Collaborative Bachelor's Degree Program of Fire Protection and Safety Engineering Technology between Southwest Jiaotong University and Oklahoma State University, U.S.A.

FPST 2023 Industrial and Occupation Safety

Electrical Safety – Part 1

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Introduction

- An average of one worker is electrocuted on the job every day
- There are four main types of electrical injuries:
  - Electrocution (death due to electrical shock)
  - Electrical shock
  - Burns
  - Falls
- Electricity is one of the most common causes of fire in homes and workplaces
- Explosions can result from electrical sources

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Three students electrocuted

STILLWATER, Okla. (AP) – Three fraternity brothers building a display for the Oklahoma State University homecoming celebration were electrocuted today when their scaffolding came into contact with a high voltage line, fire officials said.

Two other members of the Alpha Gamma Rho fraternity were treated for injuries. One was hospitalized in intensive care at a Stillwater hospital.

The dead were identified by university officials as Merle Wayne George, Manchester, Okla., freshman; Kevin Brent Wilson, Beaver, Okla., senior, and Randall D. Logan, Elk City, Okla., freshman.

- October 1977
- Three Alpha Gamma Rho (AGR) fraternity members were electrocuted and three more injured
- They were moving metal scaffolding across a lawn when the metal made contact with a 7,200-volt power line,
- 21-year-old Kevin B.Wilson, a senior majoring in agricultural economics;
- Randal D. Logan, 18-year-old agricultural economics freshman; and
- Merle Wayne George, a 17-year-old and an agricultural economics freshman,
- Watch video: Electrical Safety

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Regulations and Standards on Electrical Safety

- 1910.137 – Electrical Devices
- 1910.269 – Transmission, Distribution
- 1910.302-335 – Electrical Standards
- 1926.400-449 - Construction
- 1926.950-960 – Construction Transmission
- NFPA 70 National Electrical Code
- NFPA 70E Electrical Safety in the Workplace

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Generating Electricity

- Friction, pressure, heat, light, chemical reaction, and magnetism
- Magnetism is most practical & inexpensive method
- Electricity is produced when a magnet is moved past a piece of wire, or wire is moved through a magnetic field

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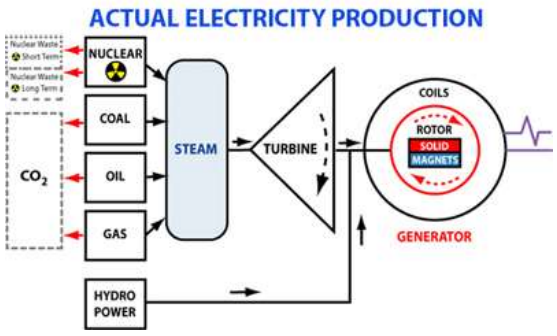
How Electricity is Generated



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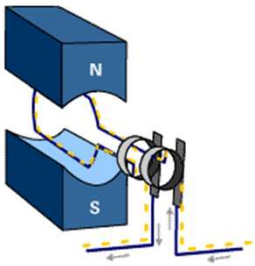

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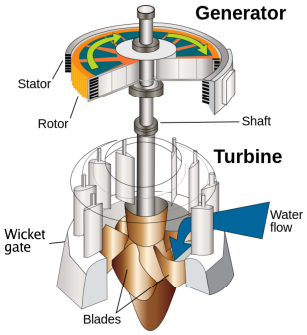

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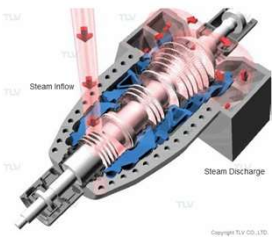

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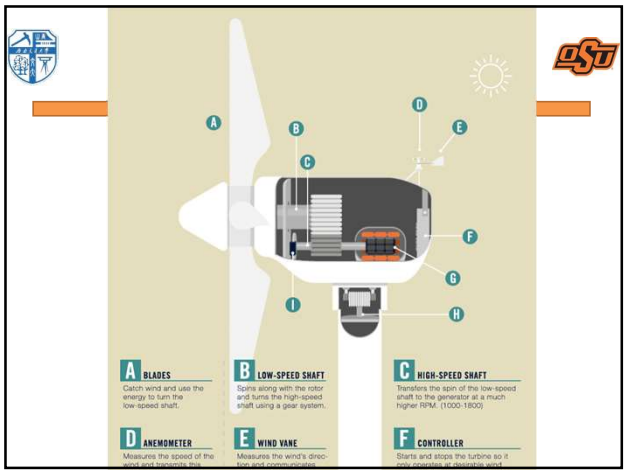

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Electrical Terminology

- **Current** – the movement of electrical charge
- **Resistance** – opposition to current flow
- **Voltage** – a measure of electrical force
- **Conductors** – substances, such as metals, that have little resistance to electricity
- **Insulators** – substances that have high resistance to electricity such as wood, rubber, glass, and bakelite
  - Polyoxybenzylmethylenglycolanhydride
  - First synthetic plastic (phenol and formaldehyde)
- **Grounding** – a conductive connection to the earth which acts as a protective measure
- **Bonding** – the joining of electrical parts to establish an equal electrical charge

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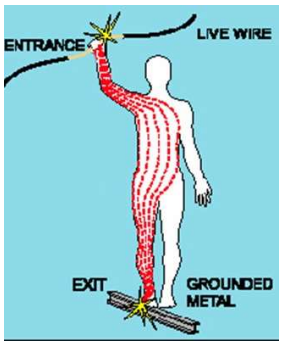
Electrical Shock

- Received when current passes through the body
- Severity of the shock depends on:
  - Path of current through the body
  - Amount of current flowing through the body
  - Length of time the body is in the circuit
- LOW VOLTAGE DOES NOT MEAN LOW HAZARD
  - The degree of injury increases the longer the body is in contact with the circuit.



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Effects of AC Electricity

- More than 3 mA- Painful shock- cause indirect accident
- More than 10 mA- Muscle contraction – "No Let Go" danger
- More than 30 mA- Lung paralysis, usually temporary
- More than 50 mA- Ventricular fibrillation, usually fatal
- 100 mA to 4 A- Certain ventricular fibrillation, fatal
- Over 4 A- Heart paralysis, severe burns

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Dangers of Electrical Shock

- Currents greater than 50 mA can cause ventricular fibrillation (rapid, ineffective heartbeat)
- Will cause death in a few minutes unless a defibrillator is used
- 50 mA is not much current – a small power drill uses 30 times as much

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Examples of Burns

- Entrance Wound:
  - High resistance of skin transforms electrical energy into heat, which produces burns around the entrance point (dark spot in center of wound). (Source: osha.gov)
- Exit Wound:
  - Current flows through the body from the entrance point, until finally exiting where the body is closest to the ground. The foot in the next slide suffered massive internal injuries, which weren't readily visible, and had to be amputated a few days later. (Source: osha.gov)

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Examples of Burns

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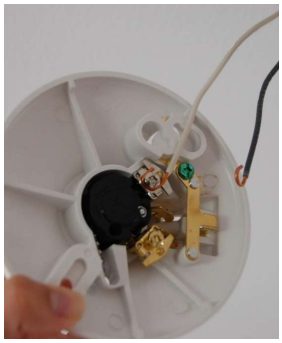
How is an electrical shock received?



- When two wires have different potential differences (voltages), current will flow if they are connected together
  - In most household wiring, the black wires are at 110 volts relative to ground
  - The white wires are at zero volts because they are connected to ground

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How is an electrical shock received?

- Electric shock occurs when the body becomes a part of the circuit. Electric shock normally occurs in one of three ways - when an individual is in contact with the ground and contacts:
  - Both wires of an electric circuit, or
  - One wire of an energized circuit and the ground, or
  - A metallic part that has become energized by contact with an energized conductor.
    - The metal parts of electric tools and machines may become energized if there is a break in the insulation of the tool or machine wiring. A worker using these tools and machines is made less vulnerable to electric shock when there is a low-resistance path from the metallic case of the tool or machine to the ground. This is done through the use of an equipment grounding conductor—a low-resistance wire that causes the unwanted current to pass directly to the ground, thereby greatly reducing the amount of current passing through the body of the person in contact with the tool or machine.

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How is an electrical shock received?

- If you come into contact with an energized (live) black wire, and you are also in contact with the white grounded wire, current will pass through your body and YOU WILL RECEIVE A SHOCK
- If you are in contact with an energized wire or any energized electrical component, and also with any grounded object, YOU WILL RECEIVE A SHOCK
- You can even receive a shock when you are not in contact with a ground
  - If you contact both wires of a 240-volt cable, YOU WILL RECEIVE A SHOCK and possibly be electrocuted

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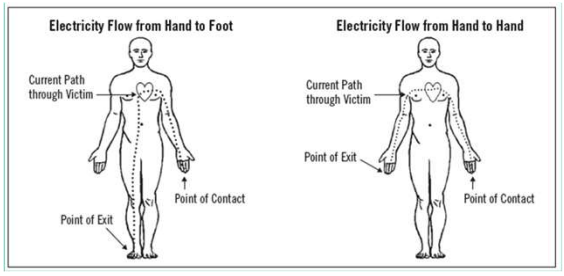

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Electrical Burns

- Most common shock-related, nonfatal injury
- Occurs when you touch electrical wiring or equipment that is improperly used or maintained
- Typically occurs on the hands
- Very serious injury that needs immediate attention

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Falls

- Electric shock can also cause indirect or secondary injuries
- Workers in elevated locations who experience a shock can fall, resulting in serious injury or death

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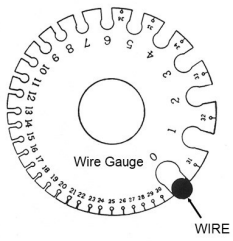
Inadequate Wiring Hazards

- A hazard exists when a conductor is too small to safely carry the current
  - *Example:* using a portable tool with an extension cord that has a wire too small for the tool
    - The tool will draw more current than the cord can handle, causing overheating and a possible fire without tripping the circuit breaker
    - The circuit breaker could be the right size for the circuit but not for the smaller-wire extension cord



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Overload Hazards

- If too many devices are plugged into a circuit, the current will heat the wires to a very high temperature, which may cause a fire

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Relocatable Power Tap or "Surge Protector"

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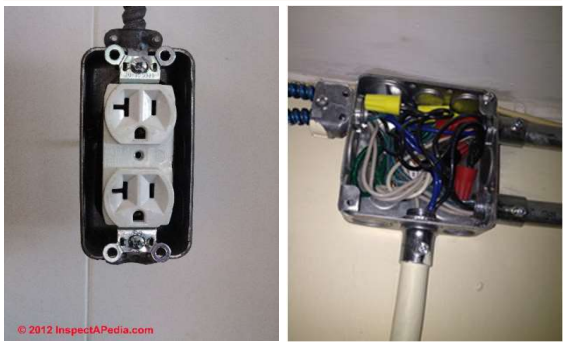
Types of Electrical Equipment



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Types of Electrical Equipment

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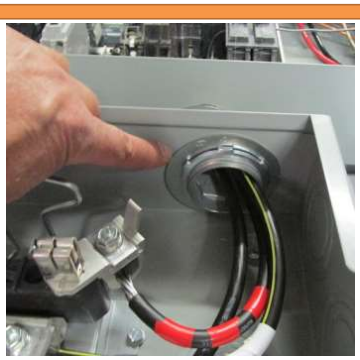

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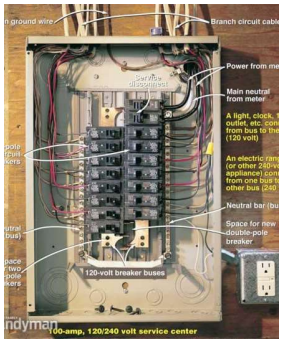

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Types of Electrical Equipment

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Types of Electrical Equipment

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Types of Electrical Equipment

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Electrical Accidents

- Caused by a combination of three factors:
  - Unsafe equipment and/or installation,
  - Workplaces made unsafe by the environment, and
  - Unsafe work practices.
- There are various ways of protecting people from the hazards caused by electricity. These include: insulation, guarding, grounding, electrical protective devices, and safe work practices.

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Electrical Protective Devices

- Fuses and circuit breakers are overcurrent devices
- These devices shut off electricity flow in the event of an overload or ground-fault in the circuit
- Include fuses, circuit breakers, and ground-fault circuit-interrupters (GFCI's)
- When there is too much current:
  - Fuses melt
  - Circuit breakers trip open
  - Basic idea of an overcurrent device is to make a weak link in the circuit

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Fuse in use

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Protective Devices (Cont.)

- Fuses: Link, plug, or cartridge; using the wrong kind can lead to injury. Over-fusing is a cause of overheating and may cause fires.
- Circuit Breakers
  - Used in high-voltage circuits with large current capacities. There are two kinds:
    - Thermal: operates on basis of increased temperature
    - Magnetic: operates on amount of current that passes through the circuit
      - Recommended device
      - Increased temperature requires overrating circuit breaker

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Ground-Fault Circuit Interrupter

- The GFCI detects a difference in current between the black and white circuit wires
  - Continually matches the amount of current going to an electrical device against the amount of current returning from the device along the electrical path
- This could happen when electrical equipment is not working correctly, causing current "leakage" – known as a *ground fault.*

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GFCI

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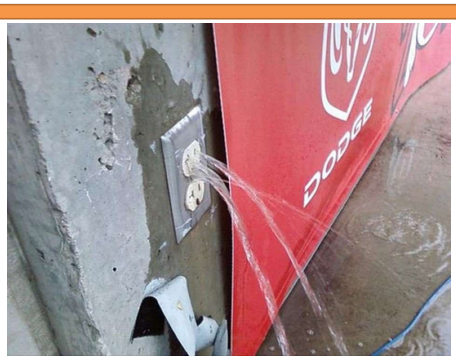
Moisture is not always outside the outlet



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Grounding

- Grounding is a physical connection to the earth, which is at zero volts.
- Hazards
  - Some of the most frequently violated OSHA standards
  - Metal parts of an electrical wiring system that we touch (switch plates, ceiling light fixtures, conduit, etc.) should be at zero volts relative to ground
  - Housings of motors, appliances or tools that are plugged into improperly grounded circuits may become energized
  - If you come into contact with an improperly grounded electrical device, YOU WILL BE SHOCKED

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Overhead Powerline Hazards

- Most people don't realize that overhead powerlines are usually not insulated
- Do not use metal ladders – instead, use fiberglass ladders
- Beware of powerlines when you work with ladders and scaffolding
- Powerline workers need special training and personal protective equipment (PPE) to work safely

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