



1926 Construction Focus Four Electrical Hazards

ELECTRICAL HAZARDS

Focus Four

Objectives

By the end of the session students will be able to:

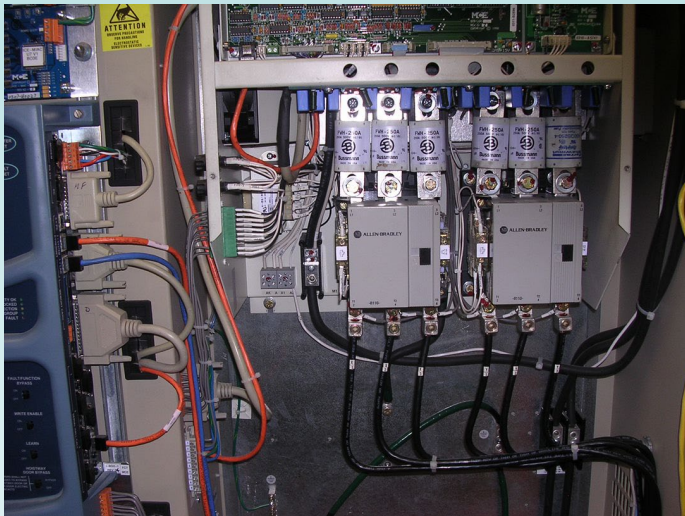
- List common causes of electrical injuries.
- List ways to reduce exposure to electrical hazards.
- Describe what to do if a co-worker gets shocked.

ELECTRICAL HAZARDS

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Electricity Can Kill You

- Contact with live circuits in electrical panels or exposed wiring
- Contact with overhead power lines
- Improperly maintained cords and power tools
- Arc-Flash



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Effects of Electricity on People

Harm is related to amps, duration of contact, and the path by which current passes through the body.



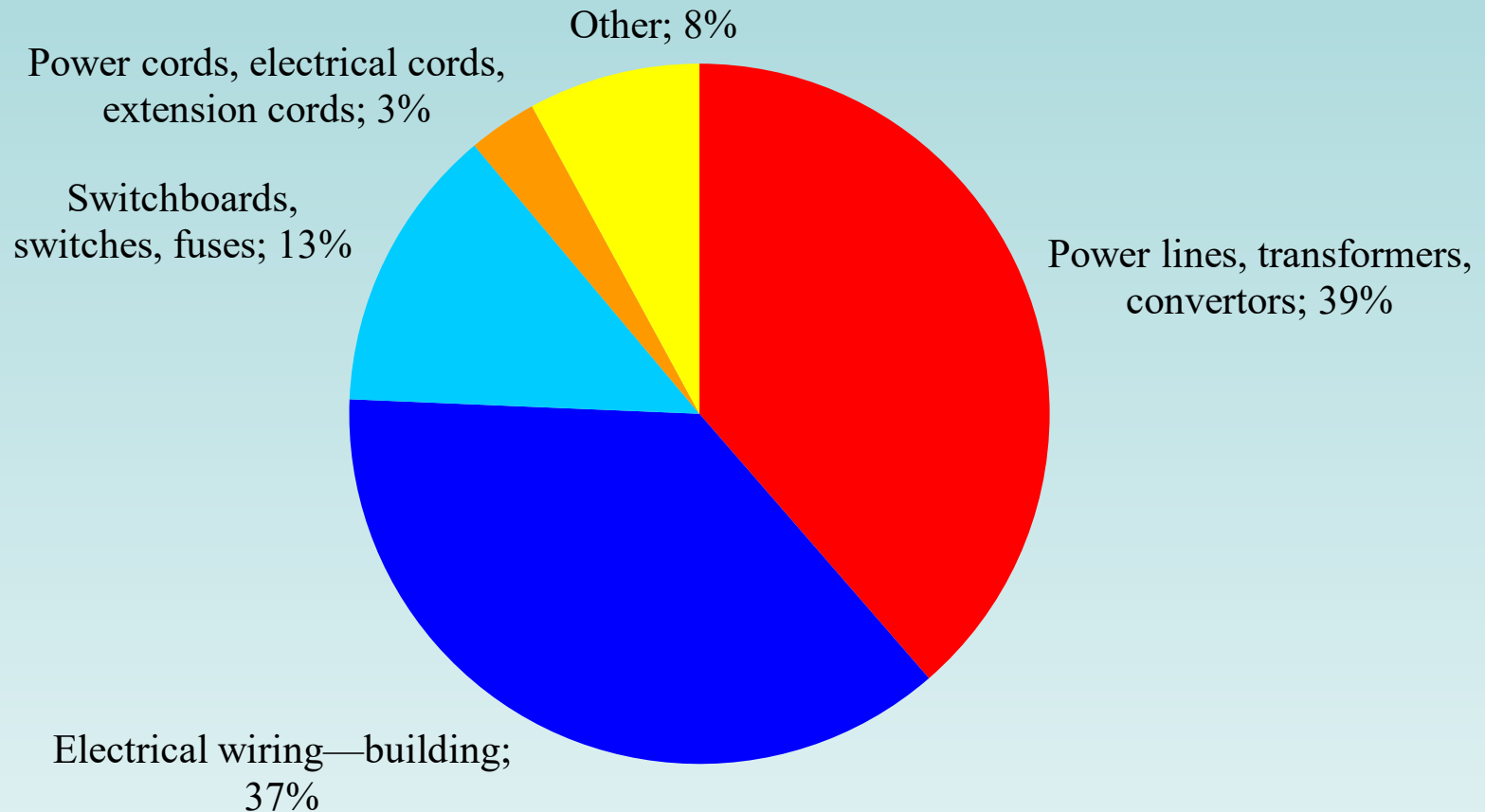
| Estimated Effects of AC Currents (U.S. Standard 60 Hz) | |
|---|---|
| 1 milliamp (mA) | Barely perceptible |
| 16 mA | Maximum current an average man can grasp and “let go” |
| 20 – 30 mA | Paralysis of respiratory muscles |
| 100 mA | Ventricular fibrillation threshold |
| 2 Amps | Cardiac standstill and internal organ damage |
| 15/20/30 Amps | Common U.S. household breakers |

ELECTRICAL HAZARDS

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Electrocution deaths caused by electric parts in construction, by primary source, 2011-2015 total

Total = 189 deaths



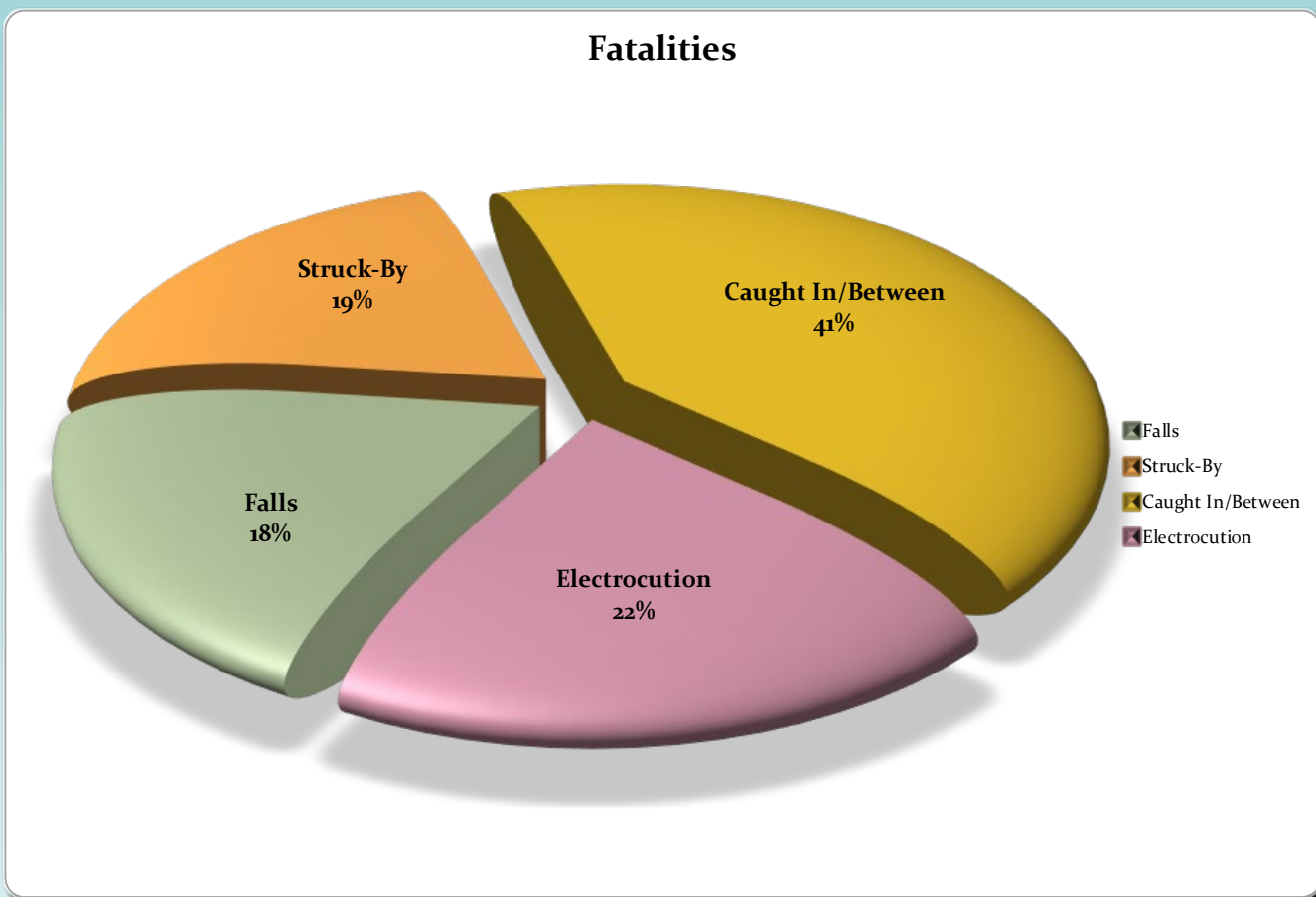
ELECTRICAL HAZARDS

Focus Four

Elevator Industry-Related Electrical Hazards

| Fatality Type | Total |
|-------------------------|-----------|
| Falls | 5 |
| Struck-By | 5 |
| Caught In/Betwee | 11 |
| Electrocution | 6 |
| Total Fatalities | 27 |

Since 2012, 22% of Elevator Constructor deaths have been Electricity-related.



ON THE JOB FATALITIES BEGINNING--JANUARY 2012

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Working Around Power Lines

- Overhead power lines carry extremely high voltage.
- Contact can cause electrocution, burns, and falls from elevations.
- Equipment contact with power lines can cause explosions and fire.



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Power Line Facts

- **Overhead lines are typically not insulated. The covering on high power lines is generally a weather protection, not insulation.**
- **In cranes or backhoe-type equipment, operators are normally safe when equipment accidentally touches a power line... if they stay inside their equipment.**
- **Workers on the ground who come in contact with power lines are 8 times more likely to be killed than workers inside equipment or vehicles.**

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Working Safely Around Overhead Power Lines

- Locate overhead lines *before* starting the job
- Keep at least 10 feet away from 50 kV or less
- Always assume that lines are energized
- De-energize and ground power lines when working within 10'



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If Equipment Contacts a Power Line the Ground May Become Energized!

- Electricity dissipates with the resistance of the ground
- As potential drops, fields develop around the electrified machine
- If you step across a line of unequal potential, you could be electrocuted

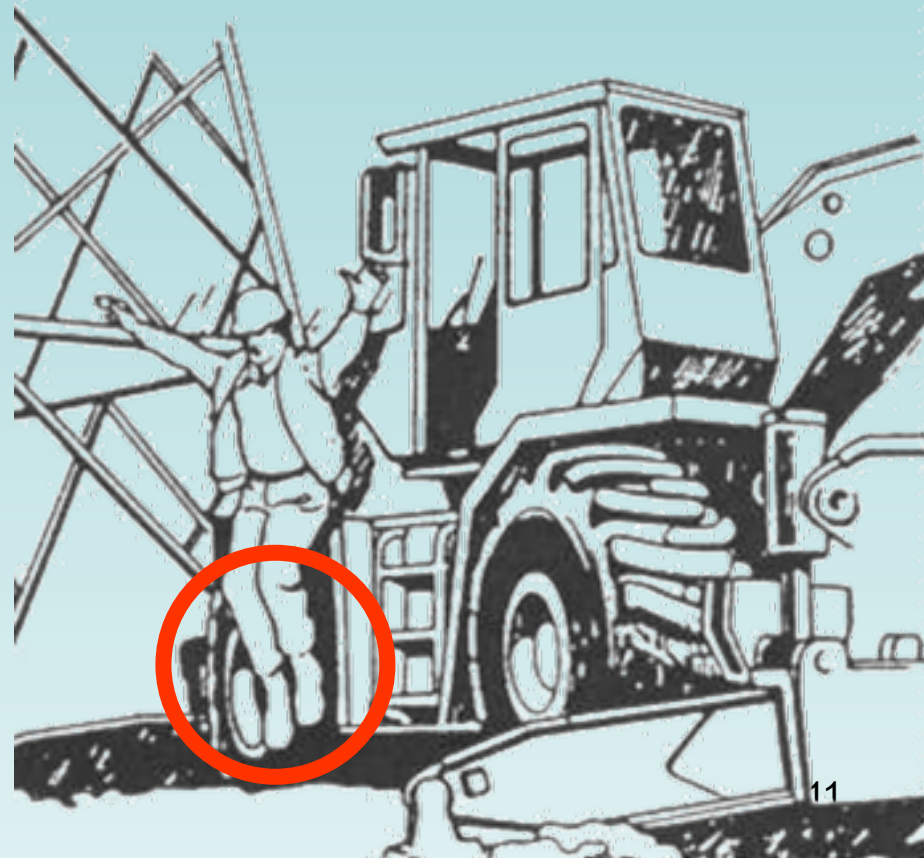


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What to Do If Equipment Contacts Overhead Power Lines

- If you are not on or in the equipment... stay away from it!!
- Do not touch the machine or outriggers
- If you are operating it, stay in it until power is shut off
- If you must get out, jump with your feet together
- Hop or shuffle away



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Elevator Industry-Related Electrical Hazards

Even though as an Elevator Constructor you may not be operating this equipment outside of the building, you should be aware of the potential for these accidents to happen.

A crane that becomes energized from overhead power lines could energize the load or any crane attachments.

Remember, simply being in the vicinity of a piece of equipment that becomes energized could cause you injury.

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Working Around Temporary Electrical Circuits on Job Sites

We will discuss four specific topics regarding temporary construction wiring:

- **GFCIs**
- **Assured equipment grounding**
- **Extension cords**
- **Electrical panel boxes**

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Ground Fault Circuit Interrupters (GFCI)

- Protect workers from shock by limiting duration of electrical shock*
- Monitor the difference in current between the hot and neutral wires
- Trip between 4-6 mA and shut off electricity in 1/40th of a second
- Must be used on all 120 volt, single-phase 15 and 20 amp receptacles



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Assured Equipment Grounding Program

- Required If GFCIs are not used
- Inspection ensures your protection
- The most common color-coding system uses these colors to indicate inspection has been done

Winter

Spring

Summer

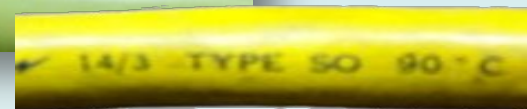
Fall

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Extension Cords

- Inspect your cords
- Ensure the insulation isn't damaged
- Confirm the grounding prong is intact
- Don't run cords through windows, doors, or holes in a wall without protection
- Should be labeled and must be 3-wire type designed for hard or extra hard use



ELECTRICAL HAZARDS

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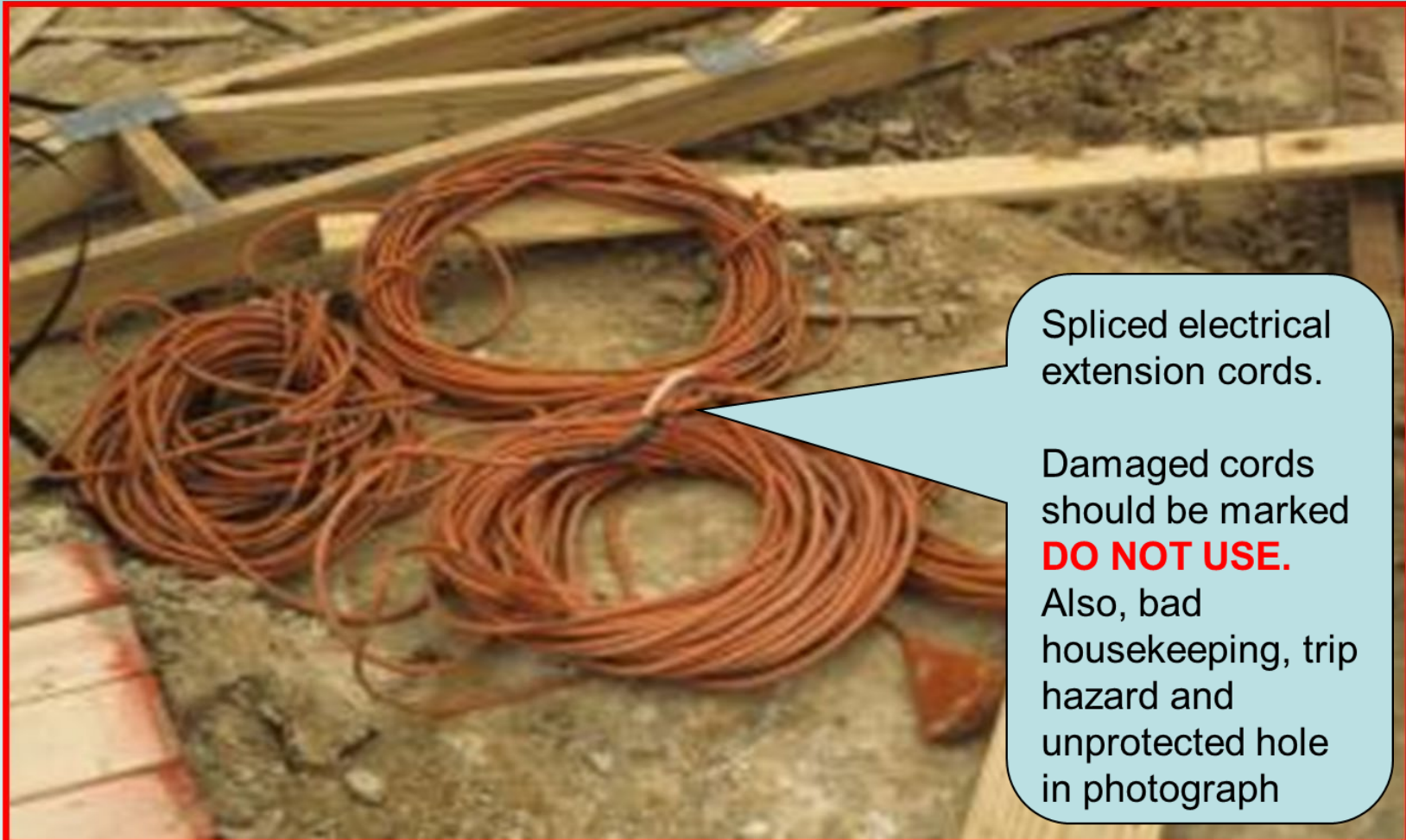
Recognize Any Hazard(s)?



ELECTRICAL HAZARDS

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Yes



Spliced electrical extension cords.

Damaged cords should be marked **DO NOT USE.**

Also, bad housekeeping, trip hazard and unprotected hole in photograph

Recognize Any Hazard(s)?



Yes

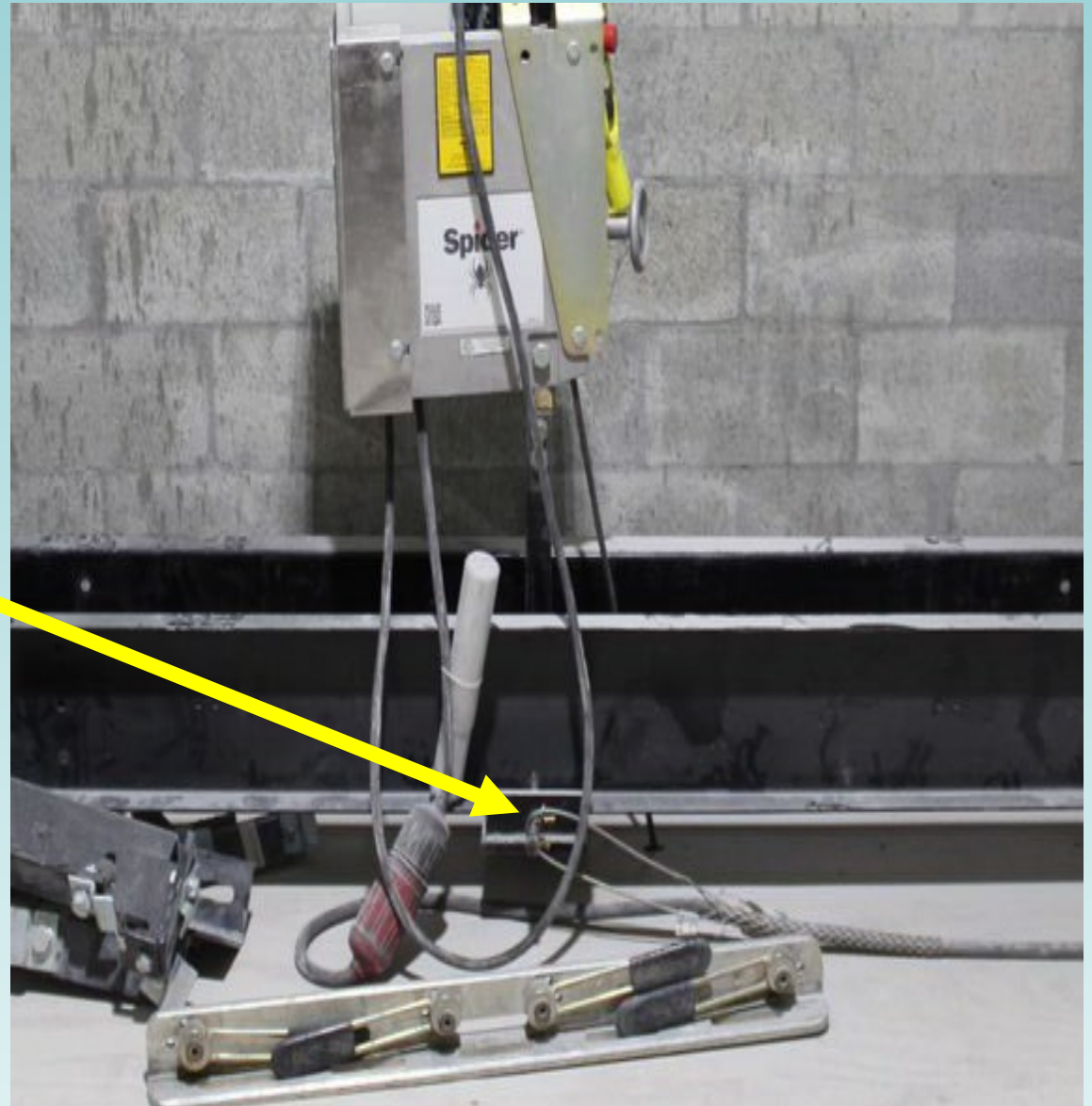
Is this foam really adequate to protect this cord?

Flexible cords and cables may pass through doorways or other pinch points, if protection is provided to avoid damage

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**Always
provide
proper
strain relief
when
hanging any
type of cord.**



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Temporary Wiring Hazards:

- Wiring like this must be protected in closed junction boxes.
- Exposed wires are an electric shock hazard.
- Even when properly wired, job site conditions change, and temporary electrical components can become unsafe from rough treatment over time



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- **Workers could be exposed to live wires around the perimeter of this box**
- **Energized electrical panels must be completely covered with a hard cover (original intended equipment)**
- **Do not use cardboard as a cover**



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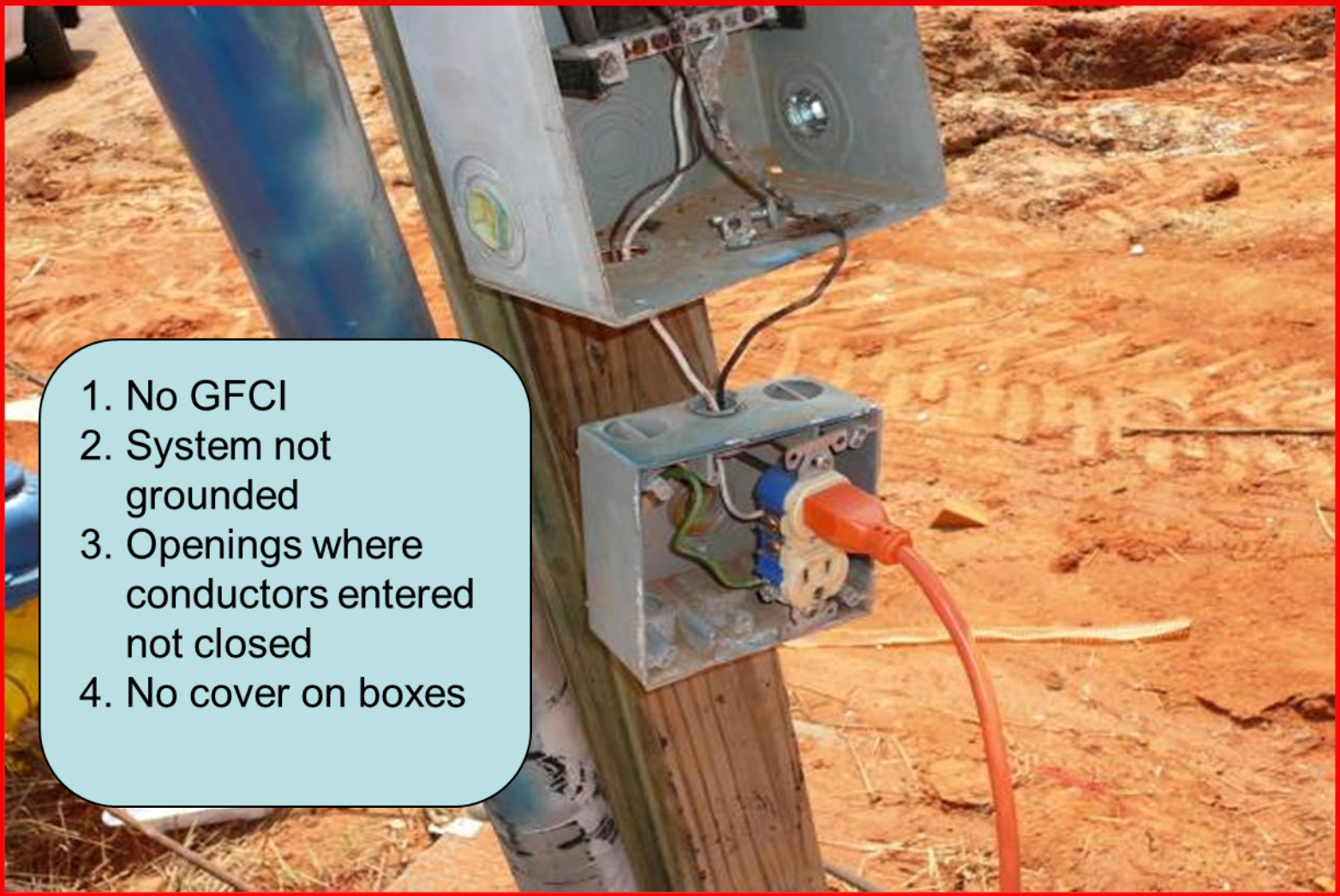
Recognize Any Hazard(s)?



ELECTRICAL HAZARDS

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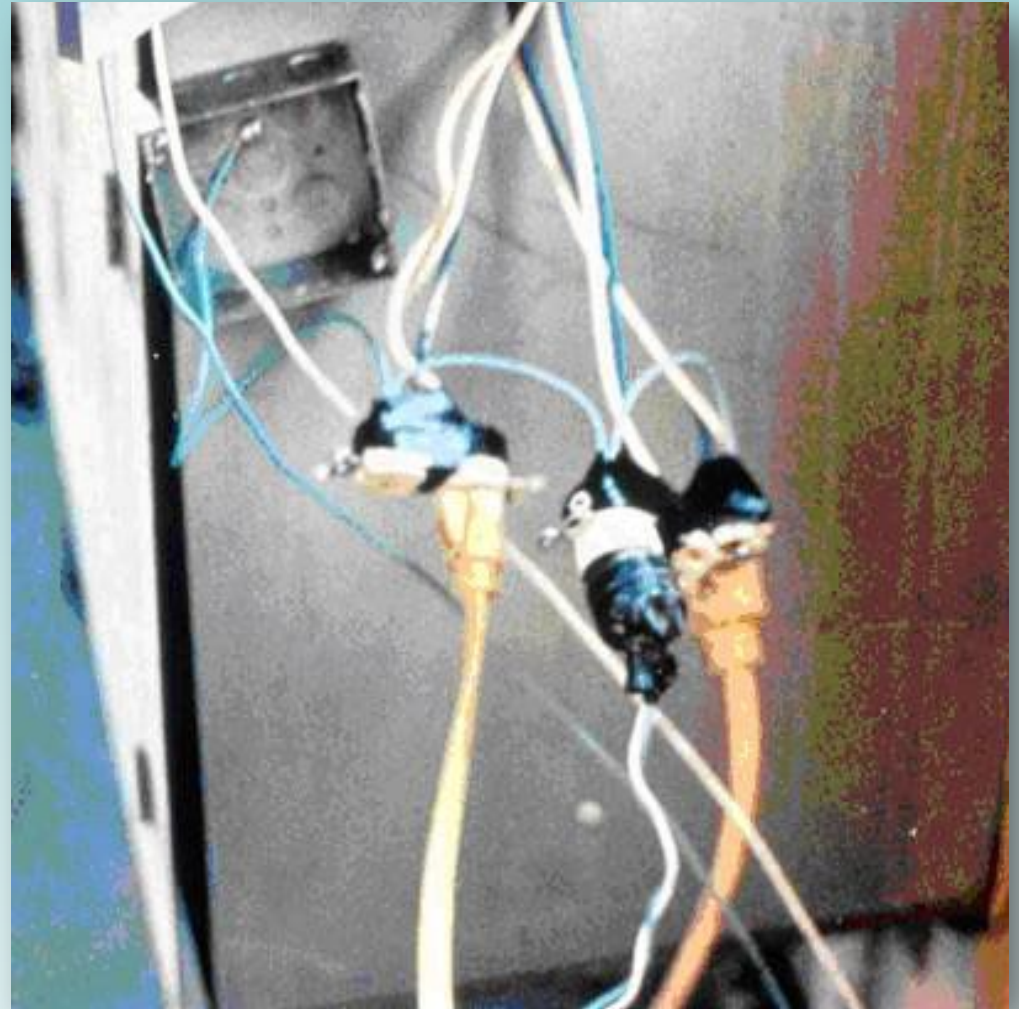
YES

- 
1. No GFCI
 2. System not grounded
 3. Openings where conductors entered not closed
 4. No cover on boxes

ELECTRICAL HAZARDS

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Recognize Any Hazard(s)?

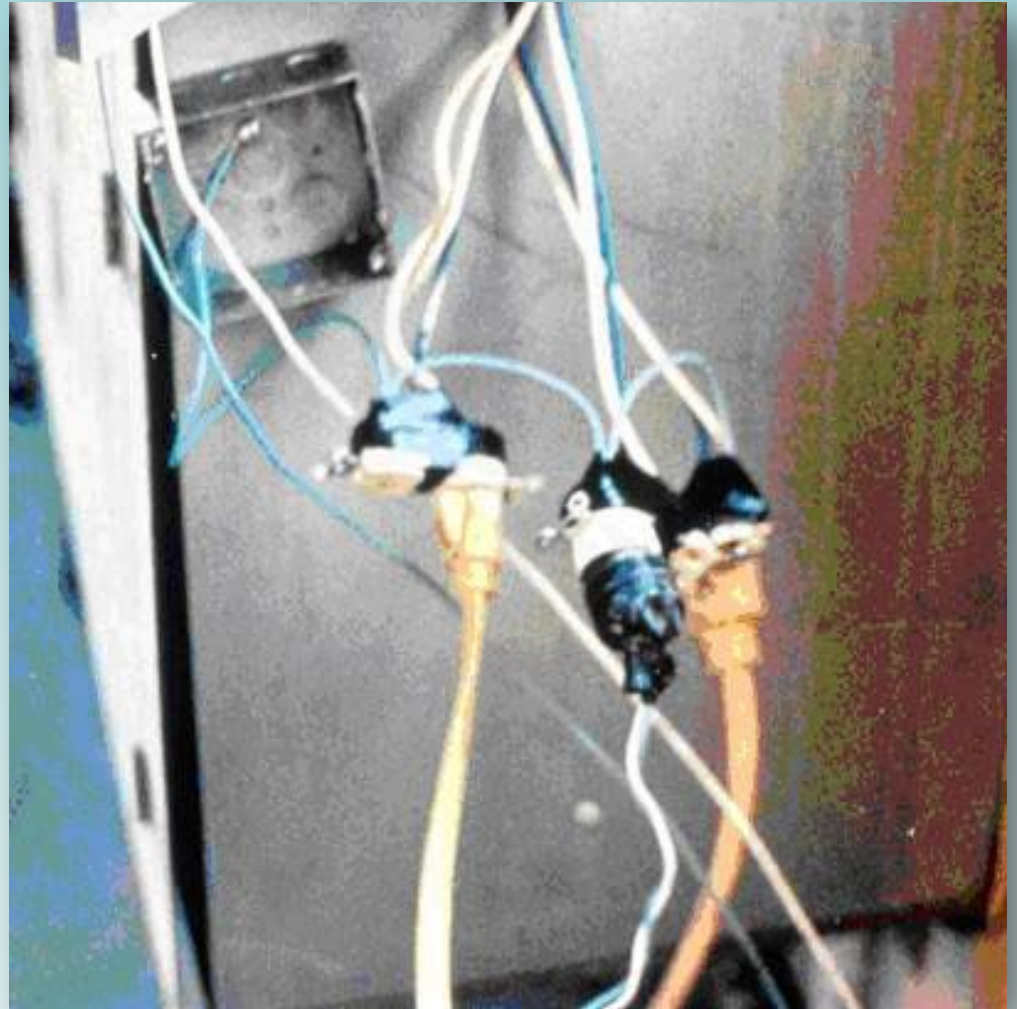


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Recognize Any Hazard(s)?

- These cords are improperly wired directly to the electrical circuit
- Not protected by a GFCI
- Two-wire cords are not grounded and not rated for hard or extra-hard service

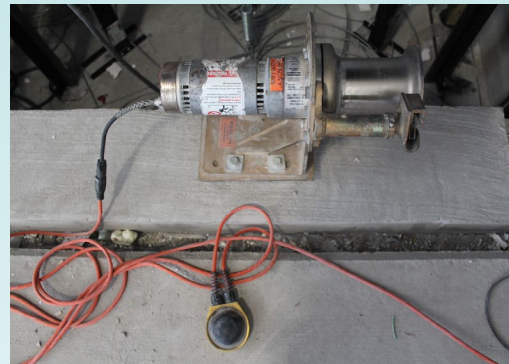
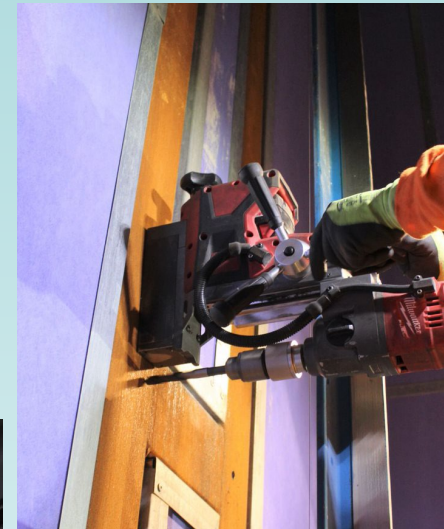


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Power Tool Safety

- Keep cords away from water, heat, oil, and sharp edges
- Disconnect tools when not in use, before servicing, and when changing accessories such as blades
- Never yank the cord to disconnect it from the receptacle.
- Never carry a tool by the cord
- ALL power tools must be double-insulated or have a 3-wire cord



ELECTRICAL HAZARDS

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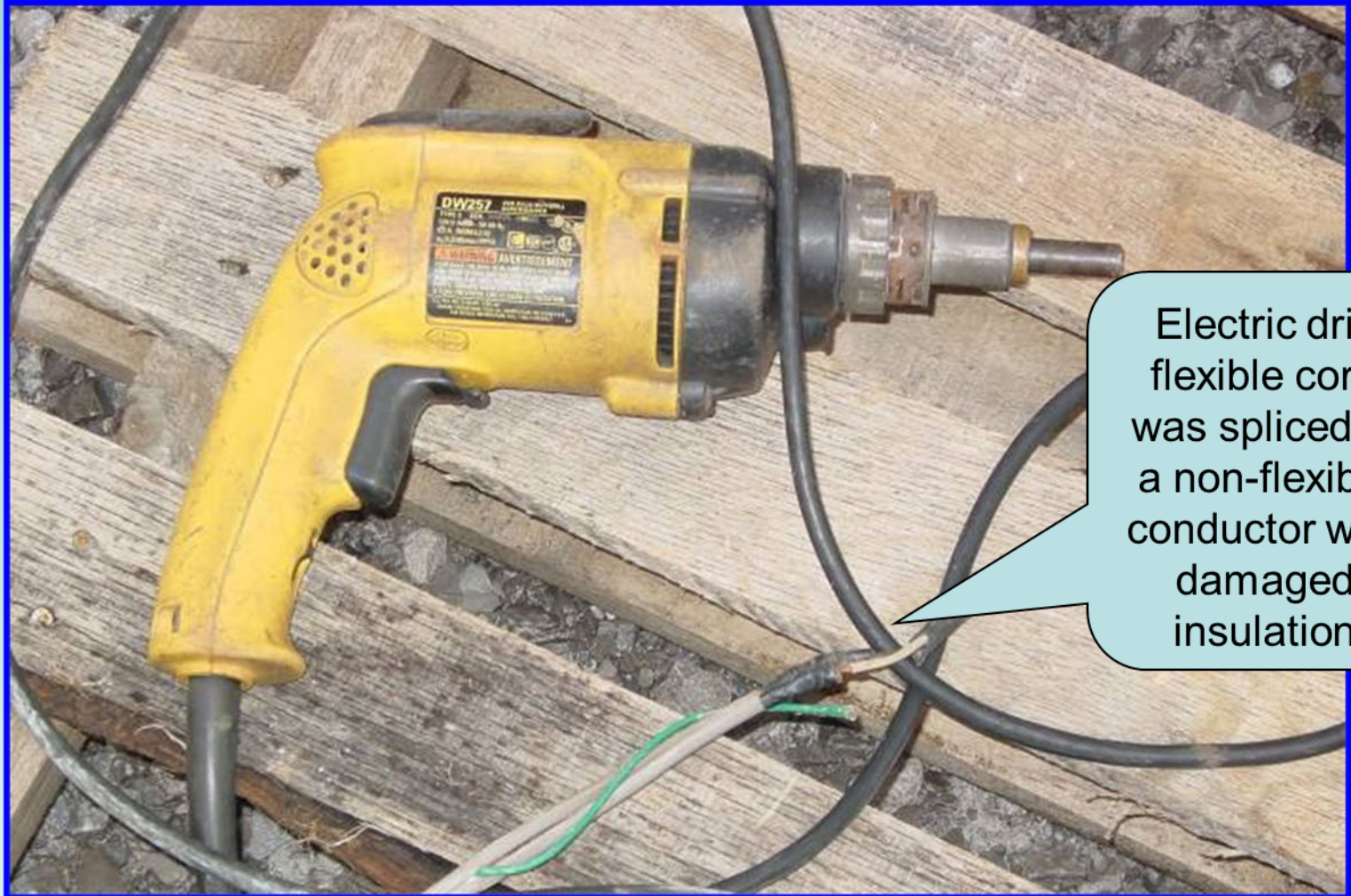
Recognize Any Hazard(s)?



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YES



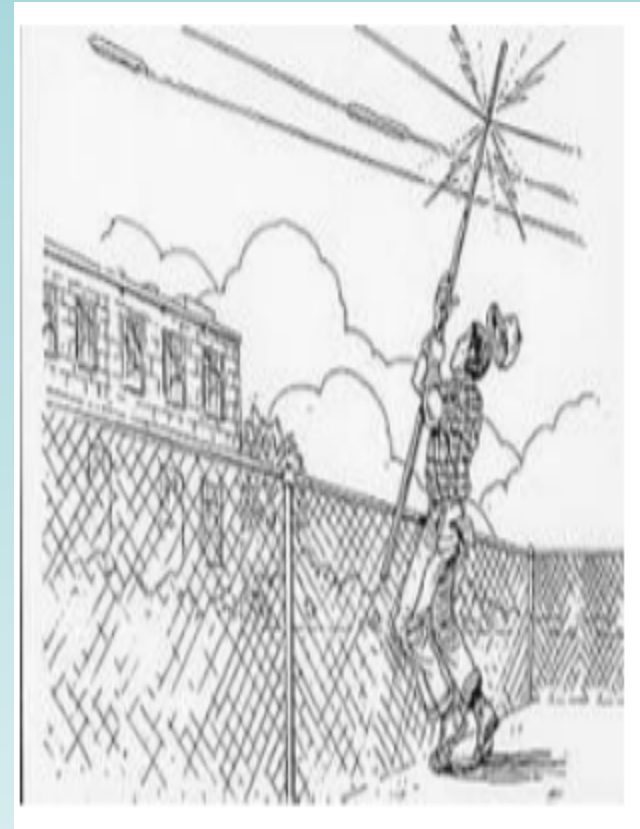
Electric drill flexible cord was spliced to a non-flexible conductor with damaged insulation

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Focus Four

What Should You Do If Someone Does Gets Shocked?

- If possible, turn off the power.
- Have someone call 911 and get an AED if available
- Do not touch the worker in contact with live electric current. You could get shocked and become a second victim
- Use nonconductive material to remove the person from the power source (a board, rope, etc.)
- When the scene is safe, start CPR or other first aid.



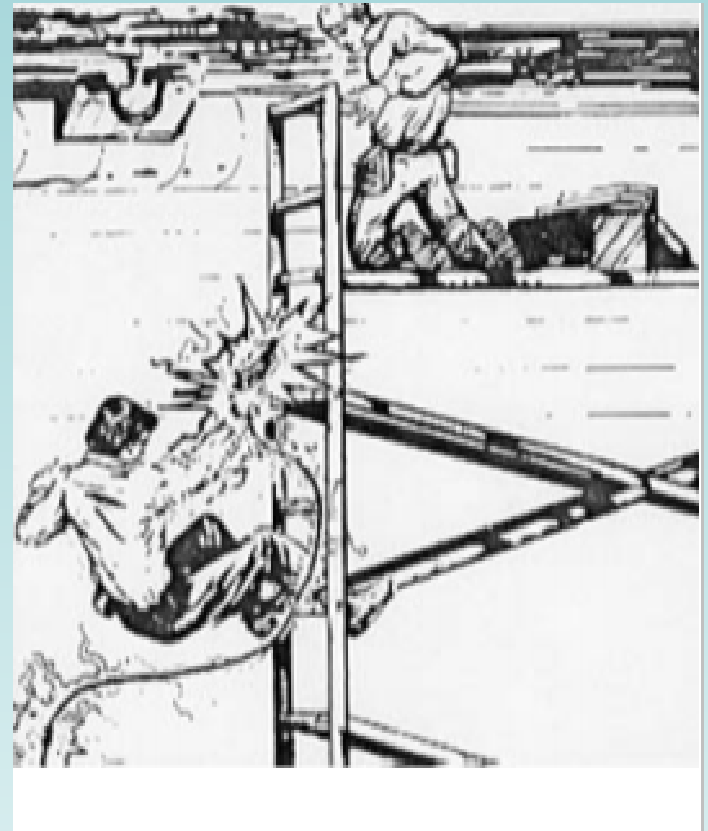
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Accident Report:

One employee was climbing a metal ladder to hand an electric drill to the journeyman installer on a scaffold about five feet above him. When the victim reached the third rung from the bottom of the ladder, he received an electric shock that killed him. The investigation revealed that the extension cord had a missing grounding prong and that a conductor on the green grounding wire was making intermittent contact with the energizing black wire thereby energizing the entire length of the grounding wire and the drill's frame. The drill was not double insulated.

INSPECTION RESULTS: As a result of its investigation, OSHA issued citations for violations of construction standards.



ELECTRICAL HAZARDS

Focus Four

Lockout/Tagout

- **§ 1926.416 General requirements.**
- **(a) *Protection of employees*—(1) No employer shall permit an employee to work in such proximity to any part of an electric power circuit that the employee could contact the electric power circuit in the course of work, unless the employee is protected against electric shock by deenergizing the circuit and grounding it or by guarding it effectively by insulation or other means.**

ELECTRICAL HAZARDS

Focus Four

Lockout/Tagout

- When work is performed on a conveyance requiring employees to place any part of their body within range of energized circuits, pinch points, points of operation, rotating or oscillating parts or where operation is not required, the conveyance must be completely de-energized, locked out and tagged. If operation is required, proper protective guards or insulation must be in place.
- If troubleshooting or testing must be performed with the power on, refer to your company's live electrical safe work practices policy.
- Once the problem is identified, shut the power off, then lock out and tag out the conveyance before performing the repair.



ELECTRICAL HAZARDS

Focus Four

Lockout/Tagout

Lockout/Tagout

A lockout/tagout procedure is required after equipment is de-energized to make sure that it is not accidentally re-energized.

Your employer determines the lockout/tagout procedure and must provide training on that procedure. Your employer provides the locks and tags. As an employee, you are responsible for installing these devices as instructed.

Lockout/tagout equipment needs to be unique and readily identifiable as lockout/tagout devices. These locks and tags are not to be used for any other purpose.



ELECTRICAL HAZARDS

Focus Four

Lockout/Tagout

For lockout/tagout procedures, only key or combination locks may be used. All lockout devices must list the name of the person who installed it, which is normally written on the tag. This individual is responsible for holding on to the key or combination until the lock is removed.

Tags used along with a lockout device need to contain a statement prohibiting unauthorized operation of the disconnecting means or unauthorized removal of the device.

Tags need to be made of a material that cannot be easily torn off and must be securely attached, following your company's guidelines. Do not reuse a tag filled out for another task.

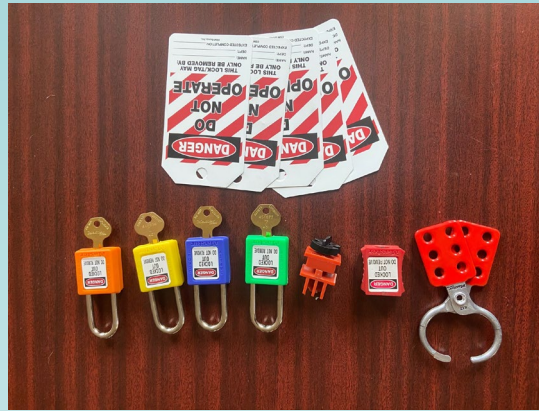


ELECTRICAL HAZARDS

Focus Four

Lockout/Tagout

LOTO equipment must be identifiable as LOTO specific



LOTO for power tools or equipment with a plug



LOTO for circuit breakers



LOTO for multiple locks



ELECTRICAL HAZARDS

Focus Four

Lockout/Tagout

Following is a general step by step process for performing LOTO. Always follow your company's policy and procedures.

Lockout/Tagout (LOTO) Sequence of Steps

- 1. Gain control of the conveyance and ensure that it is secured from public access. Make sure all necessary PPE and diagnostic hardware is readily available prior to commencing energy shut down.**
- 2. Identify and locate the specific circuit or conveyance and corresponding disconnect you intend to de-energize. Stand to the side and face away while switching off the disconnect.**

ELECTRICAL HAZARDS

Focus Four

Lockout/Tagout

Lockout/Tagout (LOTO) Sequence of Steps cont.

3. Place the appropriate lock to isolate the equipment. NOTE: If more than one employee is working on the equipment that is locked out, each employee shall place his/her personal lock on the disconnect.

4. Place a “Danger: Do Not Operate” tag with the following four items: company name, employee name, date and a contact number.



ELECTRICAL HAZARDS

Focus Four

Lockout/Tagout

Lockout/Tagout (LOTO) Sequence of Steps cont.

5. Identify a known LIVE voltage source, and test the functionality of the multimeter or non-contact voltage detector against this source.



ELECTRICAL HAZARDS

Focus Four

Lockout/Tagout

Lockout/Tagout (LOTO) Sequence of Steps cont.

6. Test and verify that the voltage has been disconnected (DEAD) with a non-contact voltage detector or a-multimeter. Check each leg to ground. For ungrounded or above-ground systems, check leg to leg to complete verification of absence of energy.

NOTE: If only de-energizing the mainline, be aware that the controller may still have live 110/120-volt circuit for cab lighting and fan. Also verify that voltage has been dissipated from capacitors and AC Drive units.

ELECTRICAL HAZARDS

Focus Four

Lockout/Tagout

Lockout/Tagout (LOTO) Sequence of Steps cont.

7. Reverify that the functionality of the multimeter or non-contact voltage detector worked properly before and after the measurement. Check against a known LIVE voltage source.

8. Ensure that all potentially hazardous stored energy is relieved, disconnected, restrained, and otherwise rendered safe. Hydraulic elevator units must be landed on buffers, pipe stands, or have rail blocks installed when working on the pressurized system. Mechanical safeguarding of escalators and moving walks shall be put in place to protect from stored energy.

ELECTRICAL HAZARDS

Focus Four

Lockout/Tagout

Lockout/Tagout (LOTO) Sequence of Steps cont.

9. Perform work.

10. Re-energize the conveyance following these steps:

- Replace all guards and remove all tools
- Recheck to ensure control of the conveyance and that is secure from public access
- The employee(s) who applied personal locks shall remove their own lock and tag
- Make sure all workers are safe and accounted for before equipment and circuits are unlocked and turned back on
- Stand to the side and face away, announce “power going on” when powering the disconnect on
- Check that the conveyance has been properly returned to service

ELECTRICAL HAZARDS

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Arc Flash

What is an Arc Flash?

An arc flash is a sudden, unexpected discharge of electricity that travels through the air between conductors, or from conductor to ground.

This short circuit releases enormous amounts of energy as light and heat.

The results can be devastating. When an unprotected person is nearby, serious injury and even death can occur.



ELECTRICAL HAZARDS

Focus Four

Arc Blast

What is an Arc Blast?

An arc flash almost always results in an arc blast. An arc blast is the high-pressure explosion caused by a sudden arc fault.

Although an arc flash and an arc blast are two distinct parts of a split-second phenomenon, for the duration of this course we'll usually refer to them together as an arc flash.



ELECTRICAL HAZARDS

Focus Four

Common Causes of Arc Flash

Common causes include:

- Dust
- Dropping tools
- Accidental touching
- Condensation
- Material failure
- Corrosion
- Faulty installation
- Wiring errors



ELECTRICAL HAZARDS

Focus Four

Results of an Arc Flash

Results of an Arc Flash:

It takes little imagination to predict how much damage an arc flash can do to you or one of your coworkers. The blast radius can exceed ten feet, injuring everyone in its path. The dangers associated with arc flash are:

- **Thermal Energy**

The sun burns at about 10,000 degrees Fahrenheit. By comparison, an arc flash can generate temperatures as high as 35,000 degrees Fahrenheit. At this extraordinarily high temperature, all known materials vaporize instantly, causing them to rapidly expand. The resulting fire can spread rapidly, resulting in catastrophic burns, smoke inhalation or death

- **Ultraviolet Energy**

The arc's high intensity flash can cause blindness

- **Acoustical Energy**

The sound can reach 140 decibels, causing permanent hearing loss

ELECTRICAL HAZARDS

Focus Four

Results of an Arc Flash cont.

- **Pressure Wave**

The pressure wave caused by the blast can hit a worker's chest with a force greater than 2,000 pounds per square foot causing internal injuries, collapsed lungs, broken bones and/or falls.

- **Debris**

In the explosion that results from the rapid expansion of these materials, droplets of molten metal spray with such force that they can penetrate the body like shrapnel. Depending on the force of the blast this debris can be ejected a great distance from the source of the blast, injuring nearby workers.

ELECTRICAL HAZARDS

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Arc Flash Injuries

Due to the violent nature of an arc flash, injuries are serious. This type of accident kills hundreds of workers every year.

If a person survives an arc flash, extended medical care is often required. Burn recovery is an incredibly painful process.

It's not uncommon for an arc flash survivor to never regain their past quality of life.

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Arc Flash Prevention

Preventing an arc flash incident starts by following up-to-date safe work practices and procedures. The National Fire Protection Association, or NFPA, publishes current safe work practices that will enable you to recognize and avoid arc flash hazards.

Almost all arc flash accidents happen when workers are untrained or ignore safe work practices.

Never work on an electrical task without being properly *qualified* for the work being performed.



ELECTRICAL HAZARDS

Focus Four

Arc Flash Standards

Who sets the standards for arc flash safety?

- **National Fire Protection Association (NFPA)**
- **National Electrical Safety Code (NESC)**
- **National Electrical Code (NEC)**
- **Occupational Safety and Health Administration (OSHA)**

ELECTRICAL HAZARDS

Focus Four

Electrically Safe Working Conditions

What are Electrically Safe Working Conditions?

In general, OSHA determines what is required to create electrically safe working conditions, and NFPA 70E describes how to create electrically safe working conditions.

An electrically safe working condition is defined as a state in which an electrical conductor or circuit part has been disconnected from energized parts, locked and tagged in accordance with established standards, tested to ensure the absence of voltage, and grounded if determined necessary.

In a few words:

work de-energized whenever possible.

ELECTRICAL HAZARDS

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Responsibilities

Responsibility for Safe Conditions

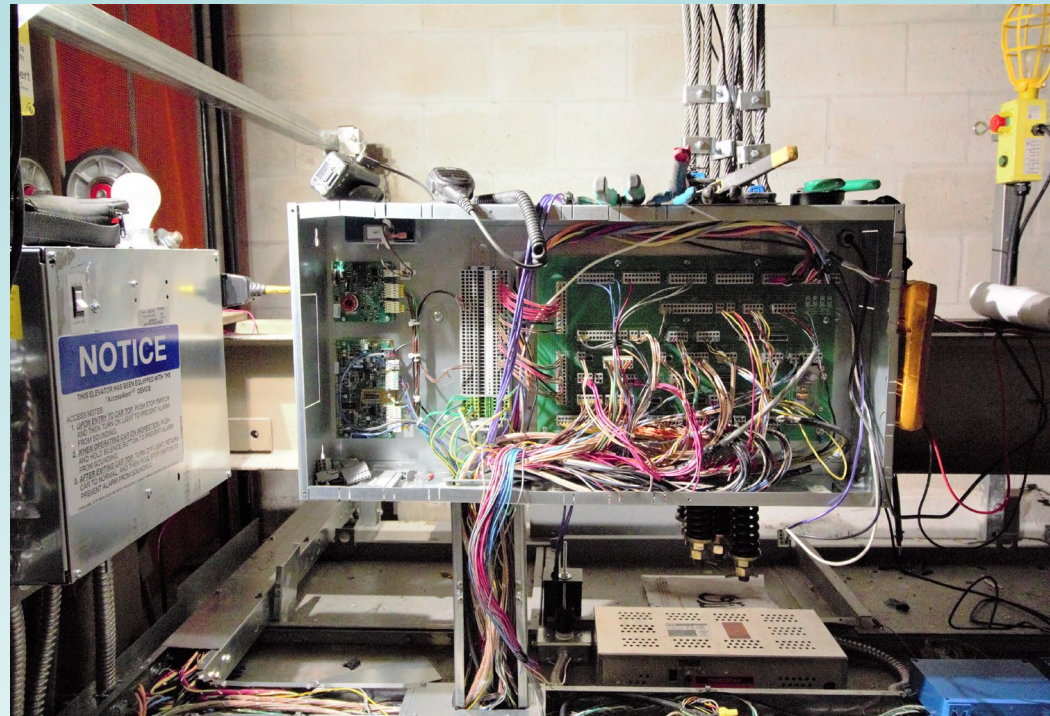
- **Both employers and employees have responsibilities for creating electrically safe working conditions**
- **Employers need to establish the safety-related work practices and train workers.**
- **Employees need to implement the safe work practices**
- **It's vital that you follow safe work practices. The consequences are too extreme to take a chance**

ELECTRICAL HAZARDS

Focus Four

Elevator Industry-Related Electrical Hazards

To eliminate the risk for contact with live electrical wiring, hoistway and car connections should be made before controller connections.

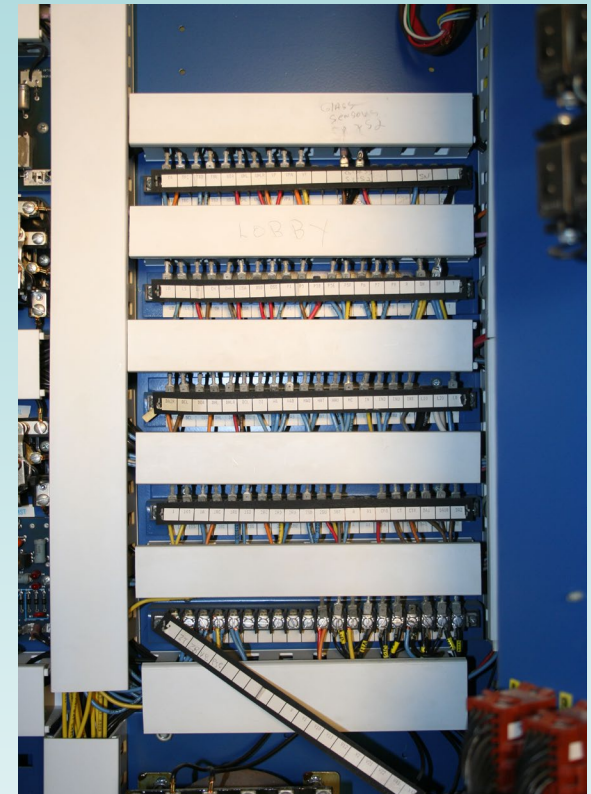
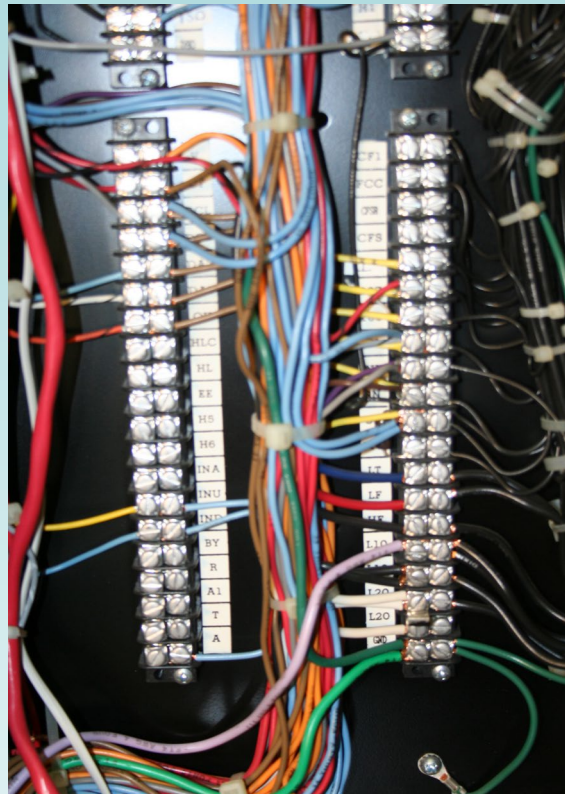
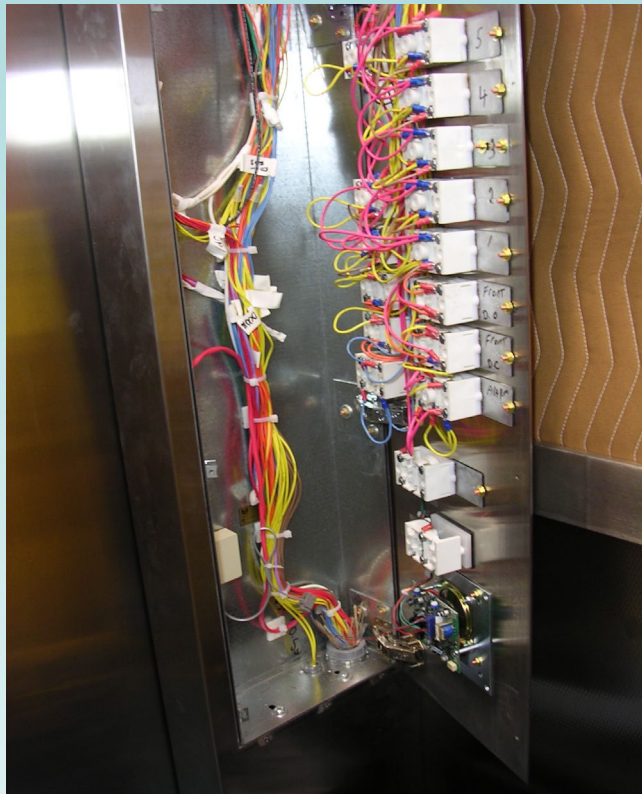


ELECTRICAL HAZARDS

Focus Four

Elevator Industry-Related Electrical Hazards

Car top junction boxes, car operating panels, and controllers should be neat and organized when construction wiring is complete.



ELECTRICAL HAZARDS

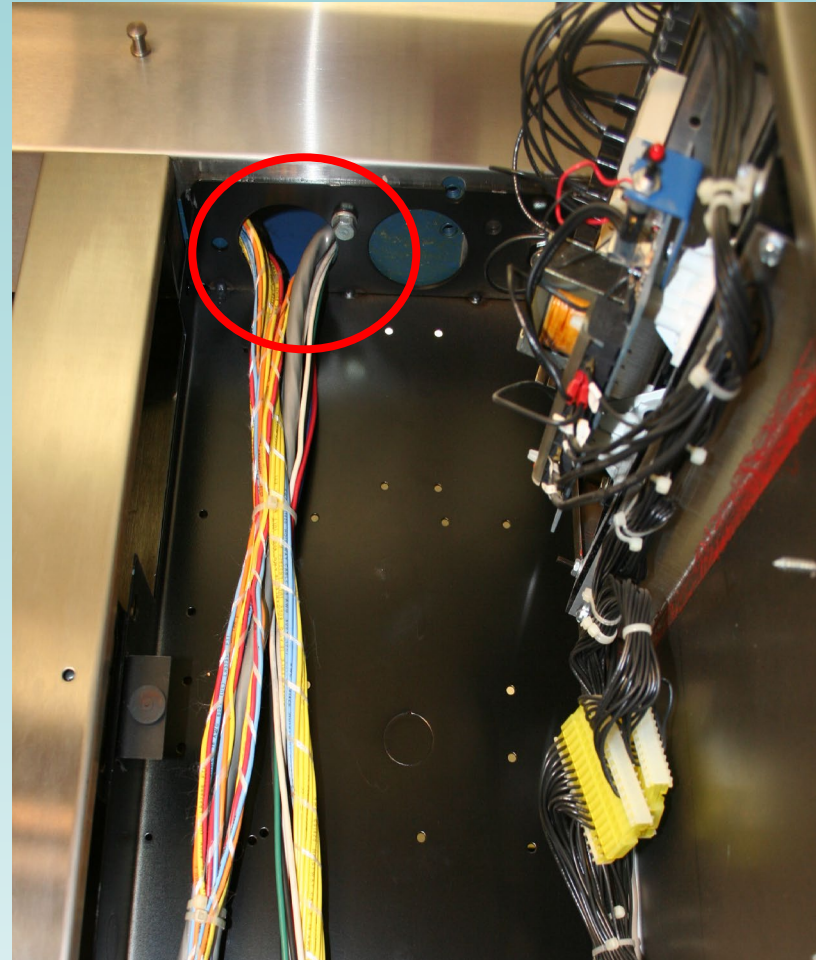
Focus Four

Elevator Industry-Related Electrical Hazards

Do you see the hazard here?

There is no protection for the wires being brought into this box. It's just a matter of time until vibration wears away the wires insulation and the live conductor contacts the metal.

Protection must be provided any time cables or wires are brought into a box or controller. This can be accomplished with a bushing or other edge protection.



ELECTRICAL HAZARDS

Focus Four

Elevator Industry-Related Electrical Hazards

Control cabinet doors should be closed any time work is not being done. This will eliminate accidental contact with any live components. The controller may be located inside the hoistway and only accessible from the car top. Whenever possible, perform LOTO procedures before doing any work inside the control panel. Always follow your company's LOTO and live work processes.

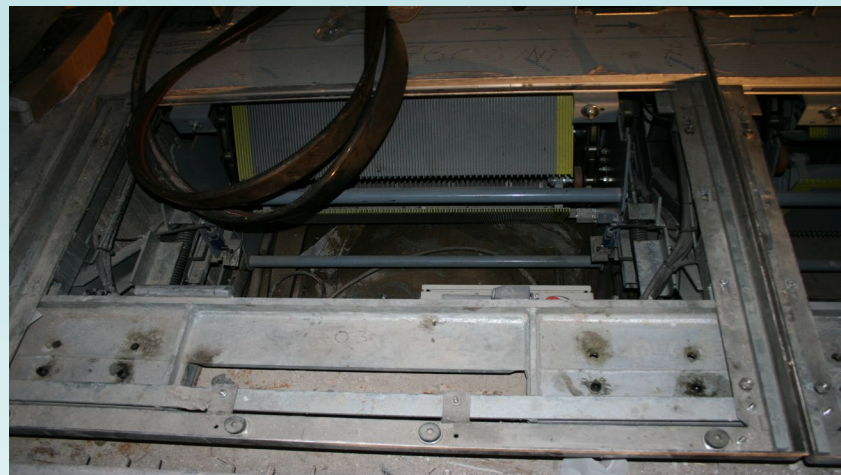


ELECTRICAL HAZARDS

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Elevator Industry-Related Electrical Hazards

Escalators and moving walks present some challenges for wiring and LOTO. Tight quarters require you to be in close proximity to caught in/between and electrical hazards. Always perform LOTO procedures and secure the unit from unintended movement before putting yourself in a position for potential injury.



ELECTRICAL HAZARDS

Focus Four

Hazard Identification

Can you identify the hazards in these next slides?

Look at the picture and identify the hazards.

Have a discussion about possible solutions.



ELECTRICAL HAZARDS

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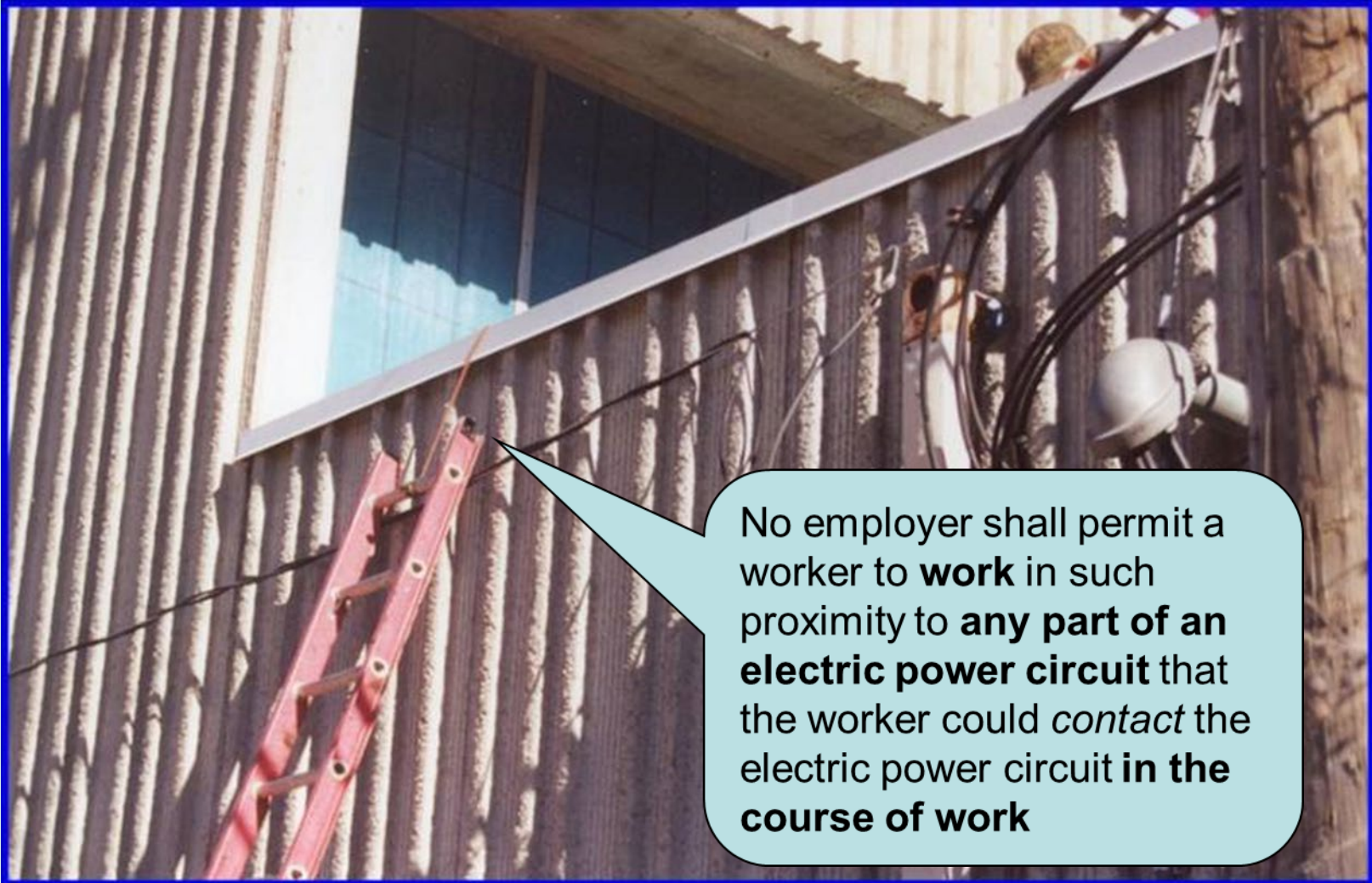
Recognize Any Hazard(s)?



ELECTRICAL HAZARDS

Focus Four

Yes



ELECTRICAL HAZARDS

Focus Four

Recognize Any Hazard(s)?



ELECTRICAL HAZARDS

Focus Four

Yes



Crossing electrical line must be supported, protected, or removed to safeguard workers

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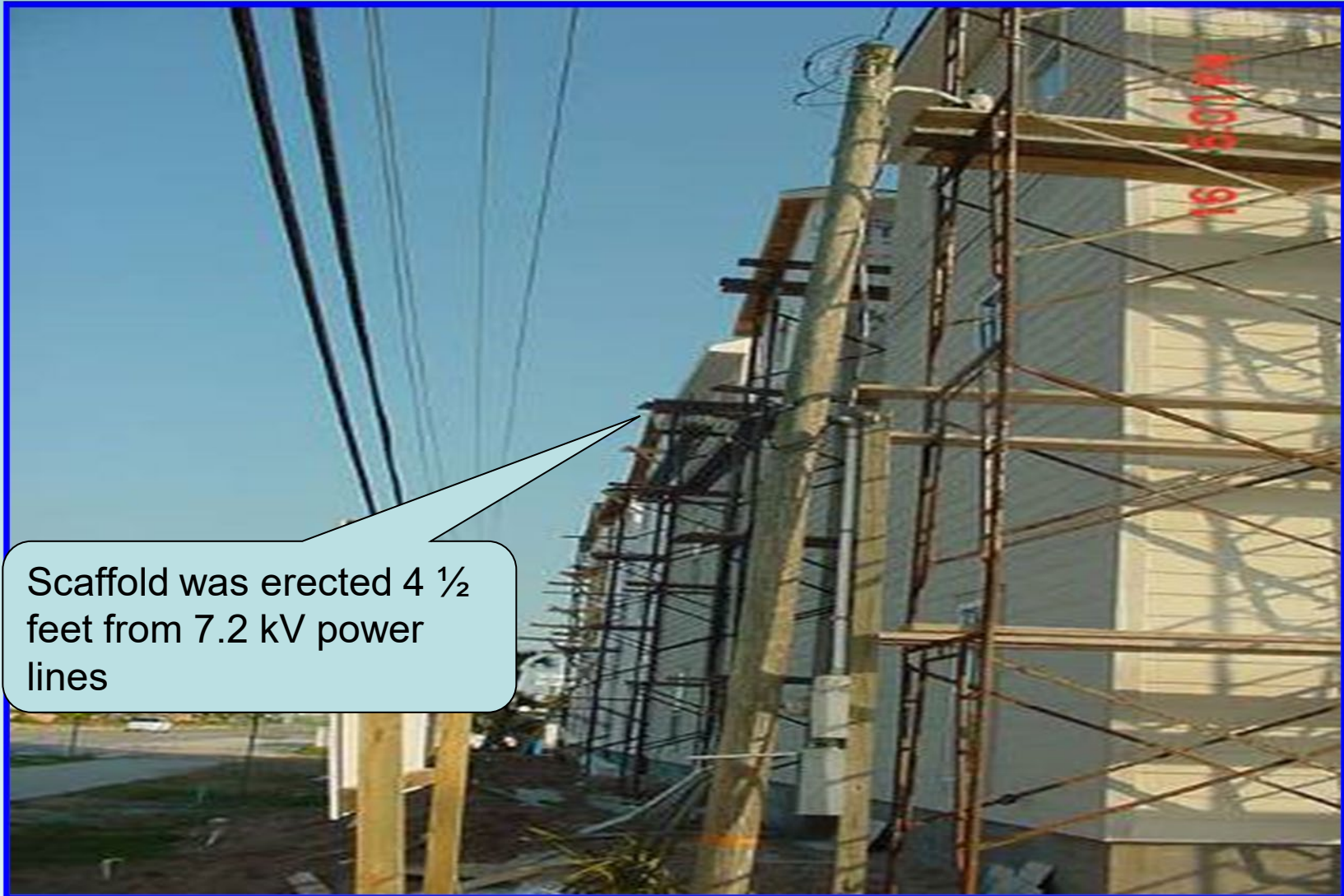
Recognize Any Hazard(s)?



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Yes



Scaffold was erected 4 ½ feet from 7.2 kV power lines

ELECTRICAL HAZARDS

Focus Four


Recognize Any Hazard(s)?



ELECTRICAL HAZARDS

Focus Four

Yes



Continuous path to ground not maintained; multiple cords used for fixed equipment

23 12:38 PM

ELECTRICAL HAZARDS

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Recognize Any Hazard(s)?

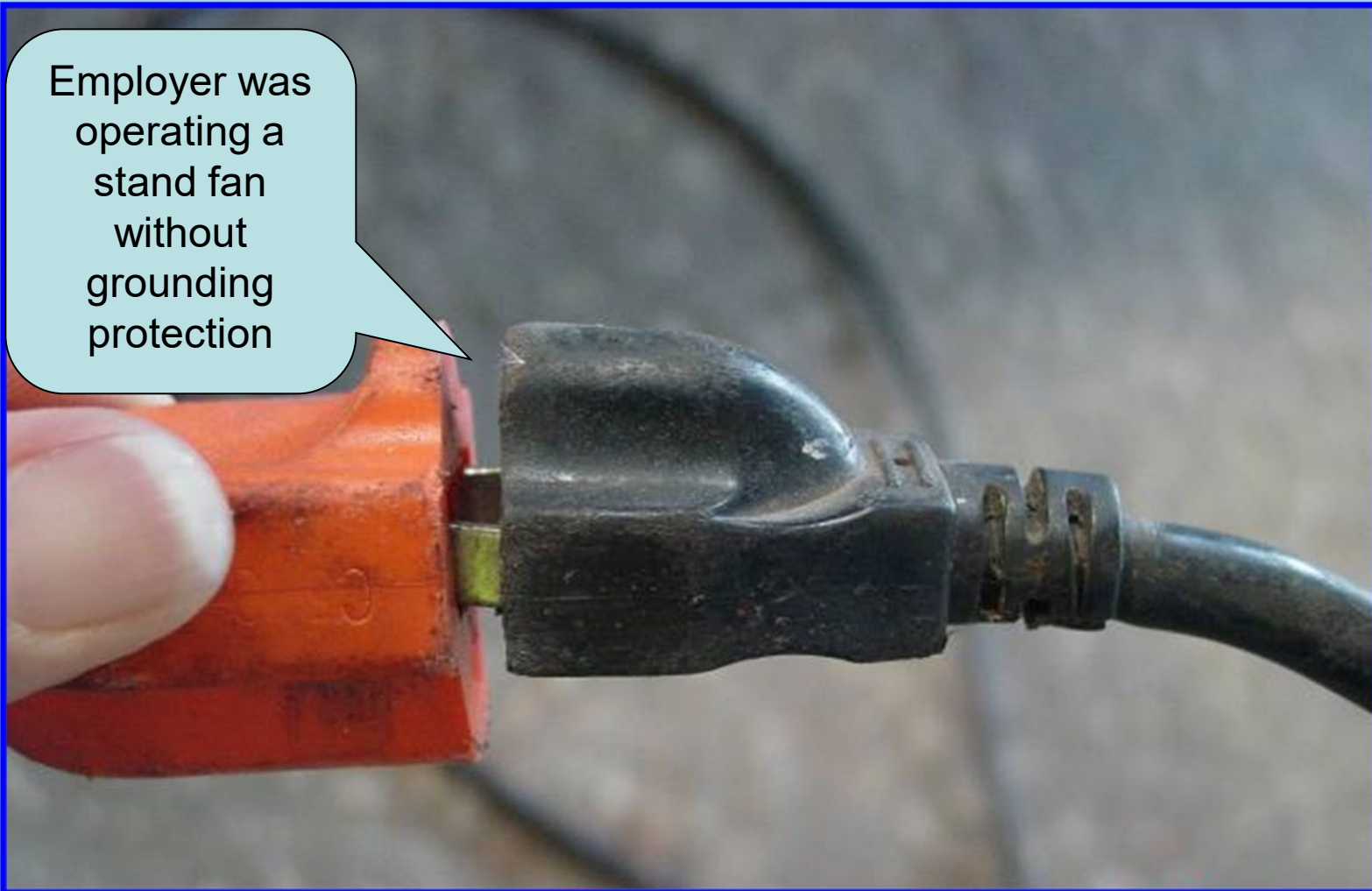


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Yes

Employer was operating a stand fan without grounding protection



ELECTRICAL HAZARDS

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Recognize Any Hazard(s)?



ELECTRICAL HAZARDS

Focus Four

Yes



ELECTRICAL HAZARDS

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Electrical Hazards Summary

- **Contact with overhead power lines causes the most electrocutions. Stay at least 10 feet away**
- **Use GFCIs for worker protection on 120V, 15- 20-amp circuits**
- **Make sure power is off when servicing or repairing tools and equipment**
- **Inspect all electrical tools and cords before use.**
- **Do not touch a worker in contact with electric current. Shut off power. If it is not possible to shut off the power, use a nonconductive material to move them or move the source of electricity.**

ELECTRICAL HAZARDS

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Through the Alliance between OSHA's 10 Regional Offices and the Elevator Contractors of America (ECA), Elevator Industry Work Preservation Fund (EIWPF), International Union of Elevator Constructors (IUEC), National Association of Elevator Contractors (NAEC), National Elevator Industry Educational Program (NEIEP), and National Elevator Industry Inc. (NEII), collectively known as The Elevator Industry Safety Partners, developed this Industry Specific Content for informational purposes only. It does not necessarily reflect the official views of OSHA or the U.S. Department of Labor. May 2021

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Any Questions?