Lab Electrical Safety

Electrical Basics for Safety

2022

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UCR Environmental Health & Safety

Electrical Safety

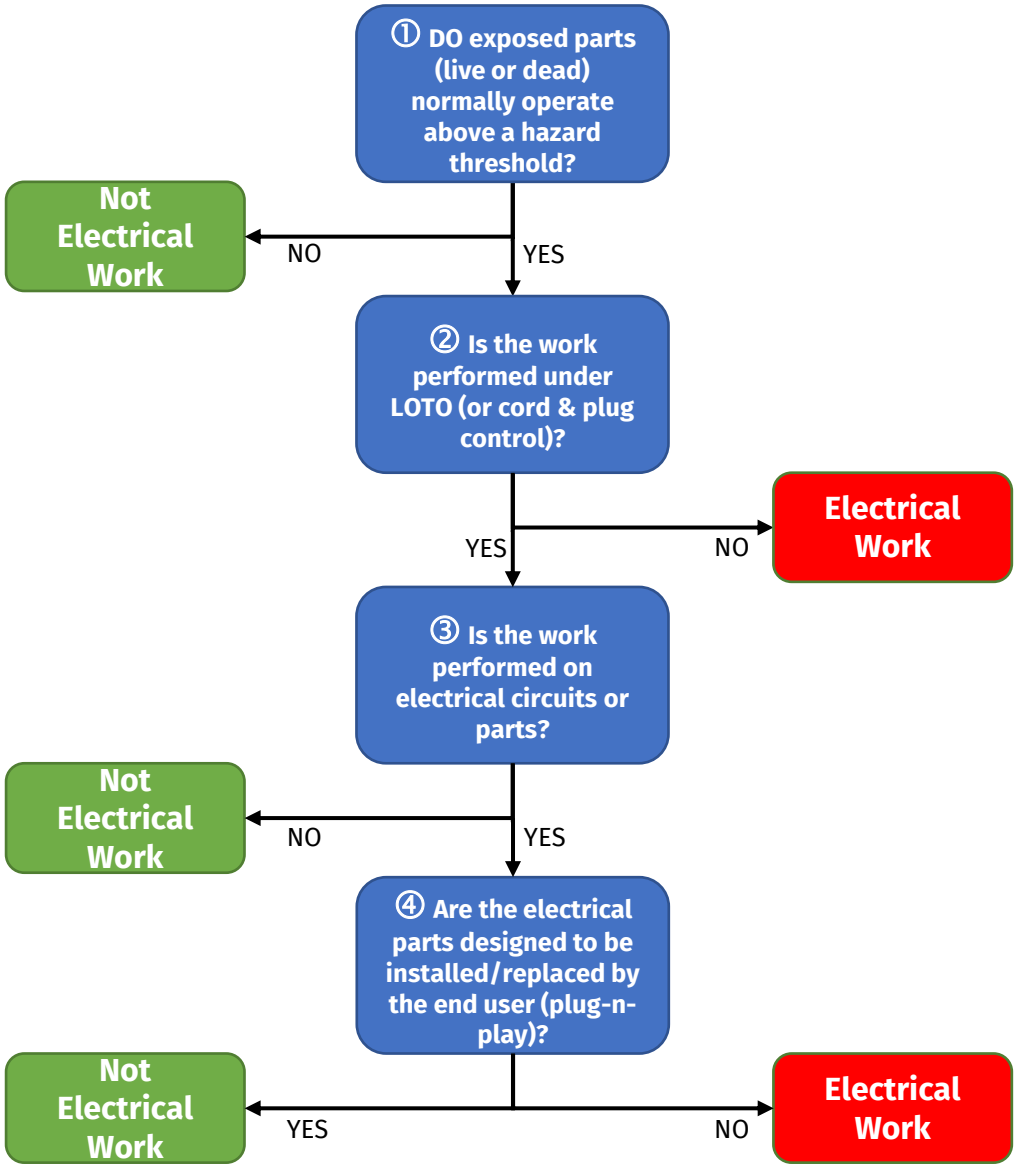
Only qualified persons are allowed to work on equipment above the hazard threshold

Electrical Hazard Thresholds

Source	Includes	Thresholds
AC	50-60 Hz nominal	≥ 50 V and ≥ 5 mA
DC	All	≥ 100 V and ≥ 40 mA
Capacitors	All	≥ 100 V and ≥ 10 J
Batteries	All	≥ 100 V
Sub-RF	1 Hz to 3 kHz	≥ 50 V and ≥ 5 mA
RF	3 kHz to 100 MHz	A func of frequency

Electrical Work

What is “electrical work”?



Electrical Hazard Thresholds

Source	Includes	Thresholds
AC	50-60 Hz nominal	≥ 50 V and ≥ 5 mA
DC	All	≥ 100 V and ≥ 40 mA
Capacitors	All	≥ 100 V and ≥ 10 J
Batteries	All	≥ 100 V
Sub-RF	1 Hz to 3 kHz	≥ 50 V and ≥ 5 mA
RF	3 kHz to 100 MHz	A func of frequency

Examples

Not Electrical Work

Changing a cartridge fuse (plug-and-play)

Electrical Work

Wiring up a new plug

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Hazard Assessment

1. **Electric Shock** – occurs when the body becomes part of a circuit either between hot/electrified part and neutral or ground
2. **Arc Flash** – Current passes through air between ungrounded conductors and grounded conductors or ground.
3. **Arc Blast** – tremendous temperatures of the arc cause explosive expansion of the surrounding metal and air in the arc path.

Hazards of Electricity

Hazards of Electricity

Assuming 1 second of hand to foot exposure to 120 volt, 60 cycle AC supply power…

Current	Reaction
1 mA	Perception
5 mA	Slight shock felt; not painful but disturbing
6-30 mA	Painful shock; "let-go" range
50-150 mA	Extreme pain, respiratory arrest, severe muscular contraction
1,000-4,300 mA	Ventricular fibrillation
10,000+ mA	Cardiac arrest, severe burns and probable death

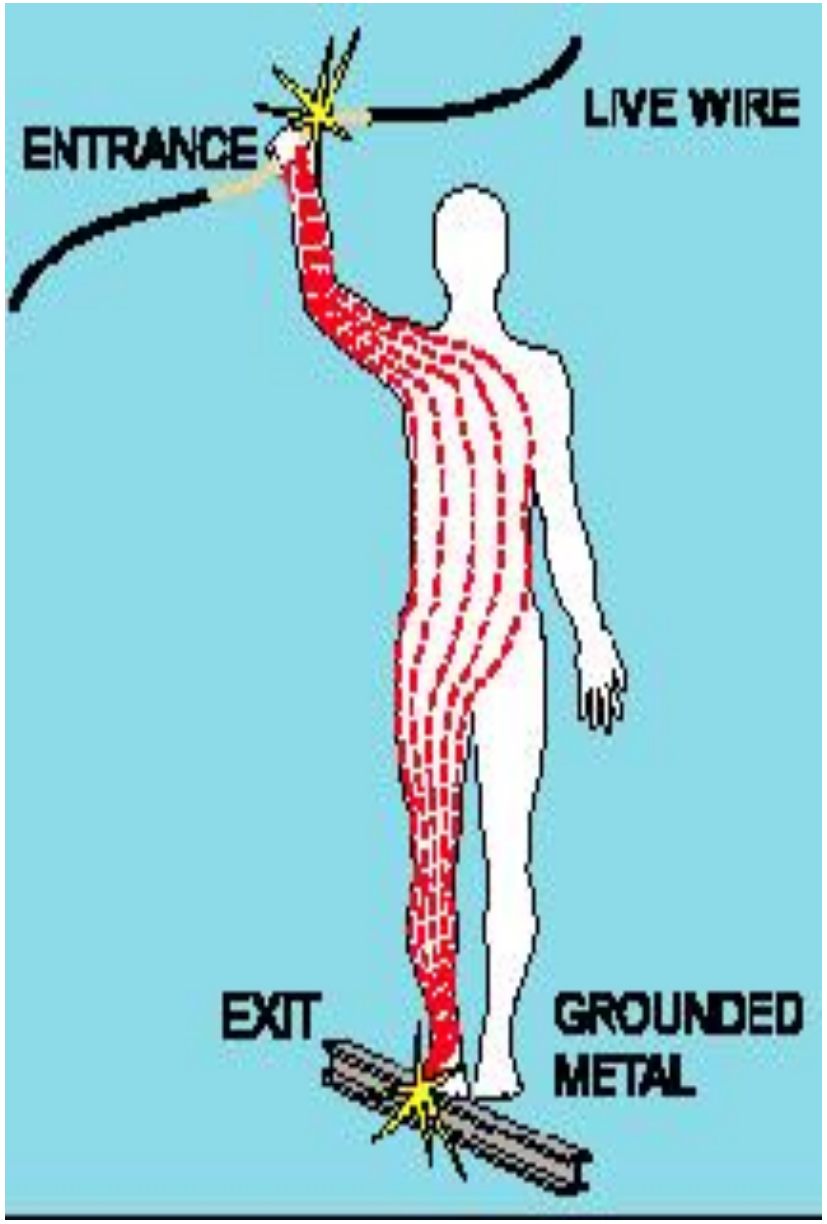
Laboratory wall outlets provide 20,000 mA !!

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**



Group Activity:

In your table group,
work together to
determine how to Respond
to Major Electric Shock

How to Respond to Major Electric Shock

1.- Do not touch the victim. Look for the hazard.

2.- Shut off the power if it is safe to do so.

3.- Call 9-1-1 for assistance.

4.- If power cannot be switched off, do not touch the victim directly. If there is a piece of wood or confirmed non-conductive item nearby it can be used to attempt to knock the victim away from the power source.

5.- If victim is free from hazard and it is safe, get the AED and connect it to the victim. Begin CPR if you have training.

6.- Block off the area and do not re-enter until EH&S and Facilities Services has released the area.

7.- Report the shock to EH&S through the "Report an Incident, Injury, or Safety Concern" online form at ehs.ucr.edu

Qualified Electrical Worker

Qualified Electrical Worker - QEW

One who has demonstrated skills and knowledge related to the construction and operation of the electrical equipment and installations and has received safety training to identify the hazards and reduce the associated risk (NFPA 70E-2018).

At UCR, we call this a Qualified Electrical Worker (QEW), and add the requirement for approval by Environmental Health & Safety.

Exception under QEW supervision

Personnel are not required to be QEWs for electrical work if:

- **A QEW provides direct field supervision**, and
- Personnel are trained and authorized to perform the work on that specific equipment, and
- (A) Cord-and-plug or (B)hard-wired requirements are followed

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Exception under QEW supervision

(A)Cord-and-plug:

- The equipment is unplugged and under continuous and exclusive control.
- Equipment meets the cord-and-plug exemption to LOTO (no stored energy).

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Exception under QEW supervision

(B)Hard-wired:

- A QEW establishes an Electrically Safe Work Condition.
- All persons join the LOTO.
- QEW performs test before touching every time job continuity is interrupted.

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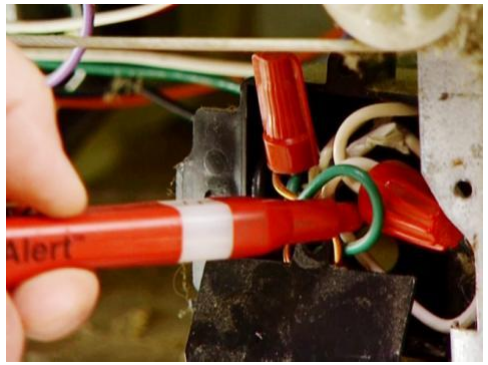
Electrical Work

Electrical Work

All electrical over 50 volts AC and 100 volts DC must be guarded against accidental contact.

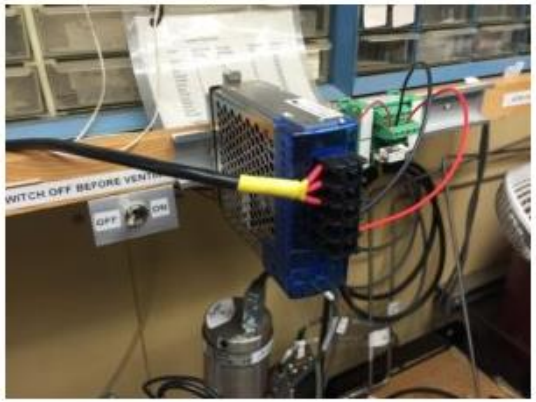
ALWAYS de-energize equipment before exposing wiring or working on it.

Non-contact voltage detector

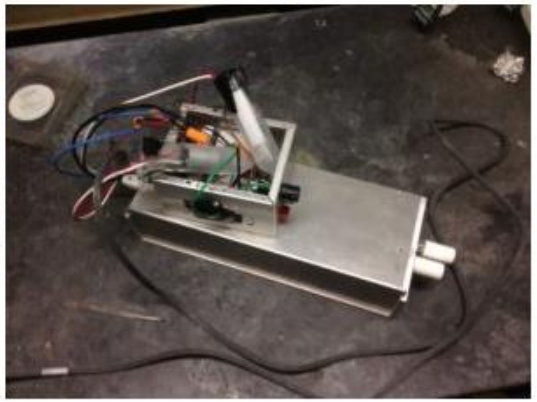


Open Panels

Broken receptacles



Unguarded parts

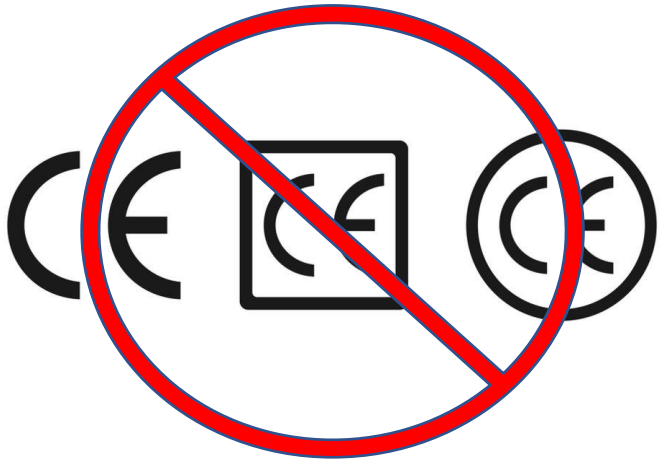


Open equipment

Electrical Hazards – Listed Equipment

All laboratory equipment ***must*** be listed by a nationally recognized testing laboratory (NRTL) accepted by the California State Fire Marshal.

- Any non-listed equipment must pass inspection prior to use. Contact EH&S for inspection.
- In some cases, a 3rd party review may be required to ensure the equipment is safe for use in the lab.
- Products from other countries will need to be inspected and may not be approved for use at UCR.



Inspect All Electrical Equipment Before Use

- Damaged wires or plugs
- Signs of electrical hazards
- Overheating
- Smoke
- Sparks

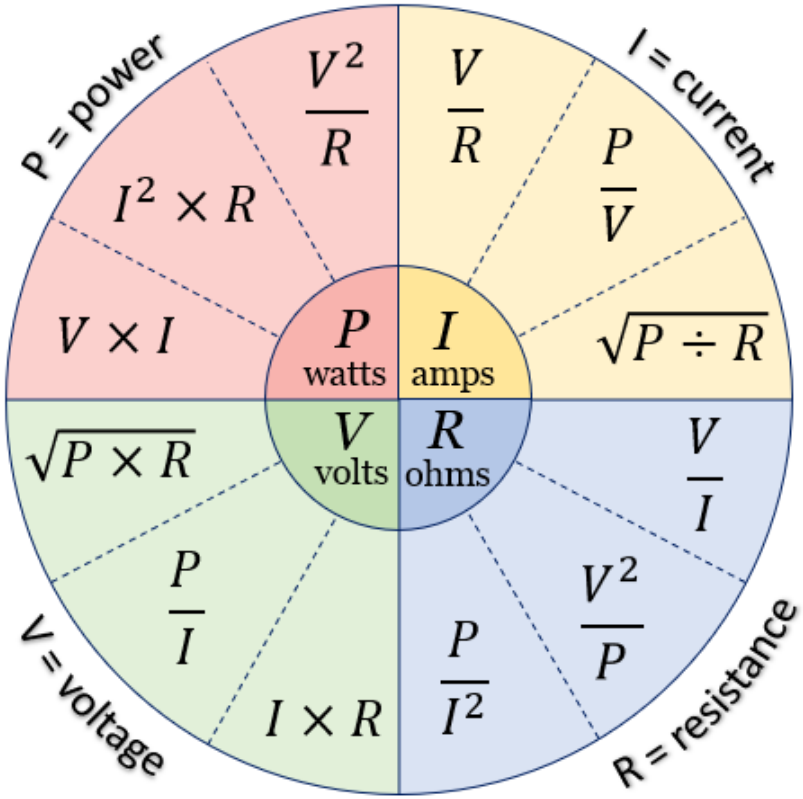
Relationship between power, current, voltage and resistance:

P = power (watts)
I = current (amperes)
V = voltage (volts)
R = resistance (ohms)

$$V = I \times R$$

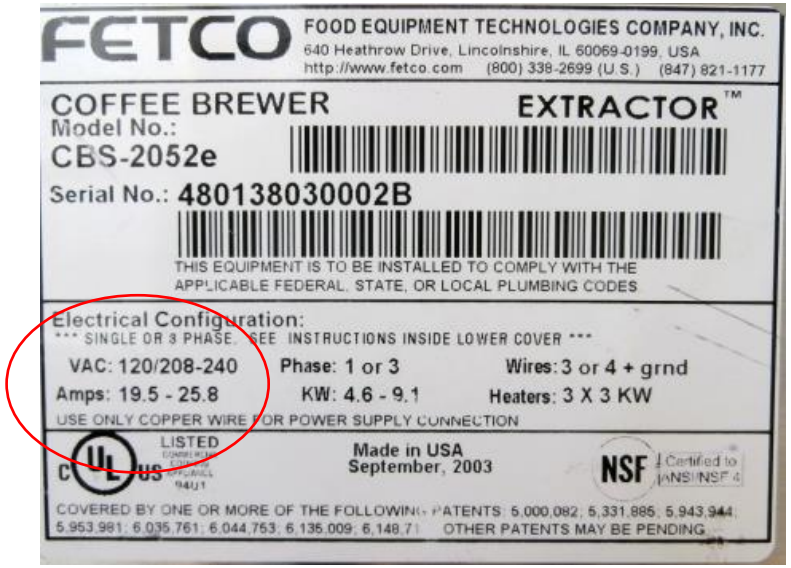
$$P = I \times V$$

$$P = I^2 \times R$$



[Ohm's Law]

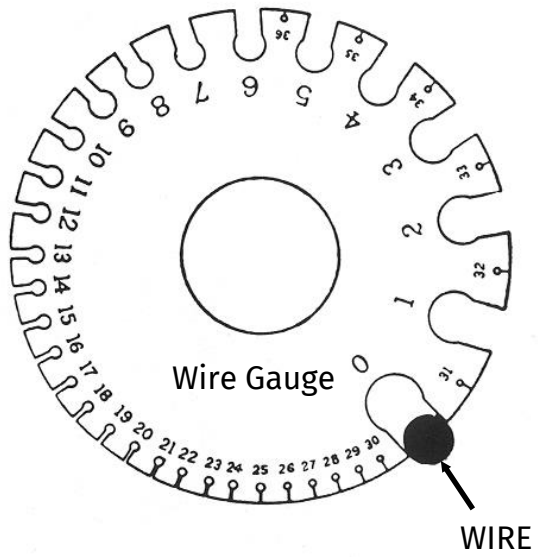
Example:
Heating tape uses 5 amps at 120 volts. Power dissipated by this device is 600 watts.

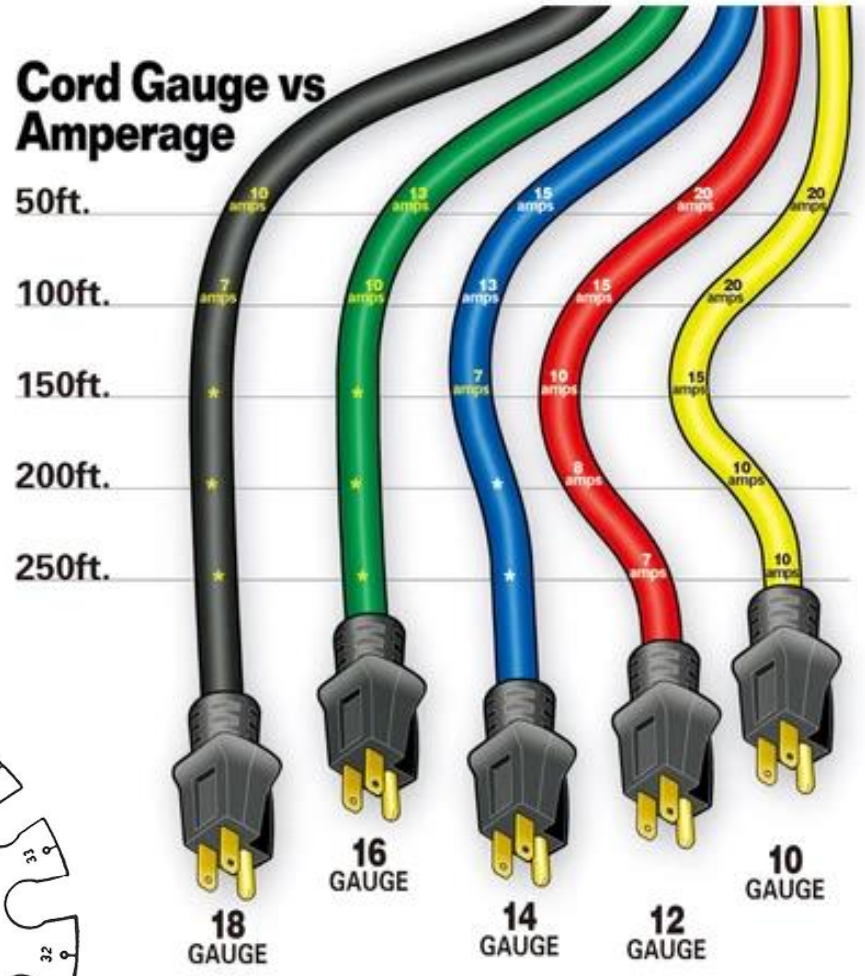


Hazards of Electrical Work

Electrical Hazards - Wiring Hazards

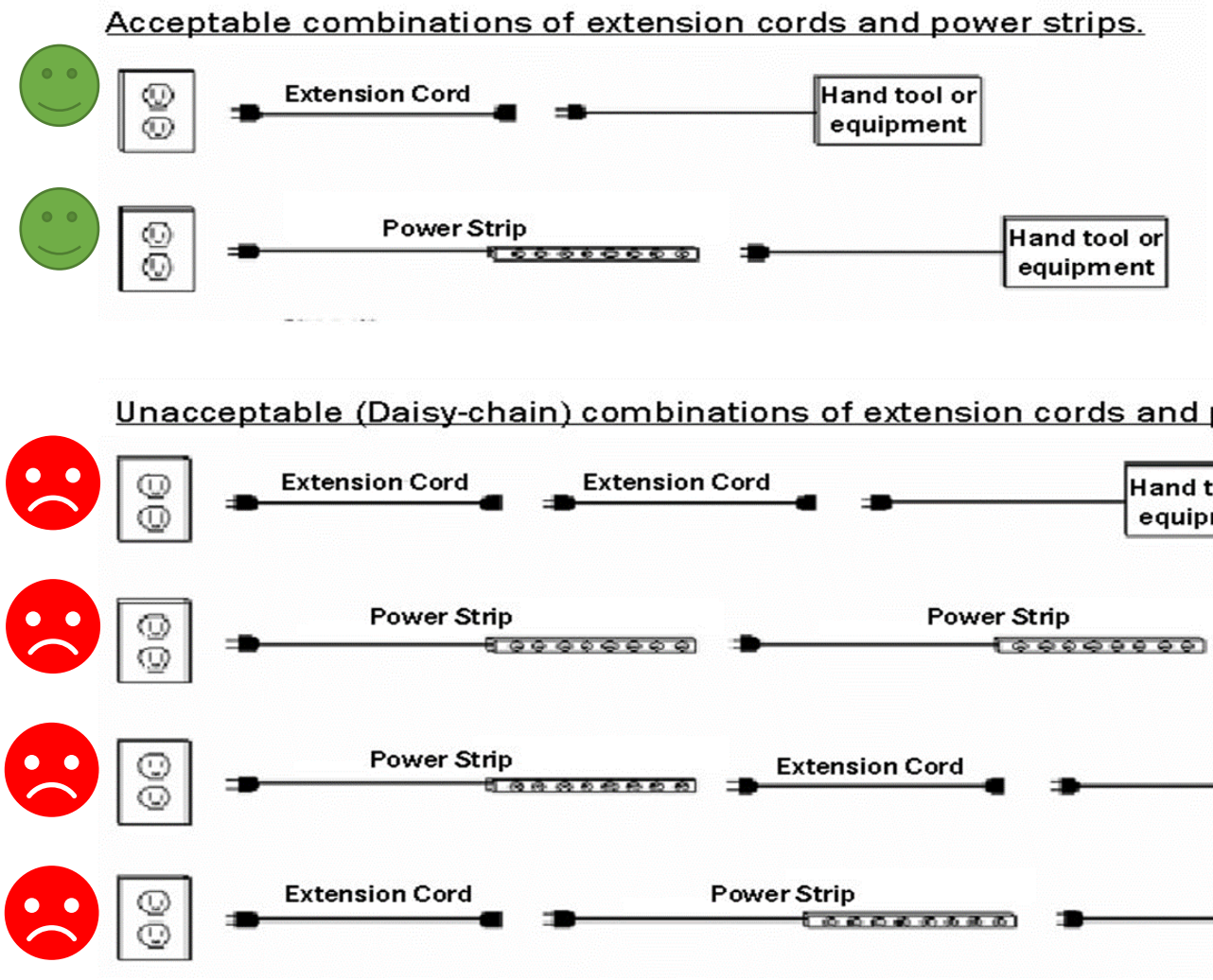
- A hazard exists when a conductor is too small to safely carry the current.
  - If the wire insulation melts, arcing may occur and cause a fire in the area where the overload exists, even inside a wall
- Equipment with an extension cord that has a wire too small for the amperage draw
  - The equipment will draw more current than the cord can handle
  - It can overheat without tripping the circuit breaker
  - The circuit breaker could be the right size for the circuit but not for the smaller-wire extension cord

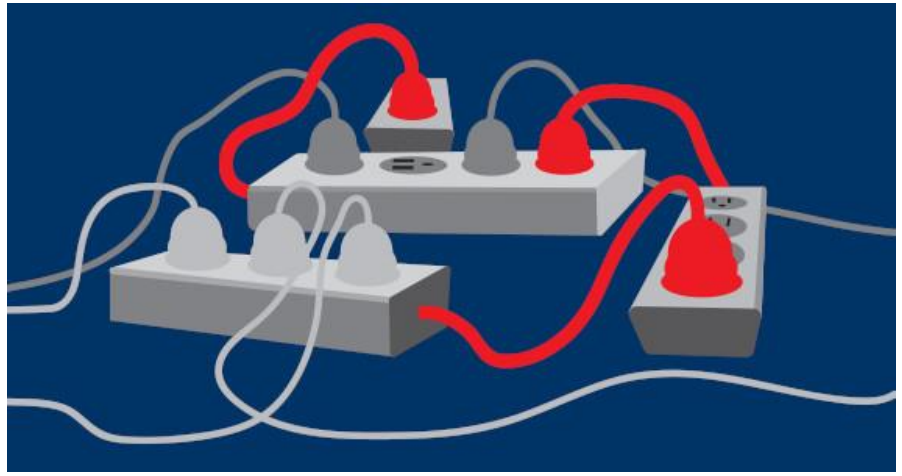




Wire gauge measures wires ranging in size from number 36 to 0 American wire gauge (AWG)

Electrical Hazards - Extension Cords and Power Strips





Electrical Hazards - Overloading

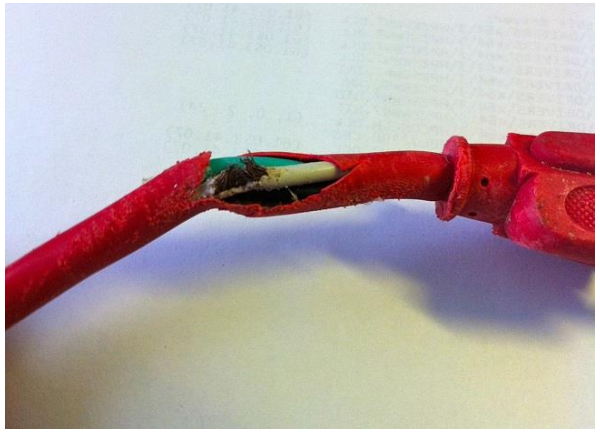
Power strips cannot be attached in any way that requires a tool to remove it.

There are key holes on the back for hanging on screws.

You can use Velcro or ties to attach but not plastic cable ties

Electrical Hazards - Extension Cords

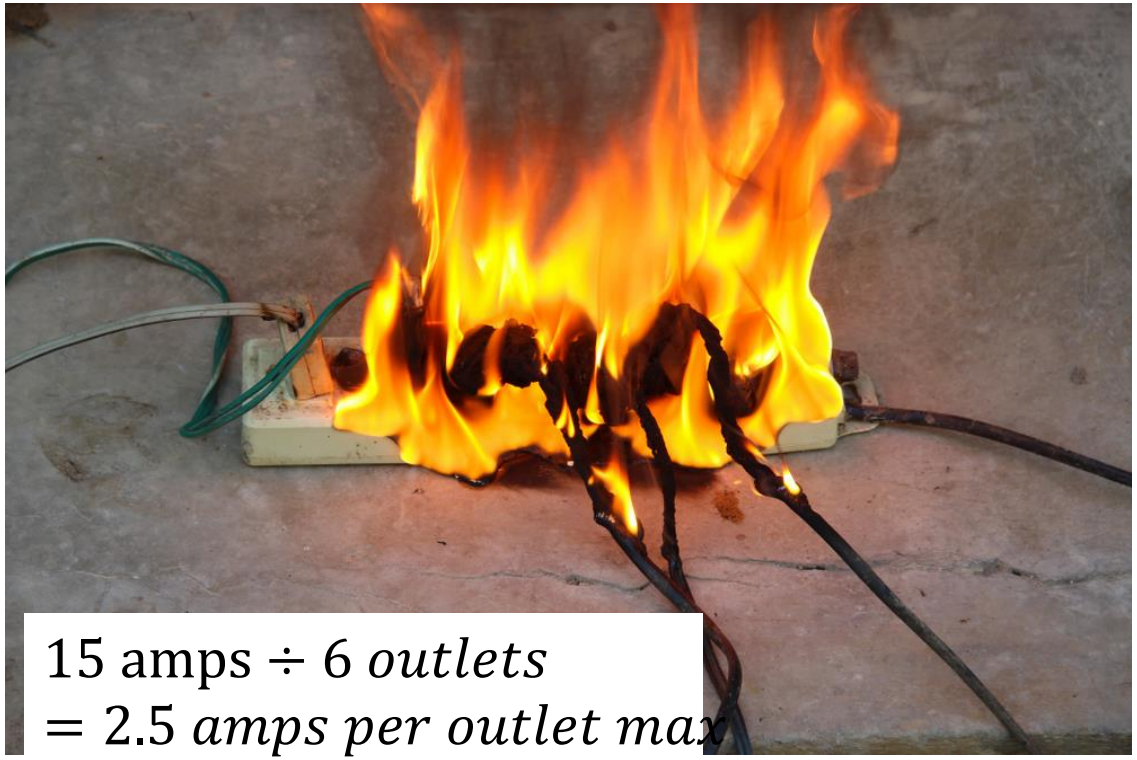
- Extension cords must be visually inspected before each use on any shift. Examine the cord for
  - Damaged other jacket (tear in insulation)
  - Possible internal damage (pinched cord)
  - Missing grounding pin

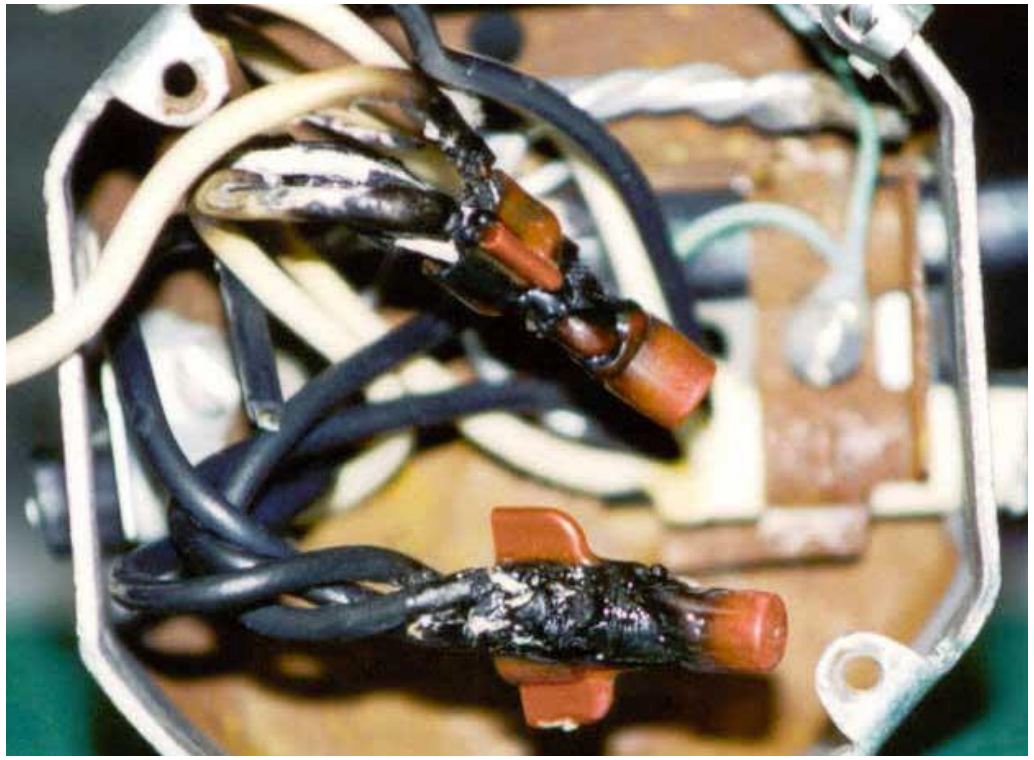


Do Not Overload Power Strips

Electrical Fires

Electrical fires can occur with little to no warning

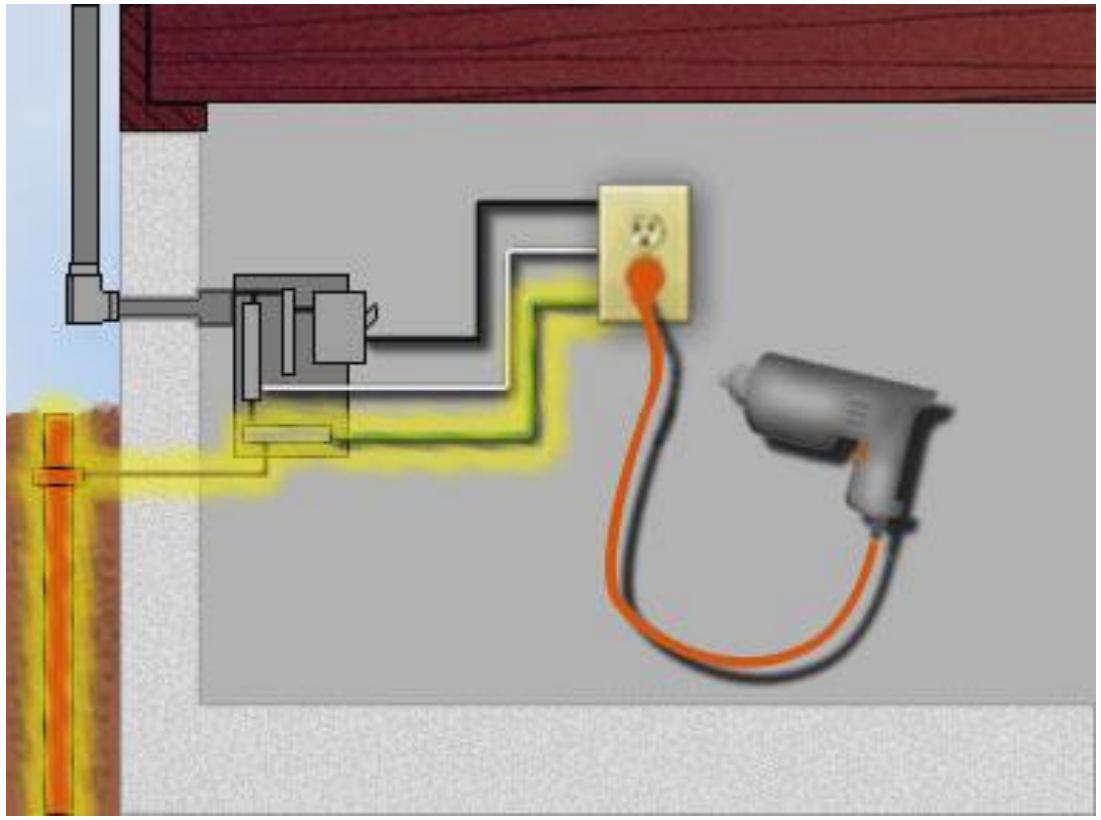


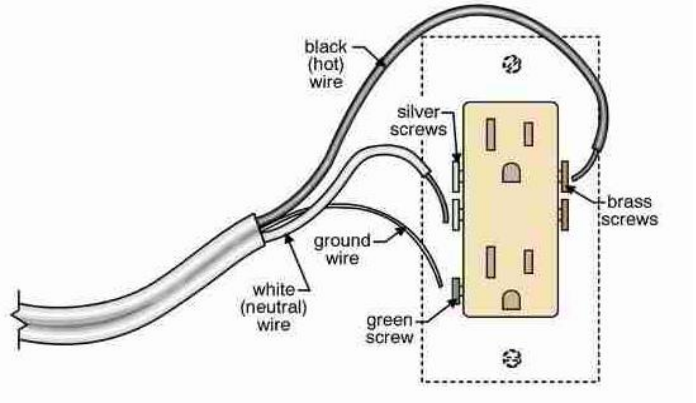


Electrical Protections

Grounding

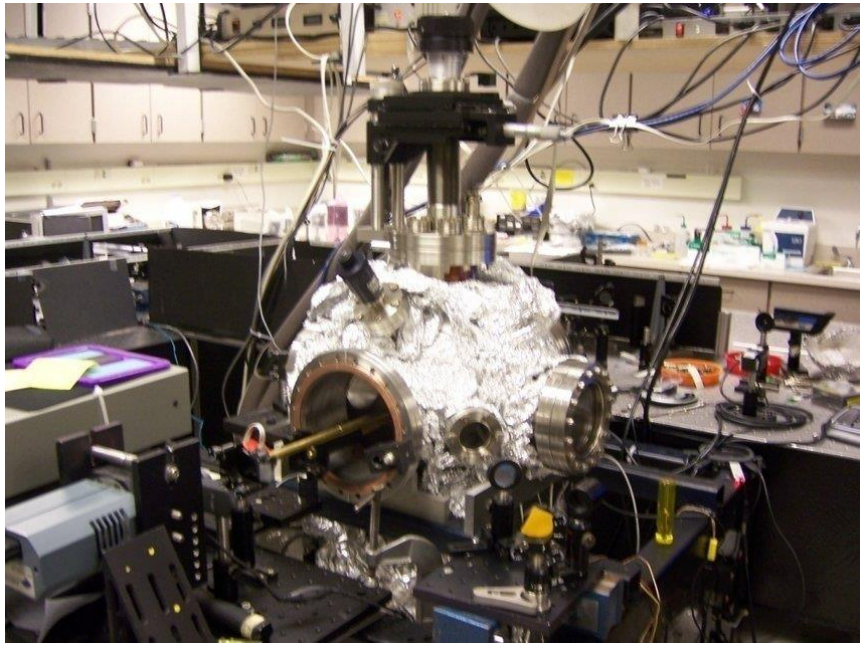
- The "ground" wire is a safety wire that has intentionally been connected to earth.
  - The grounding wire does not carry electricity under normal circuit operations.
  - It's purpose is to carry electrical current only under short circuit or other conditions that would be potentially dangerous.
  - Grounding wires serve as an alternate path for the current to flow back to the source, rather than go through anyone touching a dangerous appliance or electrical box.

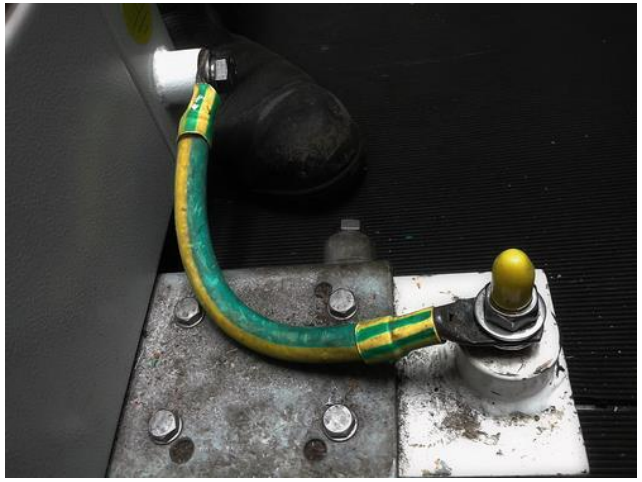


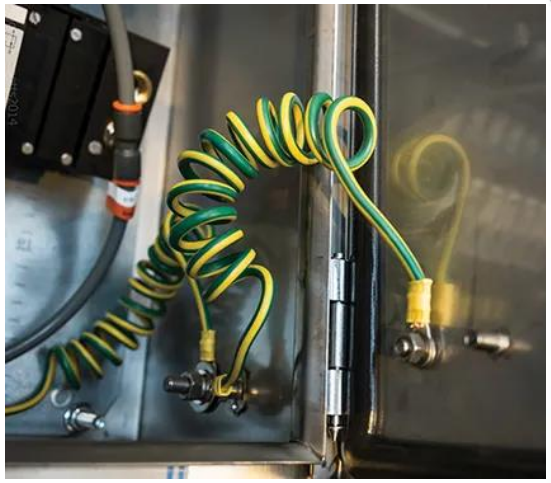


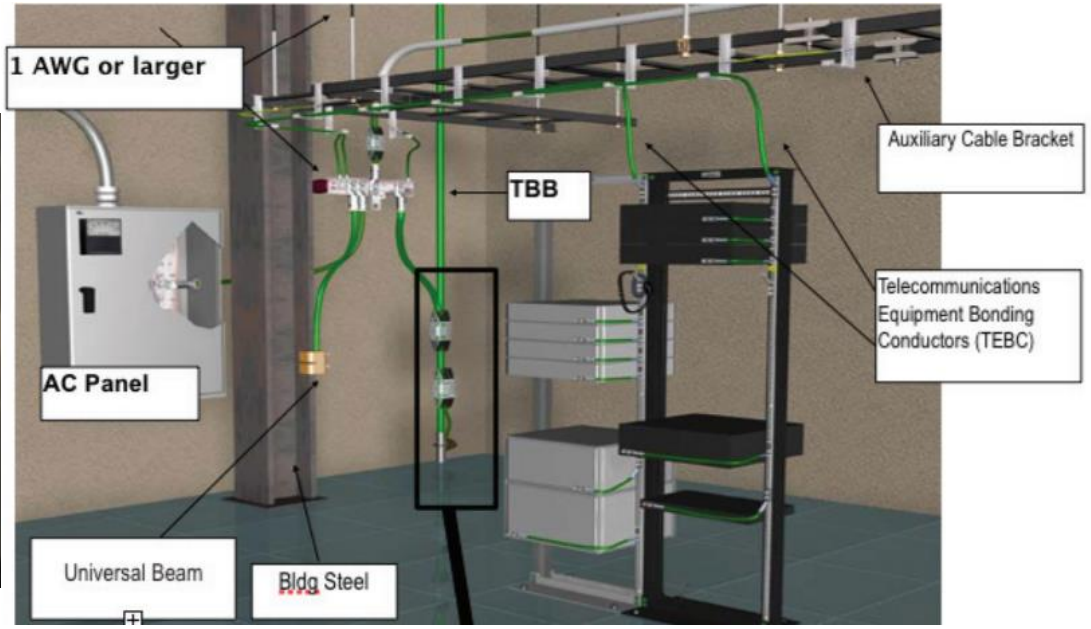
Grounding cont…

- Custom equipment housings and conductive support structures must be grounded.
- Most purchased equipment is grounded or insulated but some will have a place to attach a ground.



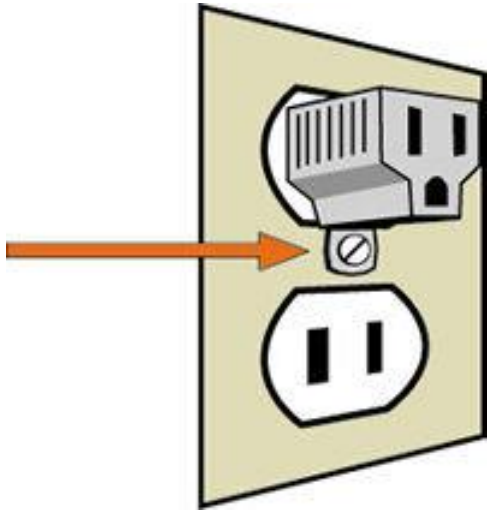




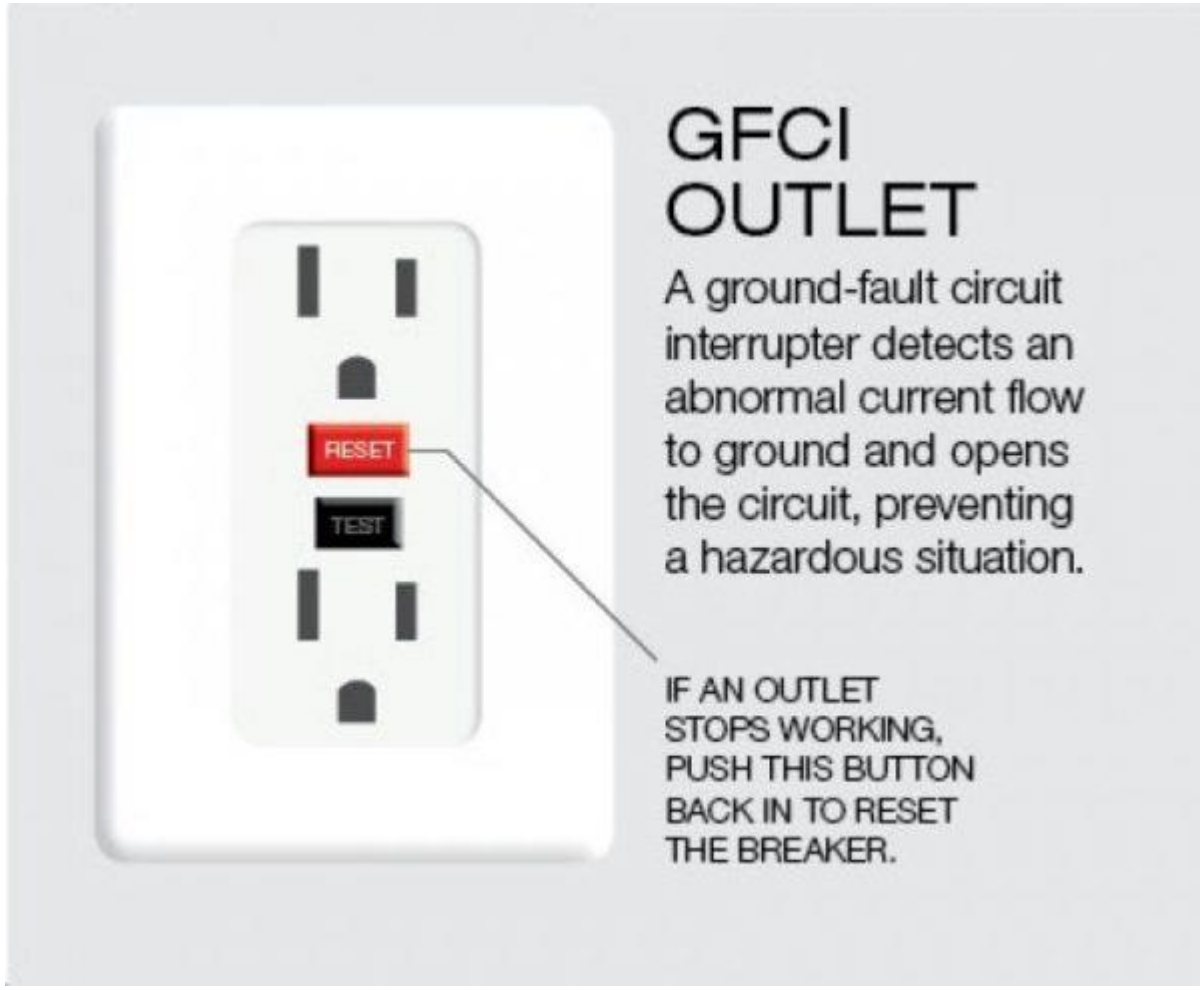


Grounding cont…

Do not use an adapter or extension cord to defeat a standard grounding device. (e.g., only place three-prong plugs in three-prong outlets; do not alter them to fit in a two-prong outlet). No ground lifters.



Ground-Fault Circuit Interrupter



Overcurrent Devices

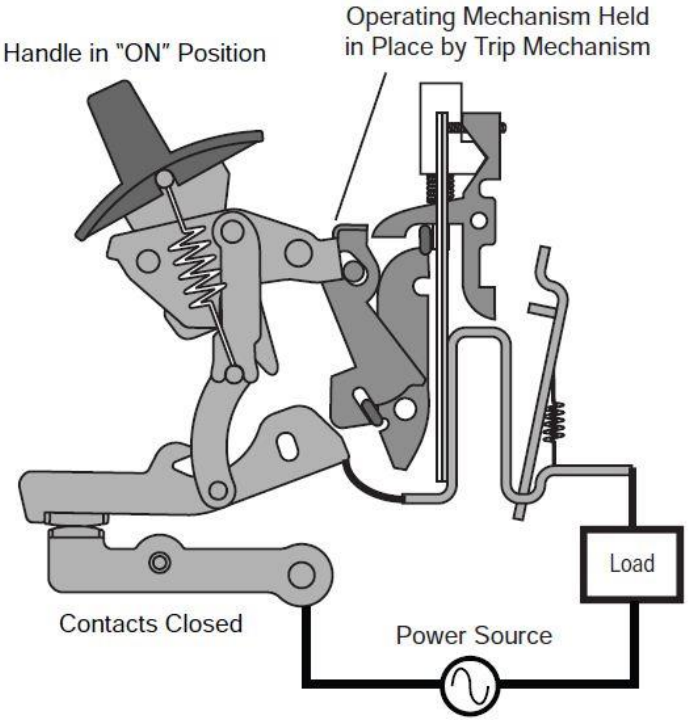
Disconnects electrical flow in the event of an overload or ground-fault in the circuit

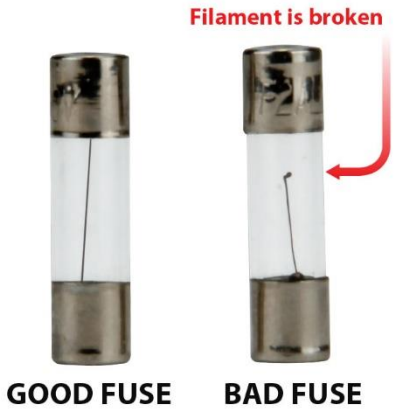
- Fuses
- Circuit breakers
- Ground Fault Circuit Interrupters (GFCIs)

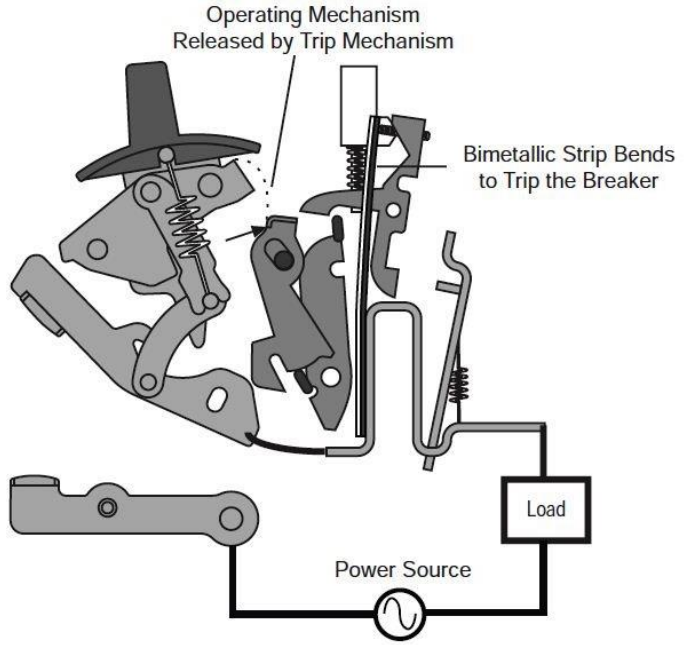
Fuses and circuit breakers are **overcurrent** devices

Overcurrent Devices cont…

- *Circuit Breakers and Fuses*
  - Provided to protect EQUIPMENT not people
  - Do not reset breakers with a line voltage higher than 120V and only reset if you know why it tripped
  - Circuit breakers and fuses should be sized 125% of the continuous load. (If max load is 12 amps then the correct fuse/breaker is 15 amps)

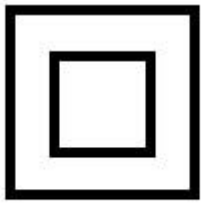




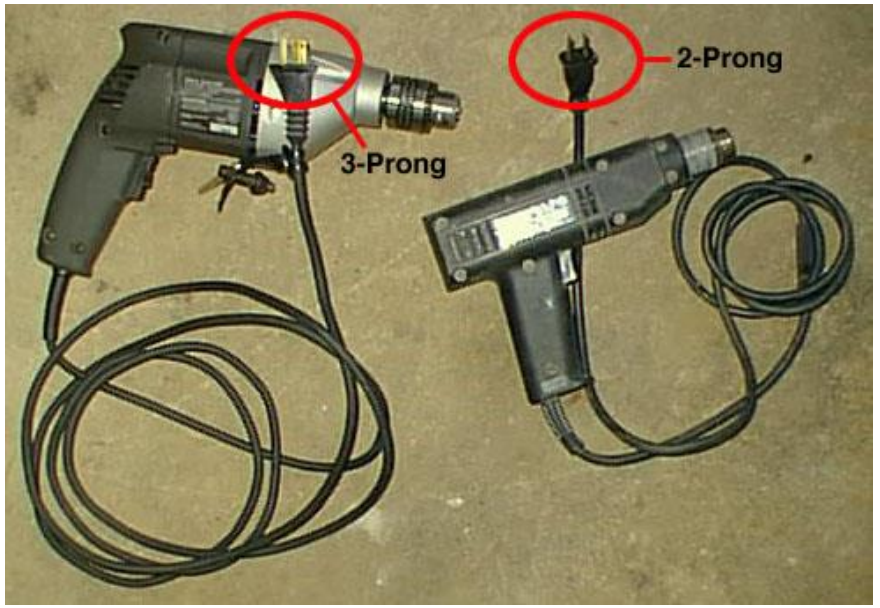


Double Insulation

- 2 prong plug
- Double insulated symbol on label
- Two levels of insulating materials the electrical parts of the appliance and any parts on the outside that you touch.



Double insulated symbol

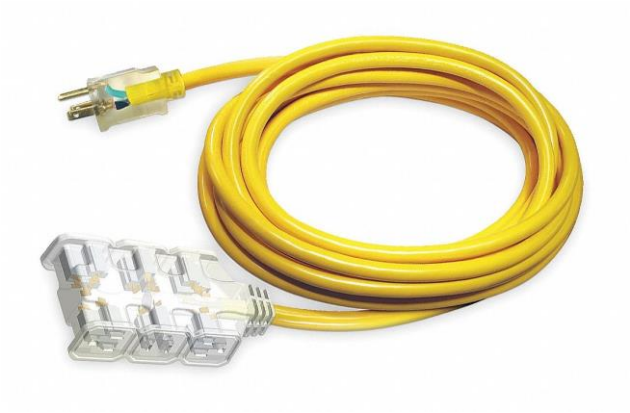


Lockout/ Tag Out

Lockout/Tag Out should be used to prevent someone from energizing a system that is being worked on or is in an unfinished state.

Everyone working on or near electricity should take Lockout/Tag Out training in the UCR Learn Center.

Cool electrical helpers



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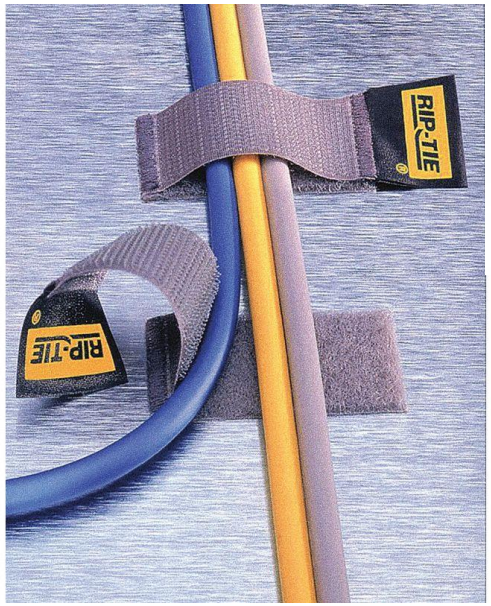
Cool electrical helpers



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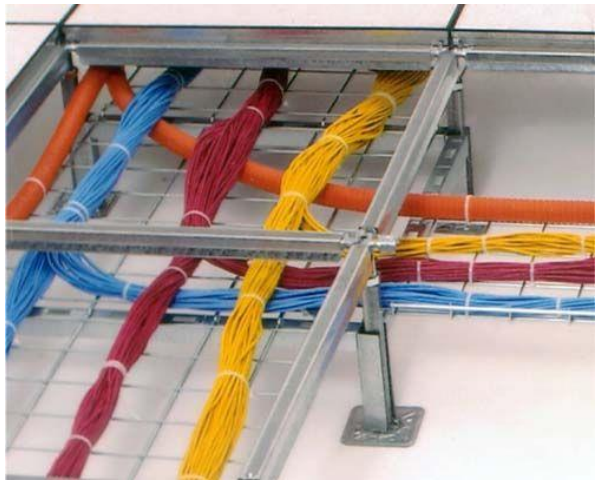
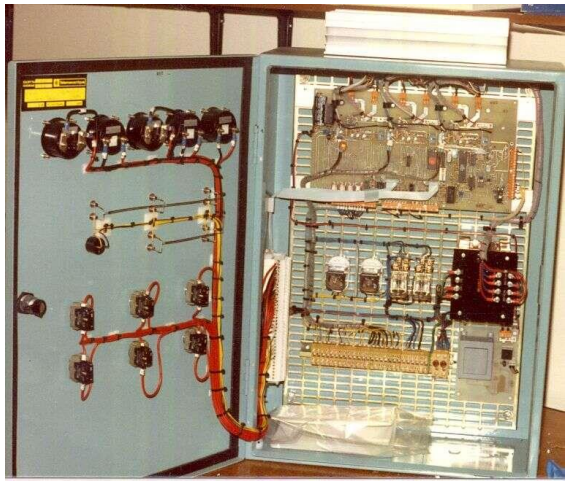
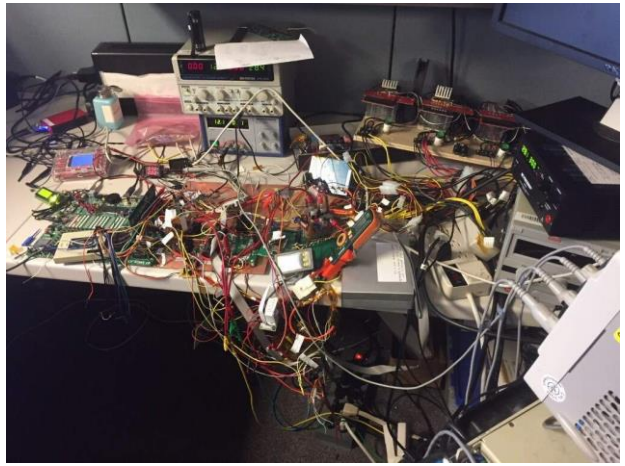
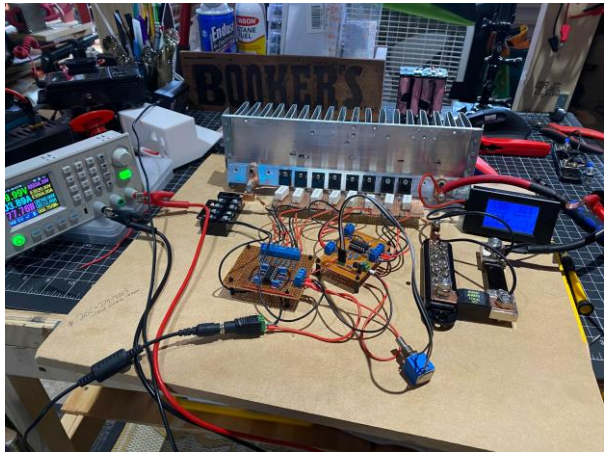
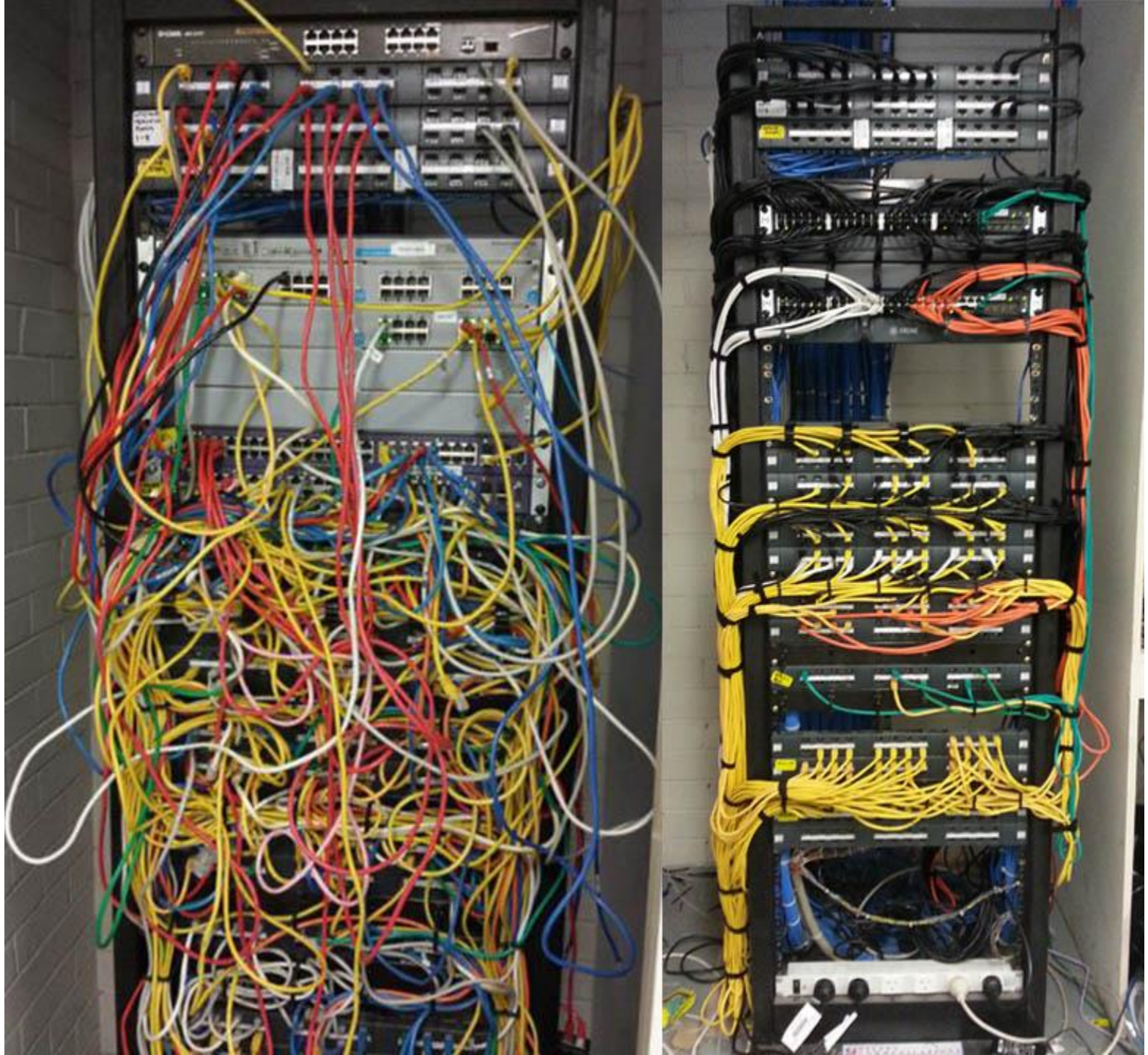







BOOKER'S

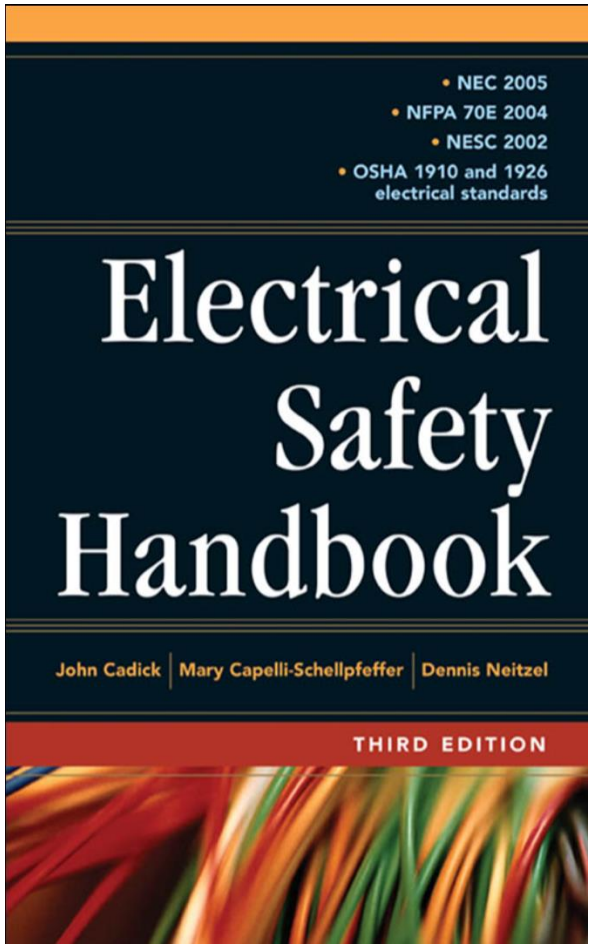


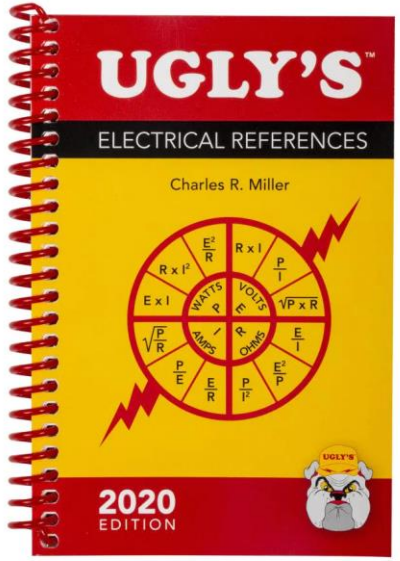
Batteries

- Proper ventilation is required
- Wear PPE when handling batteries – Apron, goggles, face shield, gloves, etc.
- Fire extinguisher should be near every charging area
- Emergency Eyewash and Shower is required near charging areas for lead-acid batteries
- Lithium-ion batteries should be charged in a fireproof case also known as a Lipo sack or Lipo safe.
- Non-conductive or insulated tools are recommended.

- Do not over charge. Use a charger with a protection circuit.
- Keep out of direct sunlight.
- All batteries must be either returned to the vendor or disposed of through UCR hazardous waste. Do not ever put them in a dumpster.

Reference Guides





Battery University
https://batteryuniversity.com/

MIT EHS Lithium-ion Battery Safety
https://ehs.mit.edu/lab-research-program/lithium-ion-battery-safety/

Berkeley Lab Electrical Safety
https://electricalsafety.lbl.gov/

Cal/OSHA Guide to Electrical Safety
https://www.dir.ca.gov/dosh/dosh_publications/Electrical_Safety.pdf

Electrical Safety Foundation International
https://www.esfi.org/

Electrical Technology
https://www.electricaltechnology.org/

Resources

I need help doing a risk assessment for my project?

- Discuss with your PI
- Contact EH&S for assistance

I need to additional outlets, breakers, panels, or different voltage?

- Discuss with your PI
- Submit a work order to Facilities Services for assistance.
- Contact EH&S for assistance.

Outlets/cords are not working or are broken, breakers have tripped, or you notice a burning smell or smoke coming from an electrical appliance?

- De-energize equipment in question.
- Discuss with your PI
- Submit a work order to Facilities Services for assistance.
- Contact EH&S for assistance

Facilities Services Service Requests: https://facilities.ucr.edu/requests

EH&S: https://ehs.ucr.edu/

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Electrical Safety Guidelines

- ✓ Be familiar with the electrical hazards associated with your work area.
- ✓ Unplug electrical equipment before repairing or servicing it.
- ✓ If a prong breaks off inside an outlet, do not attempt to remove it yourself. Call Facilities Services for assistance.
- ✓ Ensure that outlets are firmly mounted. Report loose outlets to Facilities Services.
- ✓ Report all electrical problems, including tripped breakers, broken switches, and flickering lights, to Facilities Services.
- ✓ Keep electrical equipment away from water, unless the appliance is specifically designed for use around water, such as a wet-dry shop vacuum.

Electrical Plug and Cord Safety Guidelines

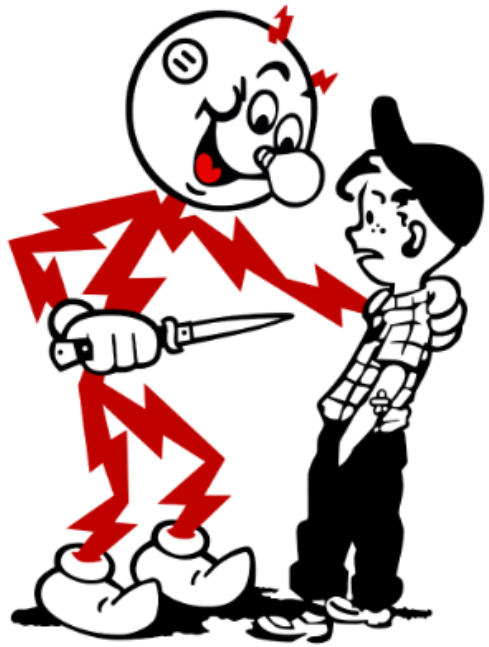
- ✓Use extension cords only when necessary and only on a temporary basis. Do not use extension cords in place of permanent wiring. Request new outlets if your work requires equipment in an area without an outlet.

- ✓Use extension cords that are the correct size or rating for the equipment in use. The diameter of the extension cord should be the same or greater than the cord of the equipment in use.

- ✓Do not run electrical cords above ceiling tiles or through walls, windows, or doors.

- ✓Discard damaged cords, cords that become hot, or cords with exposed wiring.

Do not underestimate of electricity.



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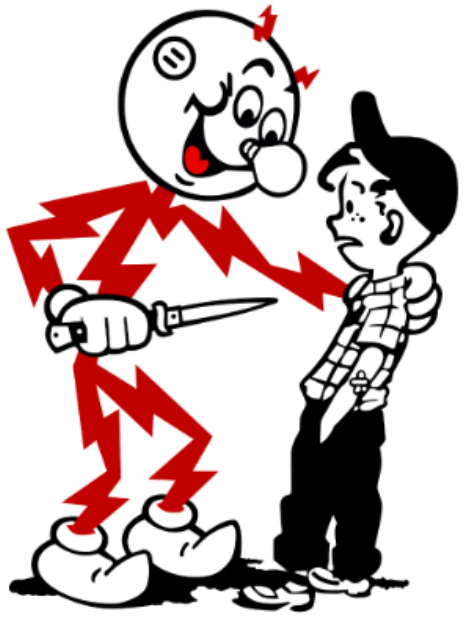

REMEMBER KIDS,
ELECTRICITY WILL KILL YOU!

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