ELECTRICAL SAFETY TRAINING
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OVERVIEW
• Regulations & Standards
• Terms
• ELECTRICAL HAZARDS
• SAFETY MODEL
  • Recognize hazards: work environment, electrical system, wrong PPE
  • Evaluate hazards: look for “clues” that hazards are present, decide if you need to take action
  • Control hazards: create safe work environment, right tools, PPE, safe work practices
• QUIZ: 100% correct is required to pass the training
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Federal Regulations:
- 29 CFR Section 1910.333-305

Standard:
- NFPA 50E

TAMUCC
- Physical Plant Rules & Regulation Manual 34.07
- EH&S Mission
**ELECTRICAL SAFETY TRAINING**

**Terms and Definitions**

- “Qualified Person”:
  - Properly trained (train & understand how to do a specific task)
  - Proper PPE
  - Proper Tools

**NOTE:** ONLY QUALIFIED PERSONS ARE ALLOWED TO WORK ON HAZARDOUS ENERGY
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- Voltage: The force of electricity, the “push” or the “pressure” required to deliver the energy to do work. It’s measured in volts.
- Current: Current is the amount of electricity that is flowing. It’s measured in amperes.
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- Resistance describes the forces that oppose the flow of the electron current in a conductor. It’s measured in Ohms
- Potential: Stored electricity that can have a potential to exert a force
  Ex. Capacitor
Conductors: Materials or elements that allow free movement of electrons and therefore allow easy flow of electricity.

Insulators: Materials or elements that do not let electrons flow very easily from one atom to another.
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Terms & Definitions

- **Power**: Force to do the work
  \[
  \text{Power} = \text{Voltage} \times \text{Current}
  \]

Why do you need to know this?

Can your extension cord accommodate the wattage required by the equipment?
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- Direct Current (DC) means the electrical current is flowing in only one direction in a circuit.
  Example of electrical source with direct current

- Alternating Current (AC) means the electrical current is alternating directions in a repetitive pattern.
  Example of electrical source with alternating current
- **Single Phase Power Circuit:** Used in common household electrical service, 120-volt AC service.

- **Three phase Power System:** A common form of electrical power for industrial equipment
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- **High Voltage**: Voltage potential of 600v or greater.
- **Dangerous Voltage**: Voltage potentials ranging from 50v to 599v.
- Although legislation is based upon the Voltage of equipment, the current must also be considered. High amperage low voltage equipment can be hazardous.
Physical Hazards of Electricity

Fires

The most common cause of fires in homes and workplaces is defective or misused electrical equipment is a major cause of electrical fires.
Electrical Physical Hazards: Arc blast/flash

Explosions or Blasts & Flash
- Intense heat (can build up to 35,000 F)
- Thermoacoustic shock wave
- Molten metal
- Shrapnel
- Blinding light
- Toxic smoke
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Shocks occur when a person’s body completes the current path with:

• both wires of an electric circuit;
• one wire of an energized circuit and the ground;
• a metal part that accidentally becomes energized due, for example, to a break in its insulation

When a person receives a shock, electricity flows between parts of the body or through the body to a ground.
Causes of an Electrical Arc:

- Workers incorrectly think the equipment is de-energized and begin to work on it energized.
- Workers drop or improperly use tools or equipment components in energized equipment.
- Dust, water or other contamination accumulate and cause insulation breakdown.
- Connections loosen, overheat, reach thermal runaway and fail.
NIOSH conducted a study of workplace electrocutions that revealed the following information about workers who were electrocuted:

- The average age was 32.
- 81 percent had a high school education.
- 56 percent were married.
- 40 percent had less than one year of experience on the job to which they were assigned at the time of the fatal accident.
- 96 percent of the victims had some type of safety training, according to their employers.
Human Hazards of Electricity

The danger from electrical shock depends on...

- the *amount* of the *shocking current* through the body,
- the *duration* of the *shocking current* through the body, and
- the *path* of the *shocking current* through the body.

Source: NIOSH
It is not just the current. It is the voltage. It is the resistance. It is the pathway through body. It is the duration of contact.
Ohm’s Law

\[ I = \frac{E}{R} \]

This equation means the amount of current flow through a body equal to the amount of voltage applied between 2 points on that body, divided by the resistance offered by the body between those 2 points.
How does this equation save your life?

- Consider the numerator
- Consider the denominator
Human Hazards of Electricity:

SHOCKS, BURN, DEATH
## SHOCKS: HOW MUCH CURRENT IS HARMFUL?

### Effects of Electrical Current in Humans

(reaction when current flow from the hand to the foot for just 1 second)

<table>
<thead>
<tr>
<th>Current</th>
<th>Reaction/ Perception</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Milliampere</td>
<td>Faint Tingle</td>
</tr>
<tr>
<td>5 Milliamperes</td>
<td>Slight shock. Average individual can let go.</td>
</tr>
<tr>
<td>6-25 Milliamperes (woman)</td>
<td>Painful shock. Muscle control usually lost. Freezing level “no let go range”</td>
</tr>
<tr>
<td>9-30 Milliamperes (man)</td>
<td>Painful shock. Muscle control usually lost. Freezing level “no let go range”</td>
</tr>
<tr>
<td>50-150 Milliamperes</td>
<td>Extreme Pain, respiratory arrest, severe muscular contractions, possible death</td>
</tr>
<tr>
<td>1-4.3 Amps</td>
<td>Ventricular fibrillation (heart ceases to pump blood), nerve damage, likely death</td>
</tr>
<tr>
<td>10 or more Amps</td>
<td>Cardiac arrest, severe tissue and organ burns, death</td>
</tr>
</tbody>
</table>

Source: NIOSH/cdc
Human Hazards of Electricity: Burns

Burns are the most common shock-related injury. An electrical accident can result in an electrical burn, arc burn, thermal burn, or a combination of burns.
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Human Hazards of Electricity: burns

First degree burn

Second degree burn

Third degree burn
Key characteristic of electrical burn is that there is an *entrance* and an *exit* wound.
Arc or Flash Burns

• This man was near a power box when an electrical explosion occurred. Though he did not touch the box, electricity *arced* through the air and entered his body. The current was drawn to his armpits because perspiration is very conductive.
Thermal Contact Burns

- Current exited this man at his knees, catching his clothing on fire and burning his upper leg.
Internal Injuries

• This worker was shocked by a tool he was holding. The entrance wound and thermal burns from the overheated tool are apparent.

• Same hand a few days later, when massive subcutaneous tissue damage had caused severe swelling (swelling usually peaks 24-72 hours after electrical shock). To relieve pressure, which would have damaged nerves and blood vessels, the skin on the arm was cut open.
Human Hazards of Electricity

- Secondary injuries resulting from falls, collisions or involuntary muscle reactions or from explosions or fires
- Eye Damage, cuts & bruises, cardiac arrest, etc.
Human Hazards of Electricity: DEATH

According to OSHA, an approximate 350 electrical-related fatalities occur each year.
Other Hazards of Electricity

Fires
- The most common cause of fires in homes and workplaces is defective or misused electrical equipment is a major cause of electrical fires.

Explosions or Blasts
- Associated with an electrical arc
- Caused by instantaneous heating of the air surrounding the arc and the expansion of metal objects
- Molten metal droplets and other flying debris also pose substantial hazards
Most electrical accidents resulted from one of the following 3 factors:

1. Unsafe equipment or installation
2. Unsafe environment, or
3. Unsafe work practices

RECOGNIZE – EVALUATE - CONTROL
1) Control of Unsafe Equipment:
- Ensure guard, barrier, or good insulation are on before using tools
- Check for faulty wiring and correct it
- Never use damaged tools
- Never remove the grounding prong to fit the plug into a two prong receptacle

RECOGNIZE – EVALUATE - CONTROL
Control of Unsafe Equipment (con’t):

- Inspect cord for fraying and wear and only use the cord rated for the load it will carry
- Never ignore signs of troubles. Look for clues that show equipment is unsafe to use:
  - A blown fuse may indicate too much current flowing in a circuit
  - A burning odor may indicate overheated insulation
  - A worn, frayed, or damage insulation around any wire may indicate an exposed conductor
  - An electrical octopus may indicate overloading of current

RECOGNIZE – EVALUATE - CONTROL
2) Control of Unsafe Environment:
   - Post warning electrical hazard signs where needed
   - Keep working environment clean, DRY, and in order
Control of Unsafe Environment (con’t)

- Treat all conductors – even “de-energized” ones as if they are energized until they are locked and tagged out
- Lock out and tag out circuits and machines
- Prevent shocking currents by grounding system or tools

RECOGNIZE – EVALUATE - CONTROL
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Extension Cords:
Only when necessary and on temporary basis
UL Rating
Size or gauge
Length
Wattage needed
For indoor use
For outdoor or damp area use
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Extension Cords:

\[ P(\text{watts}) = V(\text{volts}) \times I(\text{amps}) \]

Extension cord with 30 A

Facility voltage 120 volts

An equipment with 3000 watts

4000 watts
3) Control of Unsafe work practices:

Abide by:
- General Safe Work Practices
- TAMUCC Safe Operating Procedures
General Safe Work practices
When working with or around electrical equipment

- Ensure all guards are properly in place
- Ensure all electrical equipment and systems are grounded
- Keep all equipment properly maintained
- Never bypass safety features
- Report malfunctions to supervision immediately
- Never use electrical tools in wet condition
General Safe Work practices: Ladder Safety

1) Use non-conductive ladder when working with electricity
2) Never carry load with both hands while climbing
3) Avoid standing on the last 3 rungs of a step ladder
4) Avoid standing on the last rung or platform of a portable ladder
5) Maintain 3 point contacts while climbing
6) Observe duty rating
Ground Fault Circuit Interrupter (GFCI) is an electrical device which protects personnel by detecting potentially hazardous ground faults and quickly disconnecting power from the circuit.

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A GFCI compares the amount of current in the ungrounded (hot) conductor with the amount of current in the neutral conductor. If the current in the neutral conductor becomes less than the current in the hot conductor, a ground fault condition exists. The amount of current that is missing is returned to the source by some path other than the intended path (fault current). A fault current as low as 4 mA to 6 mA activates the GFCI and interrupts the circuit. Once activated, the fault condition is cleared and the GFCI manually resets before power may be restored to the circuit.
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GFCl Disclaimer:

• When you touch the hot and neutral conductors in a GFCl-protected circuit simultaneously, GFCl will not sense an imbalance between the departing and returning current and the switching contacts will remain closed.

• GFIC protection fails at times. According to a 1999 study by the American Society of Home Inspectors, 21% of GFCl circuit breakers and 19% of GFCl receptacles inspected didn't provide protection.

• In areas of high lightning activity, such as southwest Florida, the failure rate for GFCl circuit breakers and receptacles was over 50%.

• GFClS will also fail if it’s wired improperly.

Source: Electrical Construction & Maintenance (EC&M) magazine
Other General Safe Practices Considerations:

- Don’t wear conductive articles such as watches, rings, ear rings and other conductive jewelry while working in close proximity to exposed live high voltage sources.

- In addition, clothing with metal snaps metallic threads, studs or metal ornamentation should be avoided.

- Nylons, rayons, polyesters & acetates burn readily and can be ignited by an electrical arc and should thus be avoided.

- Cotton is preferred around electrical hazards.

- Always work in a well illuminated work area.

- Never reach blindly into an electrical cabinet or circuit box.
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TAMUCC Safe Operating Procedures (SOPs):

• Always de-energize and lockout/tagout before working on electricity.

• However, when trouble shooting or when it is absolutely impossible or infeasible to de-energize, working on live energy is allowed only when electrical PPE, insulating tools are used and TAMUCC SOPs followed.
Routine Tasks Vs Trouble shooting

- **Routine Tasks:**
  - Employees are trained in Electrical Safety
  - Employees are trained to follow SOPs by TAMUCC Techs.

- **Trouble Shooting:**
  - Employees shall use the provided guide to use proper PPE and to work at safe distance
  - Use Buddy system as necessary
Trouble Shooting including Voltage Testing:

Follow TAMUCC guidelines for:

- Insulated tools
- Electrical PPE including V-rated gloves, leather protectors, Fire Resistant coverall, EH rating shoes,
- Other PPE as needed
- Dielectric blanket or insulating mat as needed
- Proximity from electrical source
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**TOOLS & PPE REQUIRED WHEN WORKING ON LIVE ELECTRICITY INCLUDING VOLTAGE TESTING**

<table>
<thead>
<tr>
<th>Voltage</th>
<th>&lt;10kA Short Circuit Current Available?</th>
<th>Hazard Risk Category</th>
<th>&quot;V&quot; Rated Gloves Required?</th>
<th>Leather Gloves Required?</th>
<th>&quot;V&quot; Rated Tools Required?</th>
<th>Uninsulated Natural Fiber Clothing Required?</th>
<th>FR Coverall as an alternate choice for uninsulated natural fiber long sleeve shirt &amp; long pants?</th>
<th>Eye Protection</th>
<th>Face or Head Protection</th>
<th>Hearing Protection</th>
<th>Foot Protection</th>
<th>Dielectric Blankets &amp; Insulating Mats?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 to 49</td>
<td>Not specified</td>
<td>Not specified</td>
<td>Not specified</td>
<td>Not specified</td>
<td>Not specified</td>
<td>Not specified</td>
<td>Not specified</td>
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<td>Not specified</td>
<td>Not specified</td>
<td>Not specified</td>
<td>Not specified</td>
</tr>
<tr>
<td>50 to 240</td>
<td>YES</td>
<td>0 (reduced by 1)</td>
<td>Class 00</td>
<td>As needed</td>
<td>Yes</td>
<td>Long sleeve shirt &amp; long pants</td>
<td>Allowed</td>
<td>Yes</td>
<td>Not specified</td>
<td>Hard hat as needed</td>
<td>Ear plugs as needed</td>
<td>EH rated shoes required ****</td>
</tr>
<tr>
<td>241 to 500</td>
<td>YES</td>
<td>1 (reduced by 1)</td>
<td>Class 00</td>
<td>Yes</td>
<td>Yes</td>
<td>Long sleeve shirt &amp; long pants</td>
<td>Allowed</td>
<td>Yes</td>
<td>Not specified</td>
<td>Hard hat as needed</td>
<td>Ear plugs as needed</td>
<td>EH rated shoes required ****</td>
</tr>
<tr>
<td>501 to 600</td>
<td>YES</td>
<td>1 (reduced by 1)</td>
<td>Class 0</td>
<td>Yes</td>
<td>Yes</td>
<td>Long sleeve shirt &amp; long pants</td>
<td>Allowed</td>
<td>Yes</td>
<td>Not specified</td>
<td>Hard hat as needed</td>
<td>Ear plugs as needed</td>
<td>EH rated shoes required ****</td>
</tr>
<tr>
<td>&gt;600</td>
<td>EMPLOYEES ARE PROHIBITED TO WORK ON ENERGIZED PARTS.</td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

*Equipment Notes:*
25 kA short circuit available, 0.03 second (2 cycle) fault clearing time
For <10kA short circuit current available, Haz/Risk Cat. required may be reduced by one number

**V-rated gloves:** gloves rated and tested for the maximum line-to-line voltage upon which work will be done

**V-rated tools:** tools rated and tested for the maximum line-to-line voltage upon which work will be done

****Due to the low potential-electrical hazards at TAMUCC, FR lab coat is allowed to be used in lieu of FR coverall.

*****EH Rating shoes: Working from non-conductive ladder is Optional

******Proximity: within 4 feet from exposed electrical live parts
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V-Rated Insulated tools
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V-Rated Glove Maintenance

- V-rated Glove Manufacture recommends gloves to be retested for dielectric strength twice a year
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Electrical Shock Hazard Personnel Rescue

1) When rescuing an electrical-shock victim the primary consideration is for the safety and welfare of the injured employee and those effecting the rescue.

2) Removing the victim from the electrical shock hazard

Make sure you know where the source is before working –

- Shut off the proper disconnect switch
- Safely remove the employee

WARNING: The position of the employee must be checked before the current is shut off. If the sudden release from the shock current will cause the employee to fall, a means shall be provided to break the fall that will not cause the rescuer to come into contact with the victim while that victim is in contact with a live electrical source.
In case of a Life-threatening emergency:

- Call for help immediately by radio using the “ALL CALL” channel or telephone ext. 4444
- Provide the condition and the location of the victim
- Make sure the UPD calls the Paramedic
- Stay with the victim and keep him calm
- Once the Paramedic arrives, provide all information as requested.
Employees’ responsibilities:

• Report electrical deficiencies immediately
• Not work on electrical equipment unless authorized and trained
• Properly inspect all electrical equipment prior to use
Management’s responsibilities:

- Provide training for specific tasks
- Conduct inspections
- Ensure all electrical deficiencies are corrected when reported
- Ensure all new electrical installations meet codes and regulations
RECAP

- Ohm’s Law
- Human Hazards from Electricity
- Three Factors causing Electrical Accidents
- TAMUCC Safe Work Practices
  - Routine Tasks
  - Trouble Shooting including voltage testing
  - Electrical Shock Personnel Rescue
  - In case of a Life-threatening Emergency
QUIZ

- Click on the following link to take the online quiz.
- Call E, H&S @ Ext. 5555 for any Questions.
- You must pass with 100% correct.
- Good luck!