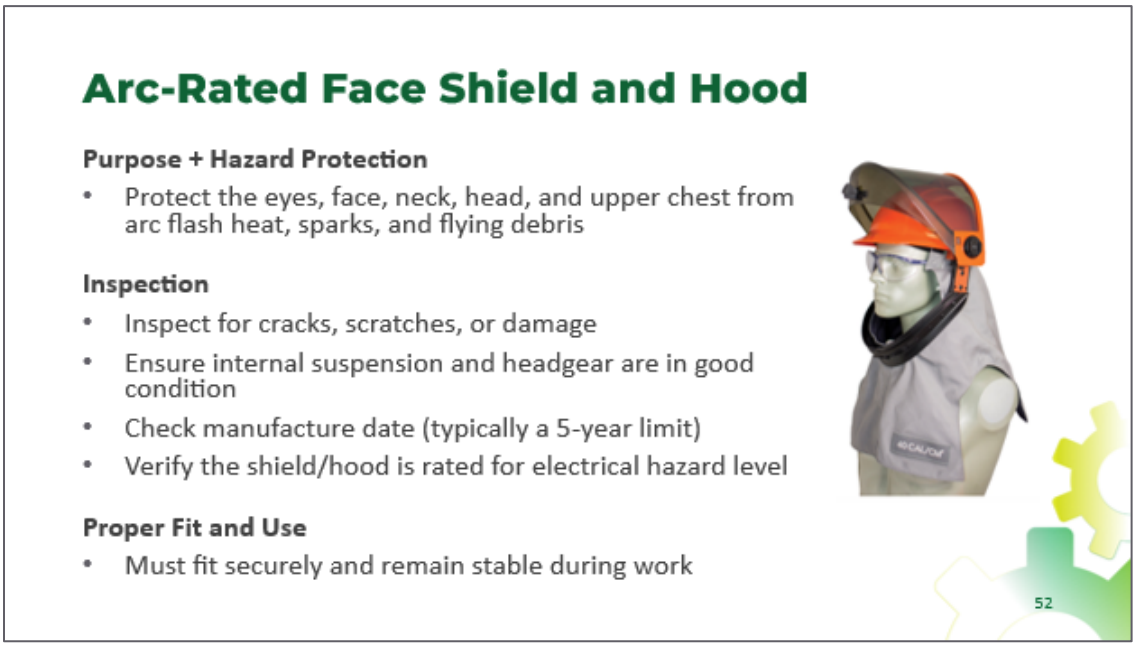


Notes:

- Before wearing an arc-rated uniform, workers should inspect the clothing for damage.
    - Look for cuts, tears, worn fabric, or other damage that could reduce the protective performance of the garment.
- Workers should also check for grease, oil, or other contamination. Contaminants can make the material more flammable, which increases the risk of injury during an arc flash.
- Proper fit and use are also important. The uniform should be worn correctly and fully fastened.
- All buttons should be secured, and shirts should be tucked in. This helps ensure that the arc-rated clothing provides continuous protection across the body.
- Wearing the uniform properly helps ensure it performs the way it was designed and tested to protect workers during an arc flash event.

Notes:

- Arc-rated outerwear provides additional protection from arc flash heat and flames, especially when working outdoors or in colder environments.
- Examples include arc-rated jackets, bib overalls, and other protective outer garments that are worn over the standard arc-rated uniform.
- One important rule is that anything worn over arc-rated clothing must also be arc rated. Wearing non-arc-rated jackets or sweatshirts over protective clothing can reduce the effectiveness of the protection.
- Outerwear should be inspected the same way as the arc-rated uniform. Workers should check for cuts, tears, damaged fabric, or contamination such as grease or oil, which can increase flammability.
- The fit and use requirements are also the same as the arc-rated uniform. Outerwear should be worn correctly and fully fastened so it continues to provide the protection it was designed to deliver.



Notes:

- Arc-rated face shields and hoods provide critical protection for the head and upper body during an arc flash event.
- They are designed to protect the eyes, face, neck, head, and upper chest from extreme heat, sparks, and flying debris that may occur during an electrical arc.
- Before use, workers should inspect the face shield or hood carefully. Look for cracks, scratches, or other damage to the visor, as this can reduce visibility or protection.
- The internal suspension system and headgear should also be checked to make sure they are secure and functioning properly.
- Workers should also verify the manufacture date, since many arc-rated face shields and hoods have a service life of about five years, depending on manufacturer guidance.
- Another important step is confirming that the face shield or hood is rated for the electrical hazard level of the task, ensuring it provides adequate arc flash protection.
- When worn, the shield or hood should fit securely and remain stable on the head, allowing the worker to maintain clear vision while staying protected.

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Notes:

- When working in colder environments, workers may need to wear additional layers to stay warm.
- If layering is necessary, it is important to make sure that all layers worn during energized electrical work are arc-rated.
- Wearing non–arc-rated clothing underneath or over arc-rated PPE can reduce the overall level of protection and increase the risk of injury during an arc flash event.
- Remember that arc protection is only as strong as the weakest layer, so workers should always check that each layer of clothing meets the required arc-rating standards for the task.

Activity: Glove Inspection

1. Inspect the gloves

2. Conduct an inflation test

3. Demonstrate putting on and taking off the glove

Activity

Inspect, Test, Use: Insulated Gloves:

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Activity

Inspect, Test, Use: Insulated Gloves

Directions: Working in pairs or small groups, practice inspecting, testing, putting on, and taking off insulated gloves and arc rated clothing.

Materials:

- One set of insulated gloves per group – One should have a hole or some kind of damage
- One set of eather protector gloves per group

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1. **Inspect** the insulating gloves provided.
   Look for:
   - Cracks, cuts, or holes in the rubber
   - Signs of wear or damage
   - Grease, oil, or other contamination
   - The glove test date stamp

2. Perform a simple **inflation test** to check for leaks.
   Steps:
   1. Roll the cuff of the glove toward the fingers to trap air inside.
   2. Gently squeeze the glove to increase pressure.
   3. Listen and feel for escaping air.
   4. Check the surface for bubbles, weak spots, or leaks.

3. Demonstrate how to:
   - Properly **put on** the insulating gloves.
   - Ensure the gloves fit securely.
   - Show how **leather protector gloves** are worn over the rubber gloves.
   - Safely **remove** the gloves without damaging them.

4. **Discuss**: Would you consider these gloves safe to use? Why or why not?

Activity: Reading Arc Labels

Goal: Practice reading arc-rated clothing labels to determine whether it provides sufficient protection for various electrical maintenance scenarios.

Part 1: Inspect the Clothing

Part 2: Scenario Analysis

Part 3: Discussion

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Activity

Reading Arc Ratings

Goal: Practice reading arc-rated clothing labels to determine whether it provides sufficient protection for various electrical maintenance scenarios.

Part 1: Inspect the Clothing

Examine the clothing and labels on page 2. Identify and record the following information.

Garmet	Arc Rating (cal/cm²)	Arc-Rated or Flame Resistant?
Ex: Hood	*12 cal/cm²*	*Arc-Rated*

Part 2: Scenario Analysis

For each scenario, decide whether the clothing provides enough protection for the job. Explain your choices.

Scneario	Garmet Used	Safe or Not Safe?	Why?
Troubleshooting an energized signal cabinet (4 cal/cm² arc flash hazard)	Sweatshirt		
Testing electrical wiring on a battery-electric bus (8 cal/cm² arc flash hazard)	Shirt		
Maintenance inside a traction power distribution cabinet (10 cal/cm² arc flash hazard)	Coveralls		
Inspecting wiring in a signal equipment room (6 cal/cm² arc flash hazard)	Overalls		

Part 3: Discussion

1. Why is it important to read the label instead of guessing about PPE protection?
2. If your jacket is 12 cal/cm² but the shirt underneath is not arc-rated, are you protected?
3. Why can't flame-resistant clothing without an arc rating be used for energized electrical work?

Sweatshirt

CPW-FR12,
BIZFLAME FLAME RETARDANT
SIZES: M, COLOURS: NAVY
SAFETY STANDARDS: EN ISO 11612 (A1 B1 C1 F1) | IEC 61482-2 IEC 61482-1-2 CLASS 1, ATPV=4 CAL/CM^2

Shirt

SIZES: UK 8, COLOURS: HI VIS ORANGE
SAFETY STANDARDS: PT. 3:2004 // CHARGE DECAY | EN 11612:2015: A1 // B1 // C1 | EN 20471:2013: CLASS 3 | IEC 61482-2:2009: CLASS 1 // ATPV=6 CAL/CM^2 // ARC 1 | RIS 3279: ISSUE 1

Coveralls

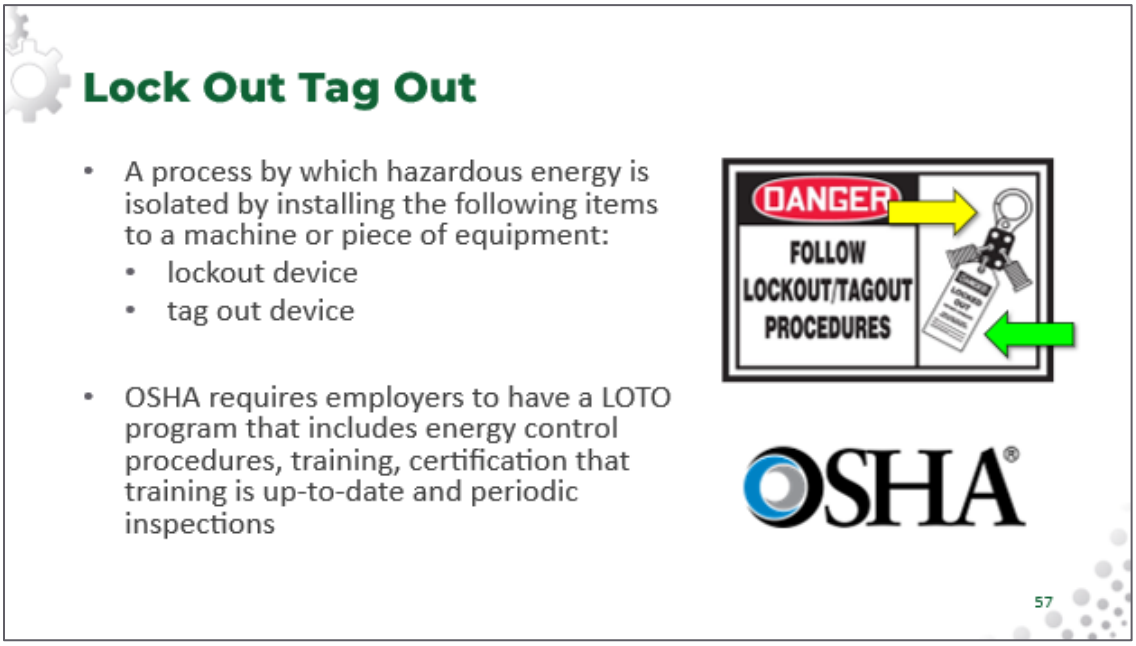
SIZES: XL, COLOUR: HI VIS YELLOW/NAVY
SAFETY STANDARDS:
EN ISO 11612:2015 A1 B1 C1, EN 1149-5:2018, EN 20471:2013 CLASS 3
IEC 61482-2:2018 APC=1
ATPV 10.7 CAL/CM^2

Overalls

100% FLAME RESISTANT MODACRYLIC RESIN INSULATION FOR WARMTH
WARMTH RATING EARNED: LEVEL 3
MEETS THE PERFORMANCE REQUIREMENTS OF NFPA 70E
UL® CLASSIFIED TO NFPA 2112/CAT 4

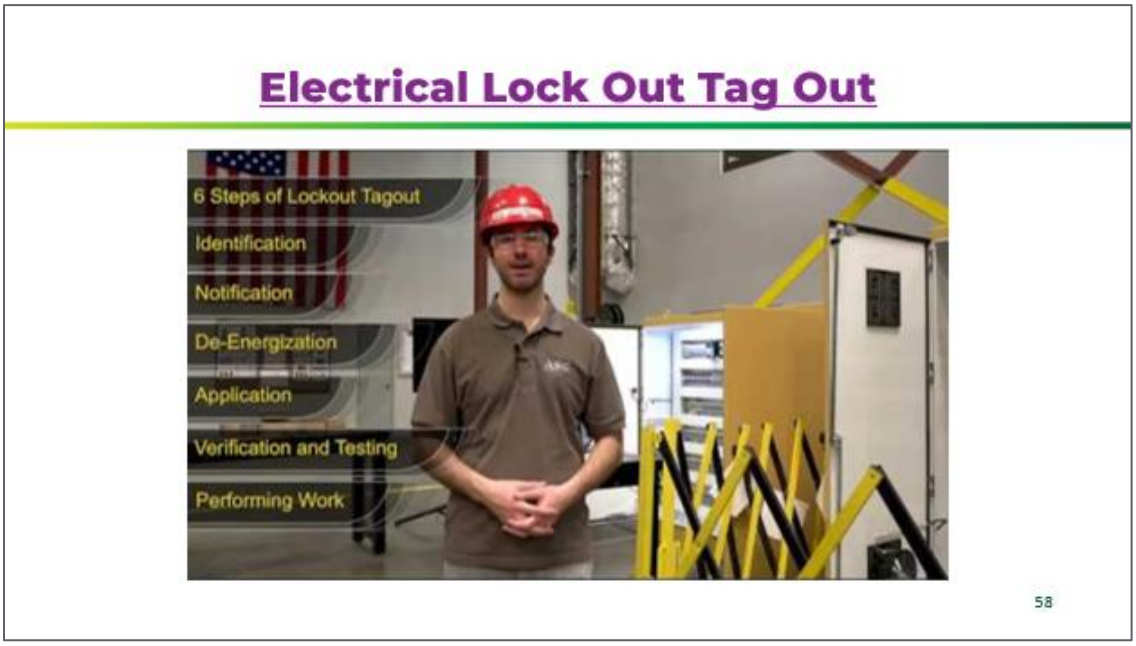
Notes:

- In this section, you'll review ways to protect workers including Lock Out Tag Out.



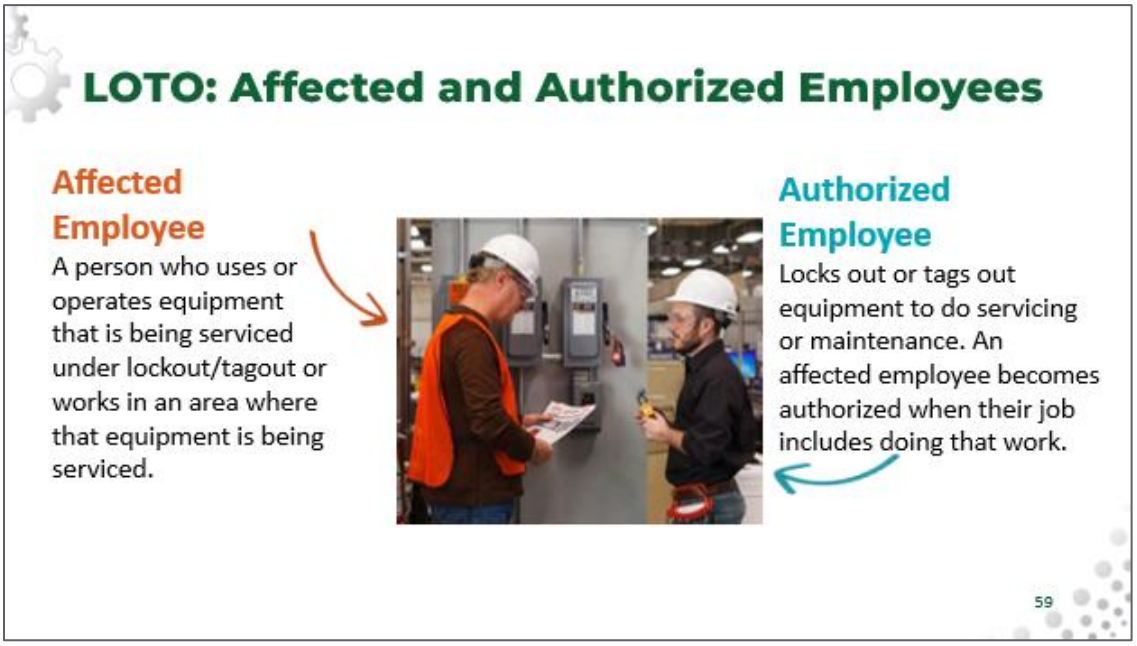
Notes:

- LOTO is a safety procedure used to isolate hazardous energy during maintenance of machines and equipment.
- Process involves installing a **lockout device** to physically prevent operation and a **tagout device** to communicate that the equipment must not be used.
- Employers must implement a LOTO program that includes written energy control procedures for each piece of equipment.
- The program must also provide training and certification for employees, ensure training is current, and conduct periodic inspections to maintain compliance.



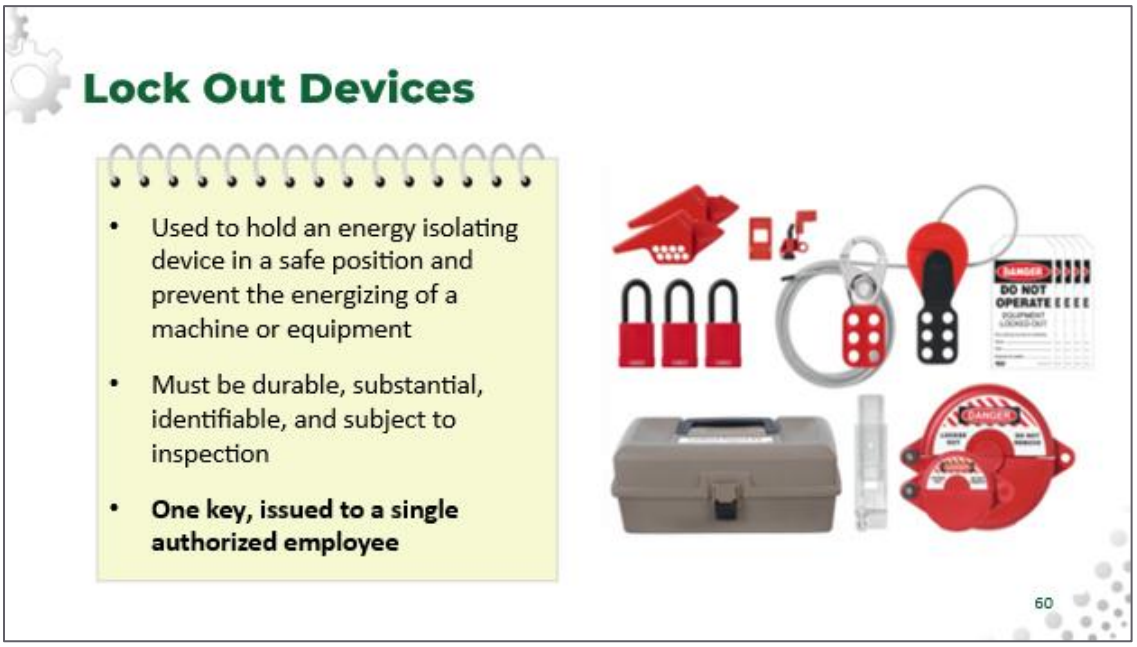
Notes:

- This video outlines the six steps in electrical lock out tag out. Let's take a look.
- **Video link**: https://www.youtube.com/watch?v=jP9HI8izPR8



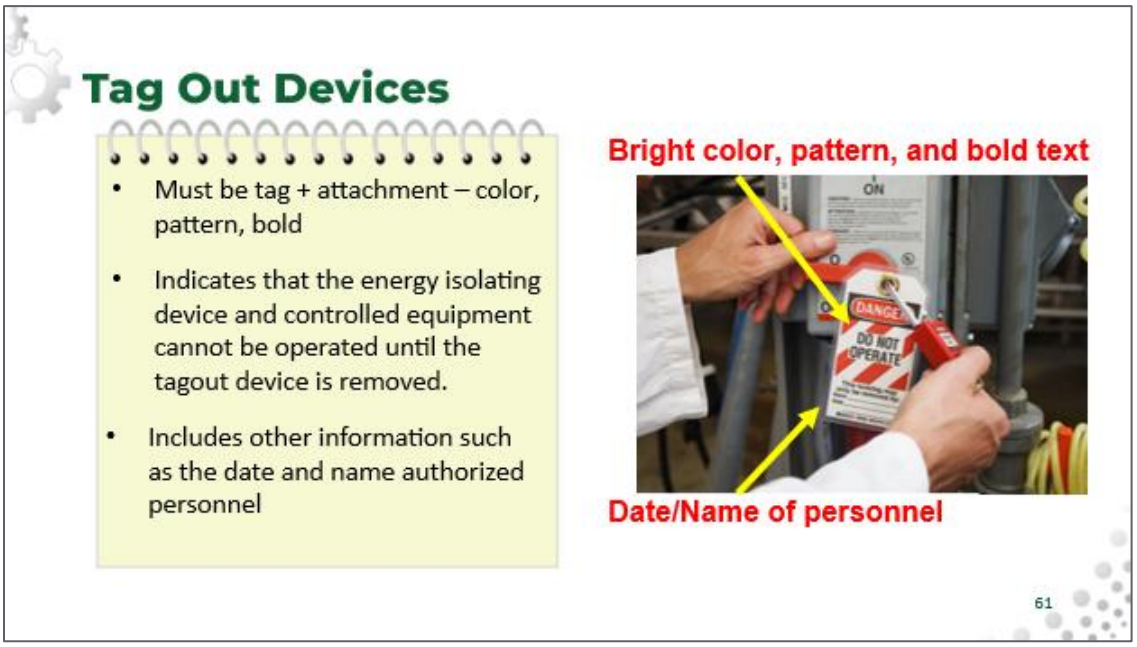
Notes:

- **Affected Employees** operate equipment that is being serviced under lockout/tagout or work in an area where that equipment is being serviced.
- **Authorized Employees** lock out or tag out equipment to do servicing or maintenance. An affected employee becomes authorized when their job includes doing that work.



Notes:

- A lockout device is used to hold an energy isolating device in a safe position and prevent the energizing of a machine or equipment.
- A lock out device must be durable, substantial, identifiable, and are subject to inspect.
    - Note that devices come in a variety of shapes and sizes and typically use a key or combination lock to secure the device.

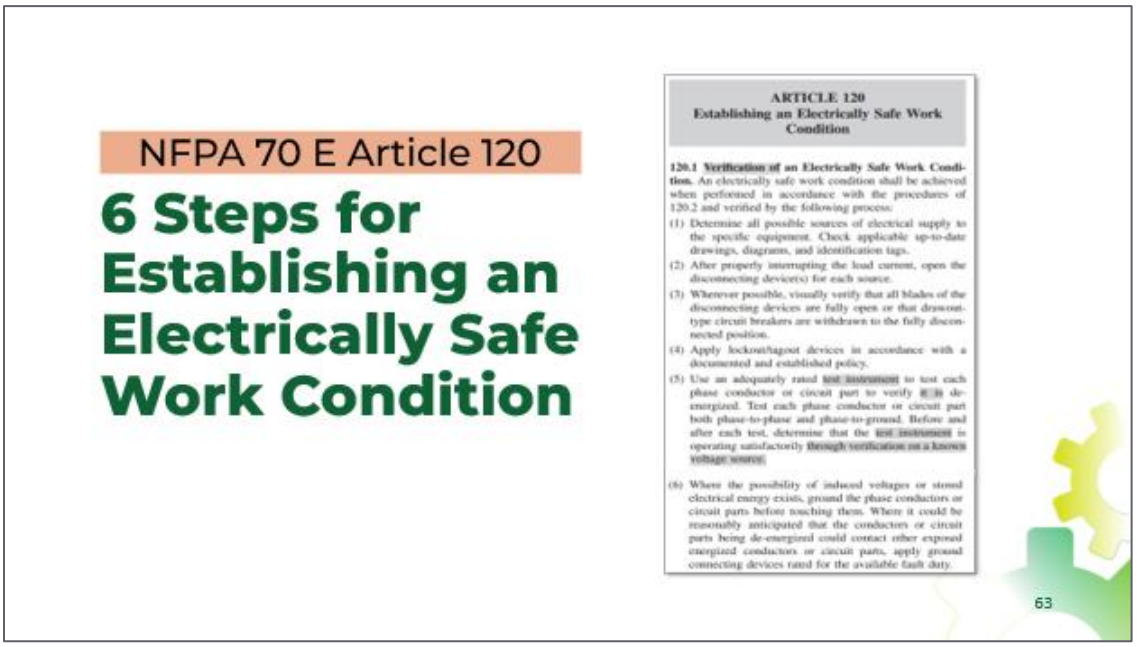


Notes:

- Tagout devices include both tag and attachment and must be clearly visible with a bright color, bold text, and pattern.
- They indicate that the energy isolating device and controlled equipment cannot be operated until the tagout device is removed.
- Other information such as the date and name authorized personnel will also be included on the tagout device.

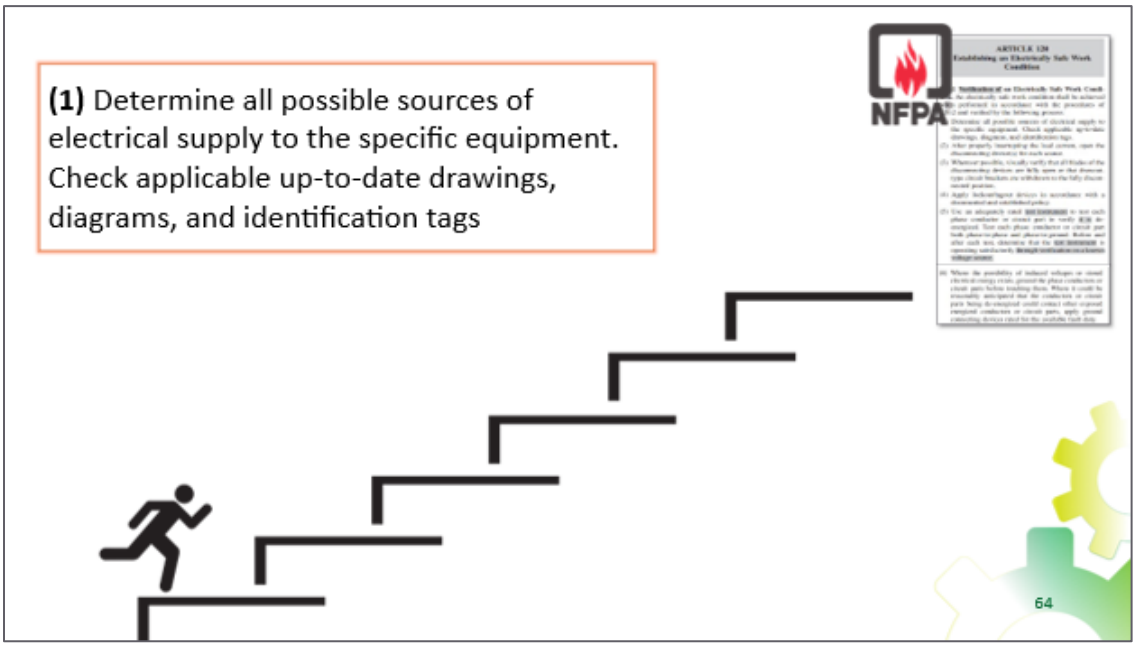
Notes:

- LOTO placards are made of durable material.
- They indicate the type of energy, location, description, method of operation, and a verification of the method.



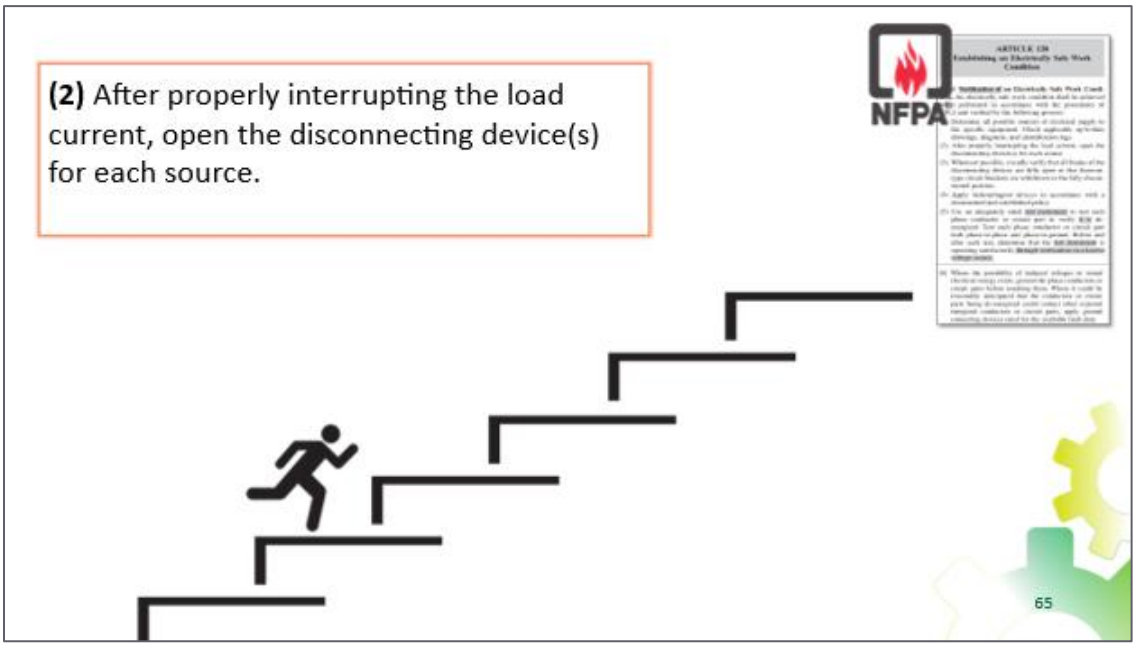
Notes:

- NFPA 70 E also establishes clear guidelines for Establishing an Electrically Safe Work Condition in Article 120. Let's take a closer look.



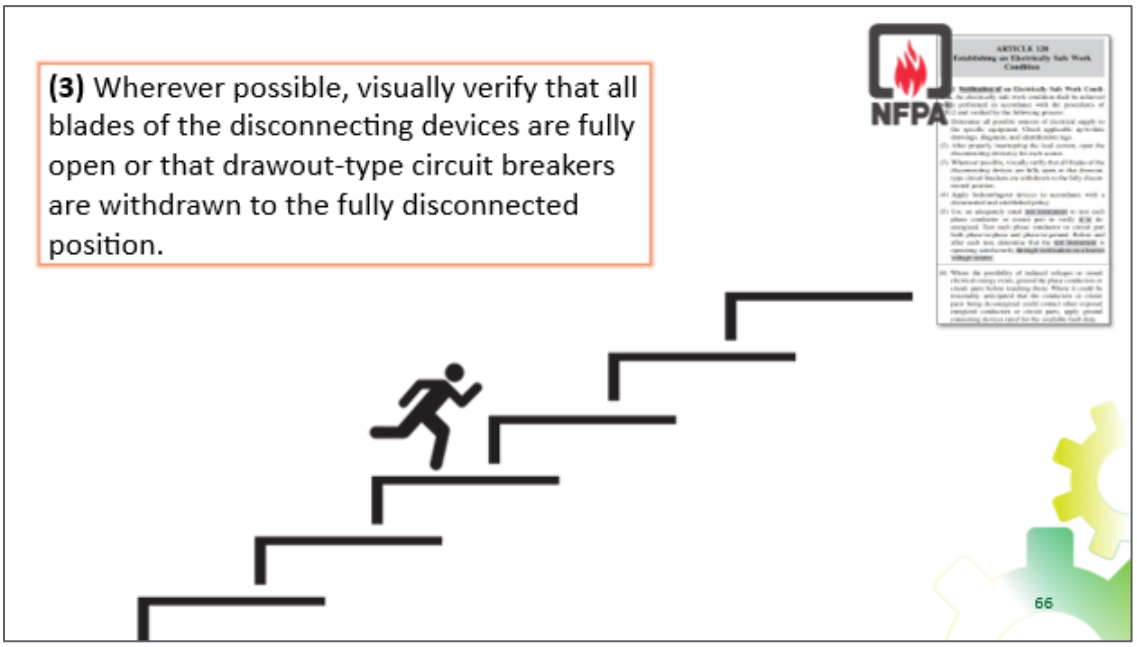
Notes:

- (1) Determine all possible sources of electrical supply to the specific equipment. Check applicable up-to-date drawings, diagrams, and identification tags.



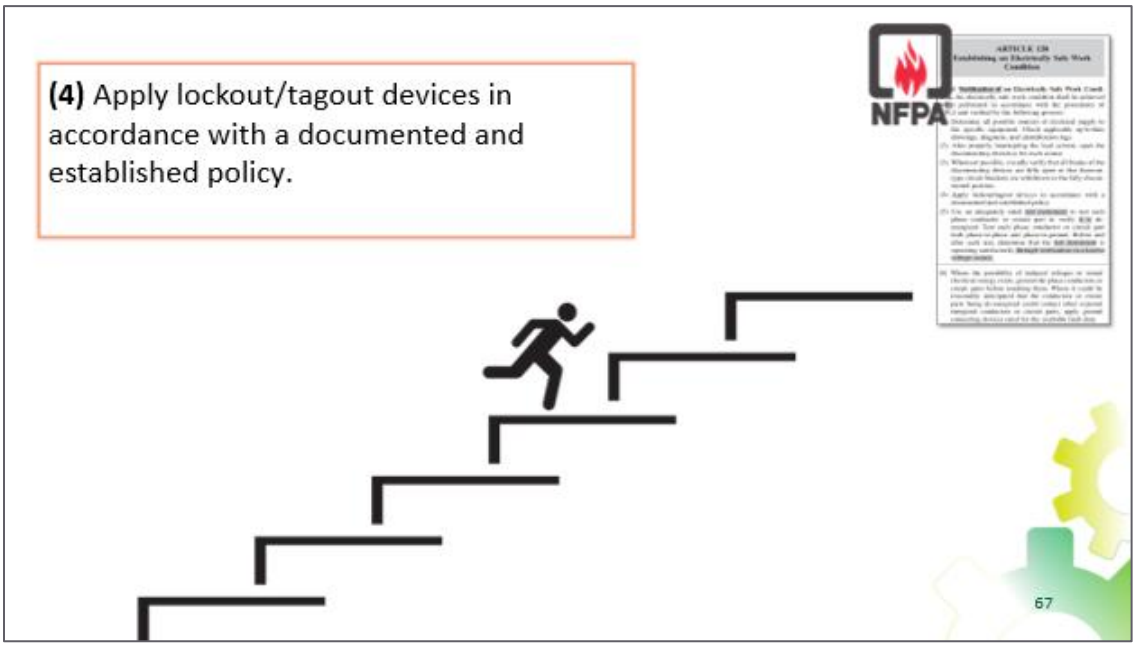
Notes:

- (2) After properly interrupting the load current, open the disconnecting device(s) for each source.



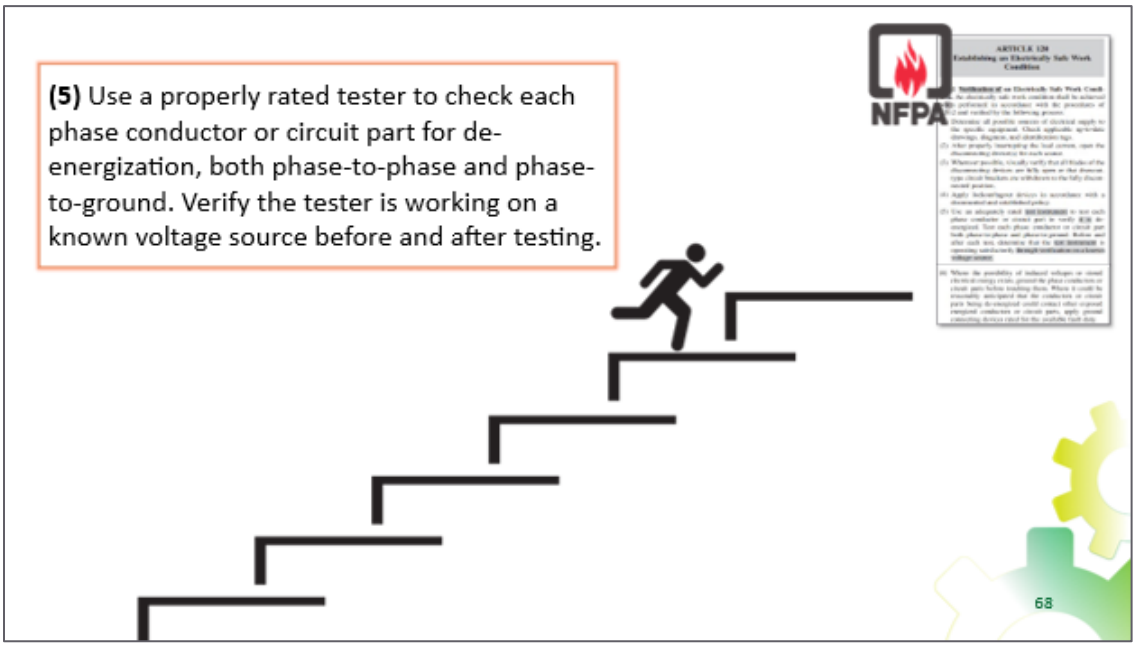
Notes:

- (3) Wherever possible, visually verify that all blades of the disconnecting devices are fully open or that drawout-type circuit breakers are withdrawn to the fully disconnected position.



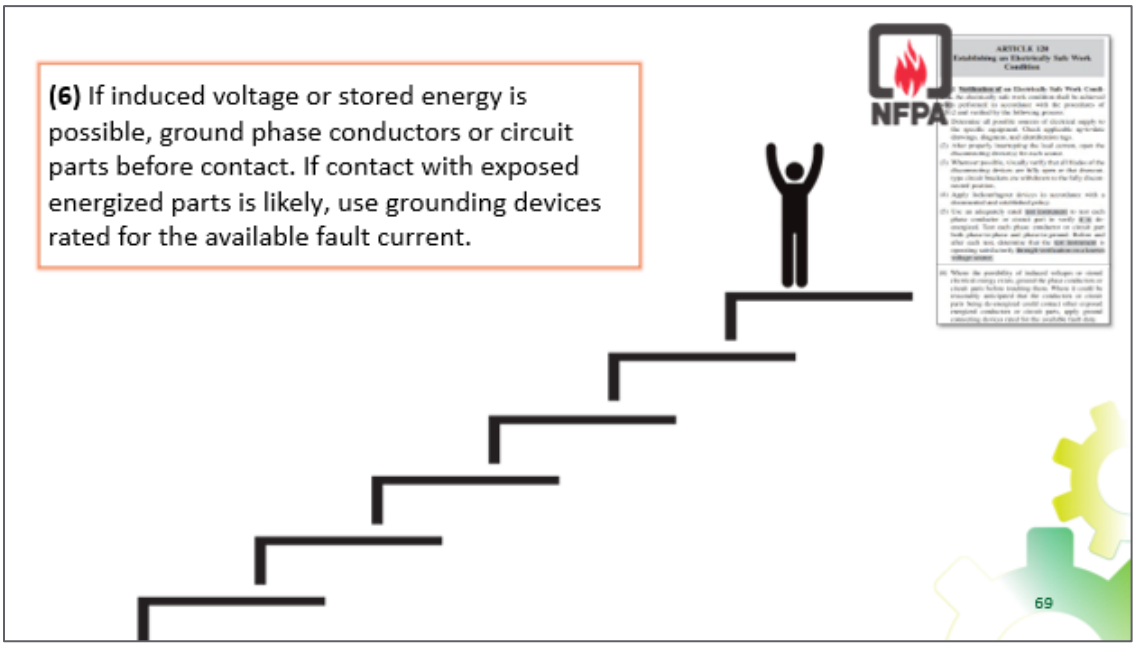
Notes:

- (4) Apply lockout/tagout devices in accordance with a documented and established policy.



Notes:

- (5) Use an adequately rated test instrument to test each phase conductor or circuit part to verify it is deenergized.
- Test each phase conductor or circuit part both phase-to-phase and phase-to-ground. Before and after each test, determine that the test instrument is operating satisfactorily through verification on a known voltage source.



Notes:

- (6) Where the possibility of induced voltages or stored electrical energy exists, ground the phase conductors or circuit parts before touching them.
- Where it could be reasonably anticipated that the conductors or circuit parts being de-energized could contact other exposed energized conductors or circuit parts, apply ground connecting devices rated for the available fault duty.

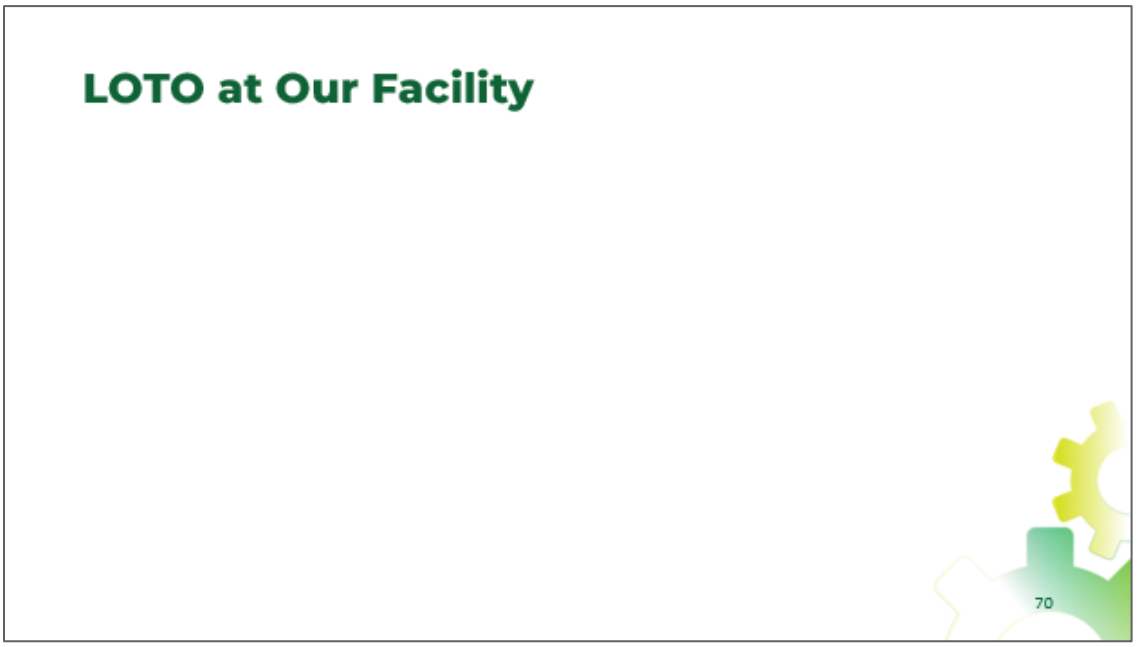
_____

_____

_____

_____

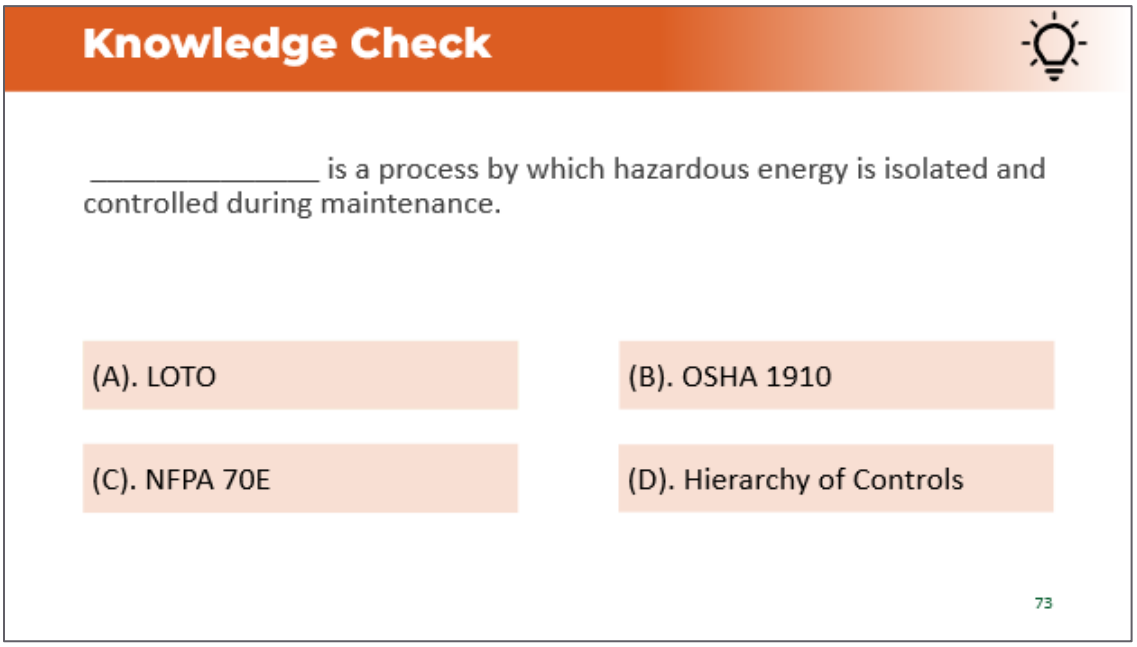
_____

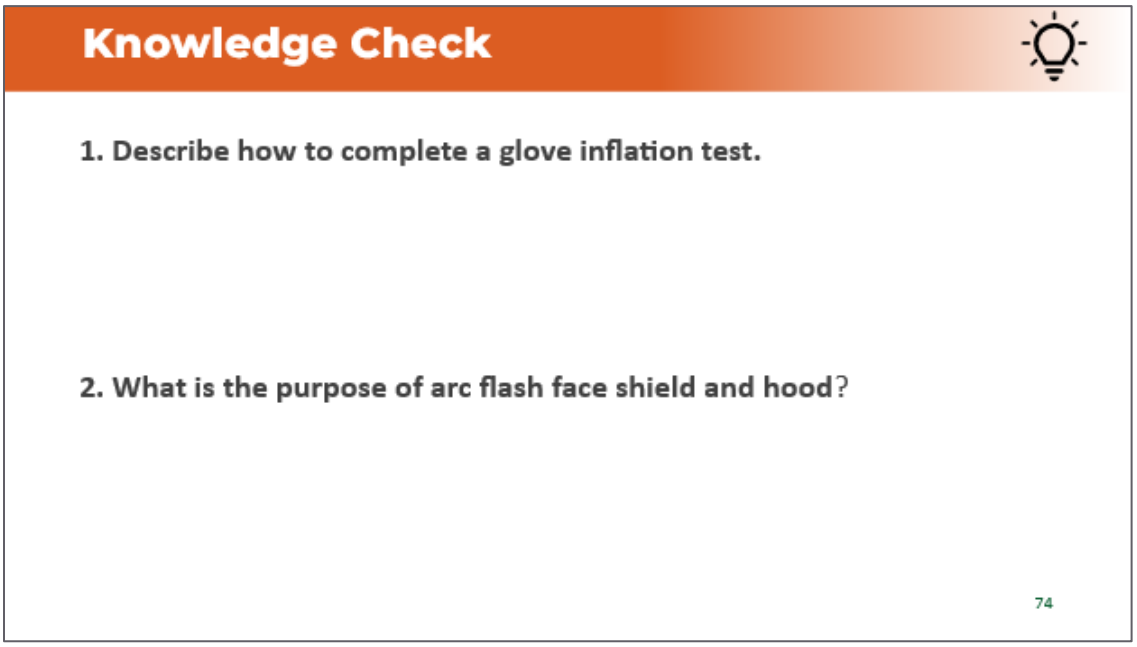

LOTO at Our Facility
70

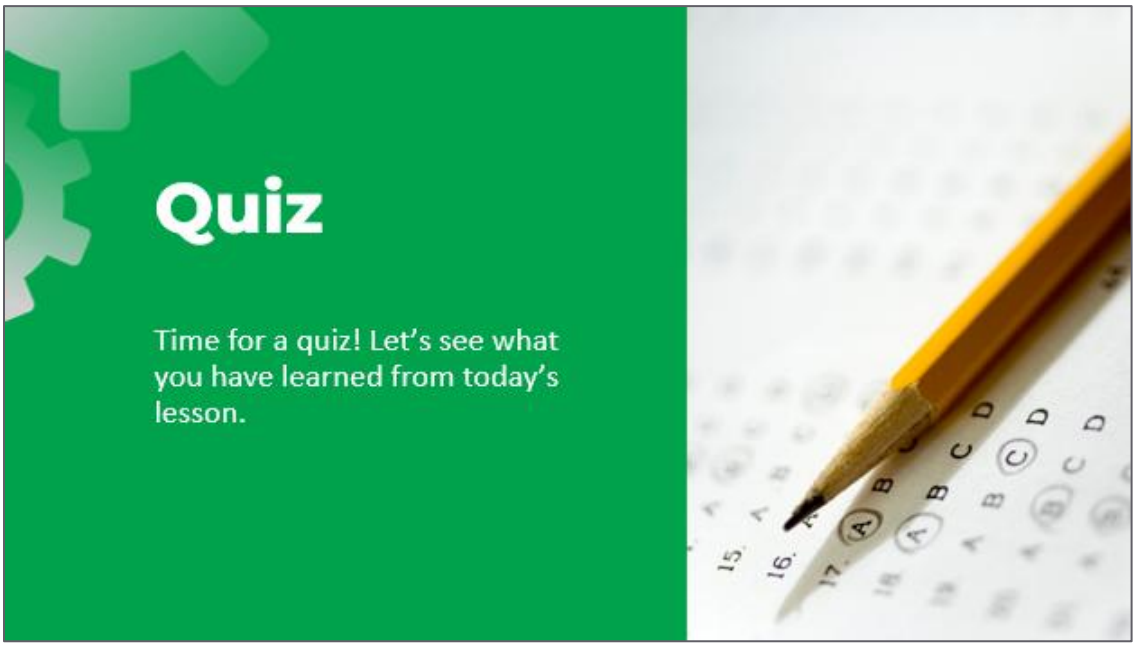
Activity: LOTO at Our Facility

Practice implementing lock out tag out procedures in our facility.

72

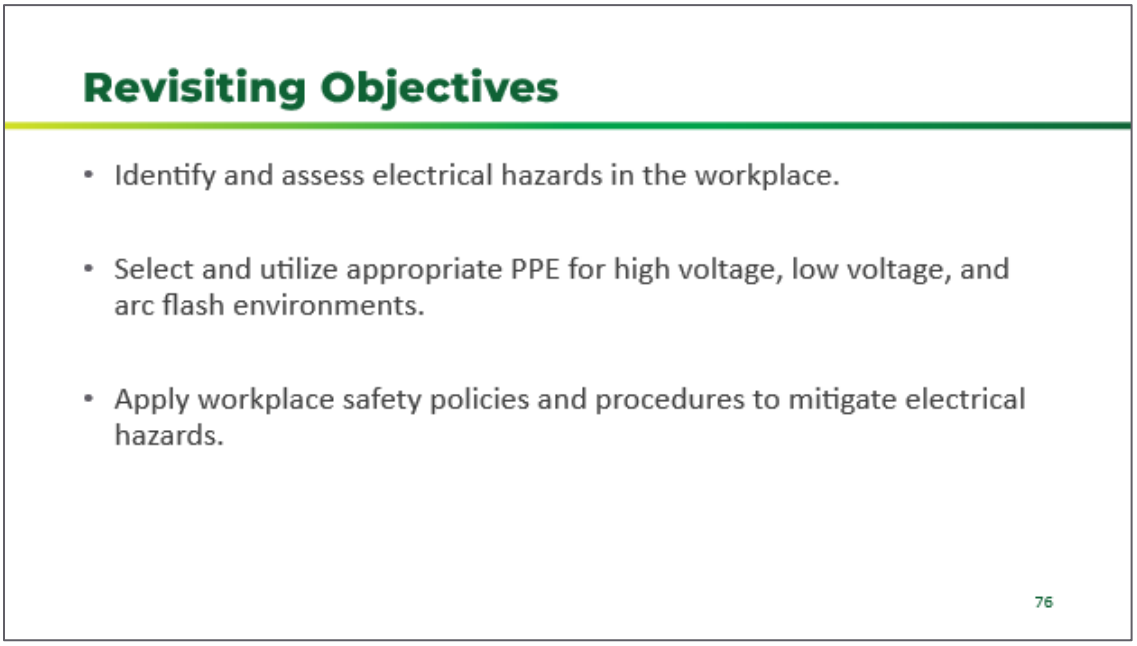

Knowledge Check
_____ is a process by which hazardous energy is isolated and controlled during maintenance.
(A). LOTO
(B). OSHA 1910
(C). NFPA 70E
(D). Hierarchy of Controls
73


Knowledge Check
1. Describe how to complete a glove inflation test.
2. What is the purpose of arc flash face shield and hood?
74



Notes:

- Time for a quiz! Let's see what you have retained from today's lesson.



Notes:

- If you were explaining today's objectives to someone else, how would you summarize what they mean and why they matter?
- Which of today's objectives do you feel most confident about? Which were most challenging? Explain your reasoning.
- Can you give an example of how you could apply one of today's objectives in a real-world situation?