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Electrical Safety

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Electricity can be dangerous!

- The hazards include
  - Shock
  - Fires
  - Explosions
  - Arc Flash
  - Arc Blast

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Electrical Basics

Current is the movement of negatively charged particles called electrons (measured in mA or A)

Resistance is the opposition to the flow of electrons (measured in ohms, Ω)

Voltage is the pushing force for electrons to move them (sometimes called electromotive force)

Conductors are materials that allow the flow of electrons easily (metals)

Insulators are materials that don't allow or have a high resistance to flow of electrons (rubber)

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Electrical Basics

- Two types of current
- DC (direct current) is a constant voltage source, like a battery
- AC (alternating current) is a sinusoidal waveform, like what comes out of your wall
  - In industry, there is 3 phase AC power
  - In your home there is single phase AC power

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Electrical Power

- Power is measured in Watts (W) and is the measure of the rate at which energy is used in a circuit
- It is the value of voltage times current

- $P = I*V$

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Electrical Shock vs Electrocution

Electrical shock occurs when a person becomes part of the current path. Current will flow through the person on its path back to the circuit or to ground

Electrocution occurs when someone dies as a result of an electrical shock

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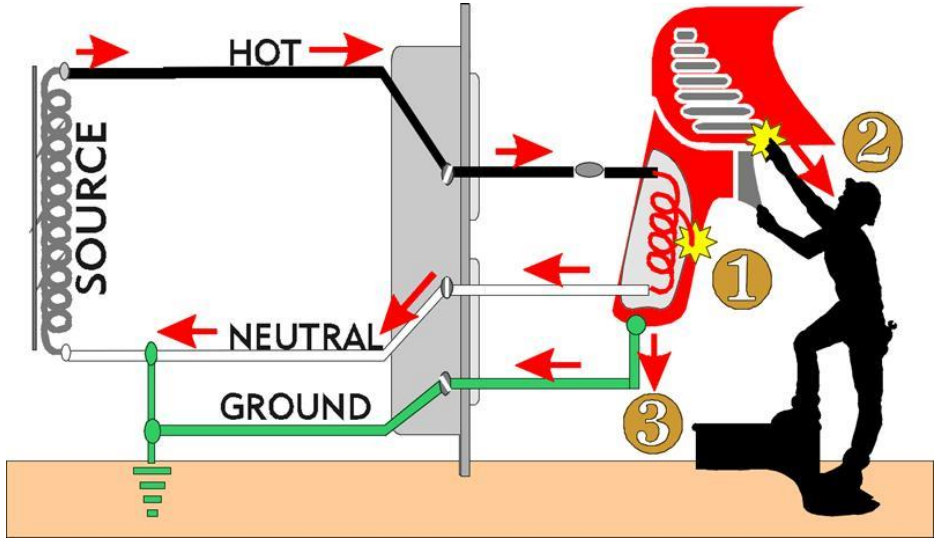
A person can become part of the circuit when…

- They come into contact with both conductors
- They come into contact with the hot conductor and ground (A ground is a low resistance path into the earth)
- A person has to become part of the circuit to receive a shock



Its not the ***voltage*** that will kill you, it's the ***current***!

Current	Reaction
< 1 mA	Generally non perceptible
1 mA	Faint Tingle
5 mA	Slight shock felt, usually not painful but perceptible
6 to 25 mA	Painful shock, possible loss of muscle control
9 to 30 mA	Cannot let go. Complete loss of muscle control. Person might be thrown back from power source
50 to 150 mA	Extreme pain, respiratory arrest and severe muscle reactions. Death is possible
1 to 4.3 A	Heart rhythm is disrupted and nerve damage likely
10 A	Cardiac arrest, severe burns and death

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Severity of Shock depends on a few things

- The amount of current
- Path through the body
- Duration of exposure
- Other personal attributes and environmental factors including if PPE was worn and the amount of resistance someone has

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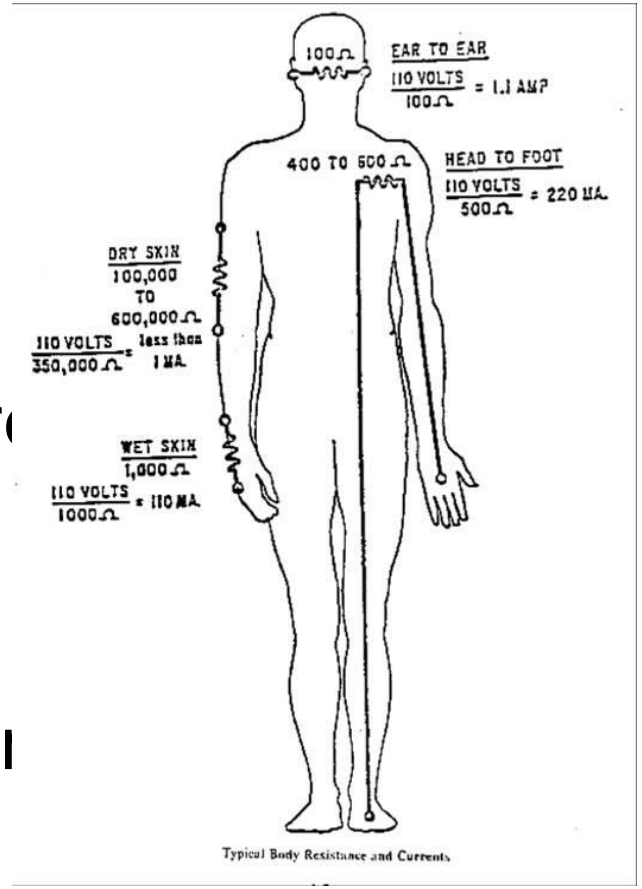
Ways to minimize shock risk

- Keep yourself dry

- Dry Skin: 120 V /100,000 Ω =.0012 amps
- =1.2 mA flowing through body to gr

- Wet skin: 120 V /1000 Ω = 0.120 amps
- =120 mA flowing through body to gr



Typical Body Resistance and Currents

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Ways to minimize shock risk

1. Guard your conductors
2. Use insulated tools and PPE
3. Insulate your conductors
4. Ground your equipment
5. Don’t work on live electrical equipment (not always feasible)

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Knowledge Check 1

- True or False: Keeping yourself dry is an easy way to minimize shock risk

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Knowledge Check 1

- True: your resistance dramatically decreases the second you get wet or are standing in water. You can reduce your risk for shock by keeping your hands and feet dry when working with energized equipment

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Approach Boundaries

- **Flash Boundary –** Outer boundary of protection for second degree burns from arc flash
  - Usually has the barriers for entry located outside this boundary

- **Limited Approach –** A limit at a distance from an exposed live part where a shock hazard exists
  - Anyone crossing this line must be qualified to work
  - Must wear protective equipment
  - Unqualified people are prohibited from crossing this boundary

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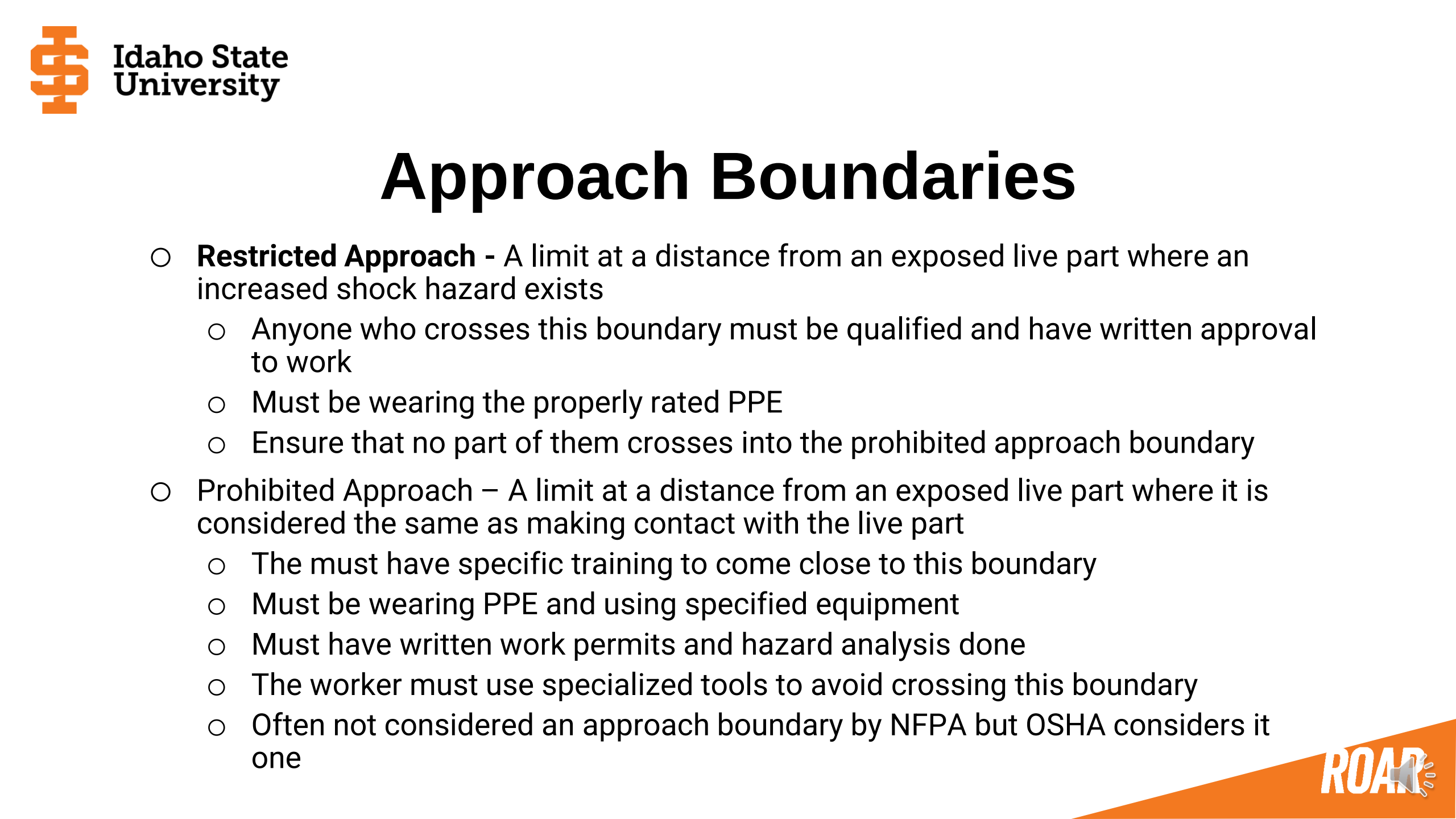
Approach Boundaries

- **Restricted Approach -** A limit at a distance from an exposed live part where an increased shock hazard exists
  - Anyone who crosses this boundary must be qualified and have written approval to work
  - Must be wearing the properly rated PPE
  - Ensure that no part of them crosses into the prohibited approach boundary
- Prohibited Approach – A limit at a distance from an exposed live part where it is considered the same as making contact with the live part
  - The must have specific training to come close to this boundary
  - Must be wearing PPE and using specified equipment
  - Must have written work permits and hazard analysis done
  - The worker must use specialized tools to avoid crossing this boundary
  - Often not considered an approach boundary by NFPA but OSHA considers it one



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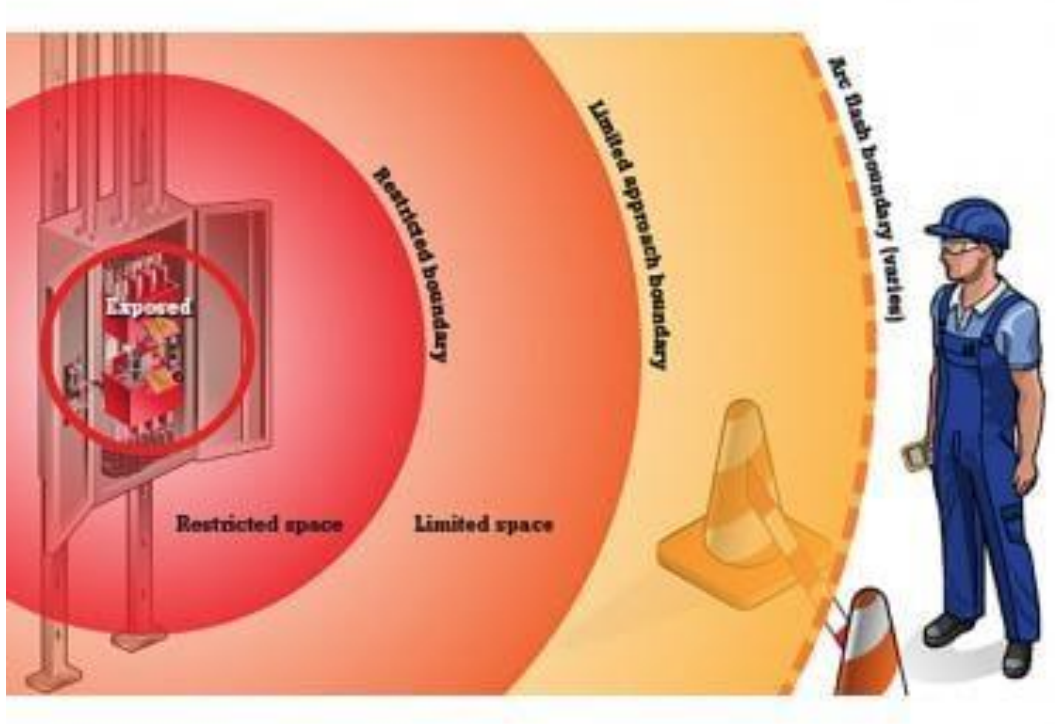
Approach Boundaries and Personnel

- Only a qualified person may enter the areas where live electricity poses a risk. They receive special training and are wearing the appropriate PPE
- It is the responsibility of the people completing the work to set up barriers (posts, warning signage, rope or chains) outside of the flash boundaries so no unqualified personnel crosses into the boundaries by accident



(1)	(2)	(3)	(4)
Nominal System Voltage Range, Phase to Phase[a]	Limited Approach Boundary[b]		Restricted Approach Boundary[b]; Includes Inadvertent Movement Adder
	Exposed Movable Conductor[c]	Exposed Fixed Circuit Part	
Less than 50 V	Not specified	Not specified	Not specified
50 V–150 V[d]	3.0 m (10 ft. 0 in.)	1.0 m (3 ft. 6 in.)	Avoid contact
151 V–750 V	3.0 m (10 ft. 0 in.)	1.0 m (3 ft. 6 in.)	0.3 m (1 ft. 0 in.)
751 V–15 kV	3.0 m (10 ft. 0 in.)	1.5 m (5 ft. 0 in.)	0.7 m (2 ft. 2 in.)
15.1 kV–36 kV	3.0 m (10 ft. 0 in.)	1.8 m (6 ft. 0 in.)	0.8 m (2 ft. 9 in.)
36.1 kV–46 kV	3.0 m (10 ft. 0 in.)	2.5 m (8 ft. 0 in.)	0.8 m (2 ft. 9 in.)
46.1 kV–72.5 kV	3.0 m (10 ft. 0 in.)	2.5 m (8 ft. 0 in.)	1.0 m (3 ft. 6 in.)
72.6 kV–121 kV	3.3 m (10 ft. 8 in.)	2.5 m (8 ft. 0 in.)	1.0 m (3 ft. 6 in.)
138 kV–145 kV	3.4 m (11 ft. 0 in.)	3.0 m (10 ft. 0 in.)	1.2 m (3 ft. 10 in.)
161 kV–169 kV	3.6 m (11 ft. 8 in.)	3.6 m (11 ft. 8 in.)	1.3 m (4 ft. 3 in.)
230 kV–242 kV	4.0 m (13 ft. 0 in.)	4.0 m (13 ft. 0 in.)	1.7 m (5 ft. 8 in.)
345 kV–362 kV	4.7 m (15 ft. 4 in.)	4.7 m (15 ft. 4 in.)	2.8 m (9 ft. 2 in.)
500 kV–550 kV	5.8 m (19 ft. 0 in.)	5.8 m (19 ft. 0 in.)	3.6 m (11 ft. 8 in.)
765 kV–800 kV	7.2 m (23 ft. 9 in.)	7.2 m (23 ft. 9 in.)	4.9 m (15 ft. 11 in.)

Notes:

(1) For arc flash boundary, see 130.5(A)

(2) All dimensions are distance from exposed energized electrical conductors or circuit part to employee.

[a] For single-phase systems above 250 volts, select the range that is equal to the system's maximum phase-to-ground voltage multiplied by 1.732.

[b] See definition in Article 100 and text in 130.4(D)(2) and Informative Annex C for elaboration.

[c] Exposed movable conductors describes a condition in which the distance between the conductor and a person is not under the control of a person. The term is normally applied to overhead line conductors supported by poles.

[d] This includes circuits where the exposure does not exceed 120 volts nominal.

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Knowledge Check 1

- Order the boundaries from furthest away from the panel to closest to the panel

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Knowledge Check 1

The furthest away approach boundary is the flash boundary, then it’s the limited approach, then the restricted approach and the closest to the panel is the prohibited approach

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Electrical Current and Heat

- The movement of negatively charged particles, referred to as current, creates heat in wires, components and appliances

- Different appliances draw different amounts of current and are rated for different power consumption. In electrical terms, we consider this the power “load”

- It is important to know how much power your device is going to draw to adequately size wiring and extension cords

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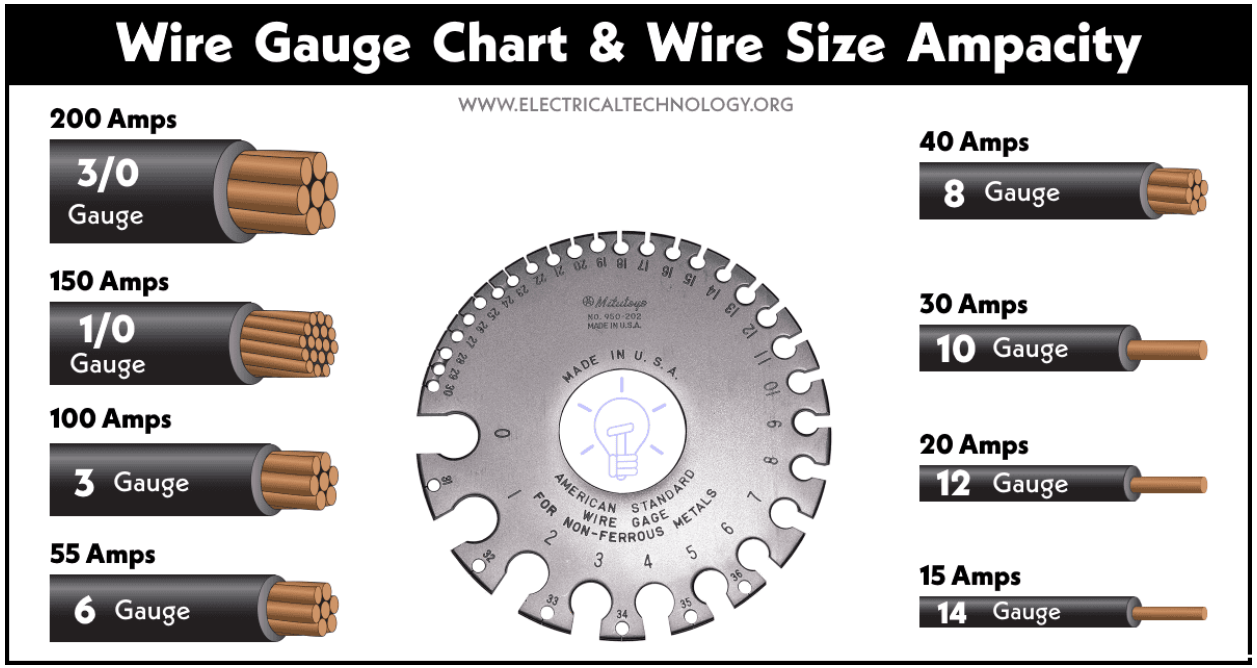
Wiring Sizes and Gage

- Wiring diameter is measured in “gage”
  - America uses AWG standard
- The larger the gauge number the smaller the diameter (thinner wire)
- Thicker wire can handle more heat which means you can use it for power-heavy loads



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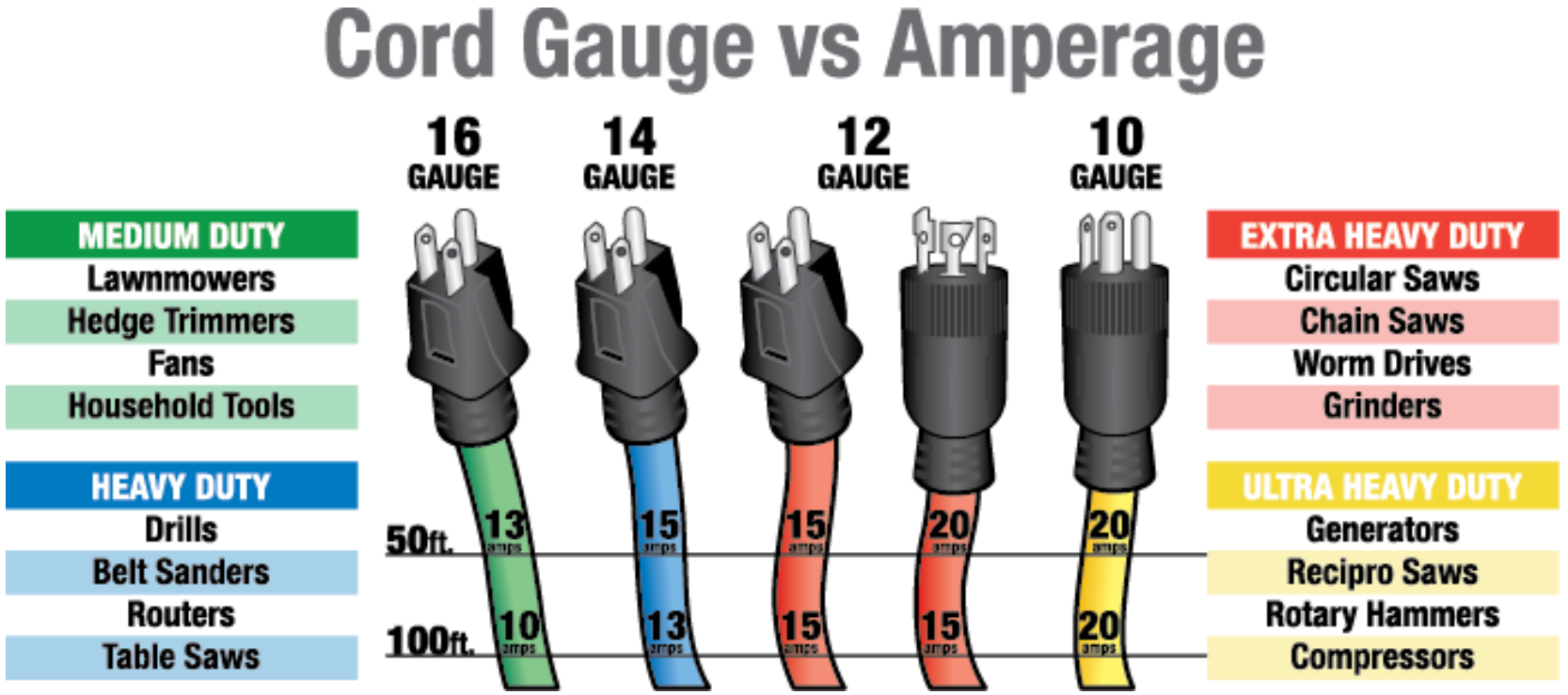
Extension Cords

- Extension cords must be sized correctly for the load you are using to avoid over heating and fires



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Extension Cords and Multi Outlet Strips

- NEVER daisy chain (plug one cord into another to get more length) extension cords because they can overload and catch fire
- Especially for high power loads
- Find an extension cord that is the proper length

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Multi Outlet Strips

- Do not overload multi-outlet strips, they may not be designed for the amount of current draw you are using them for
- This is especially true for items that heat up
- This can lead to fire and melted equipment

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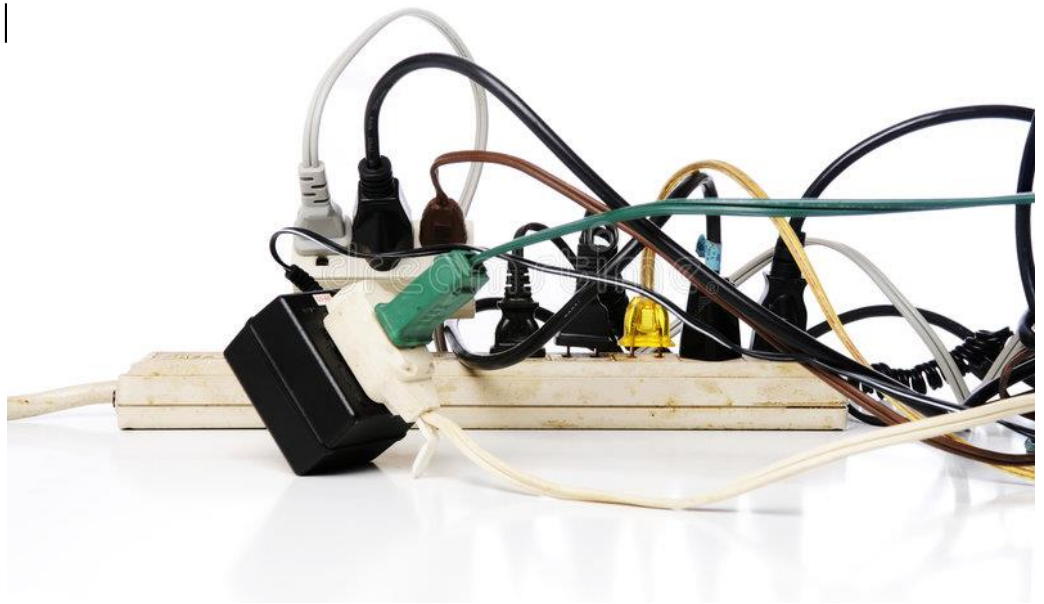
Multi Outlet Strips

- Do not plug in additional outlets or space saving devices into a power strip
- This can cause it to overload a



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Temporary Wiring

- OSHA 1926.405 and 1910.305 provides guidelines on temporary wiring
  - Not designed for permanent use
  - Cabling must be protected from damage and may pass through doorways if protection from damage is in place
  - It may not remain in place for longer than 90 days
  - May be used during and for remodeling, maintenance, or repair of buildings, structures, or equipment, and similar activities

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Knowledge Check 2

- Which is larger:
- A 20 AWG wire or a 30 AWG wire

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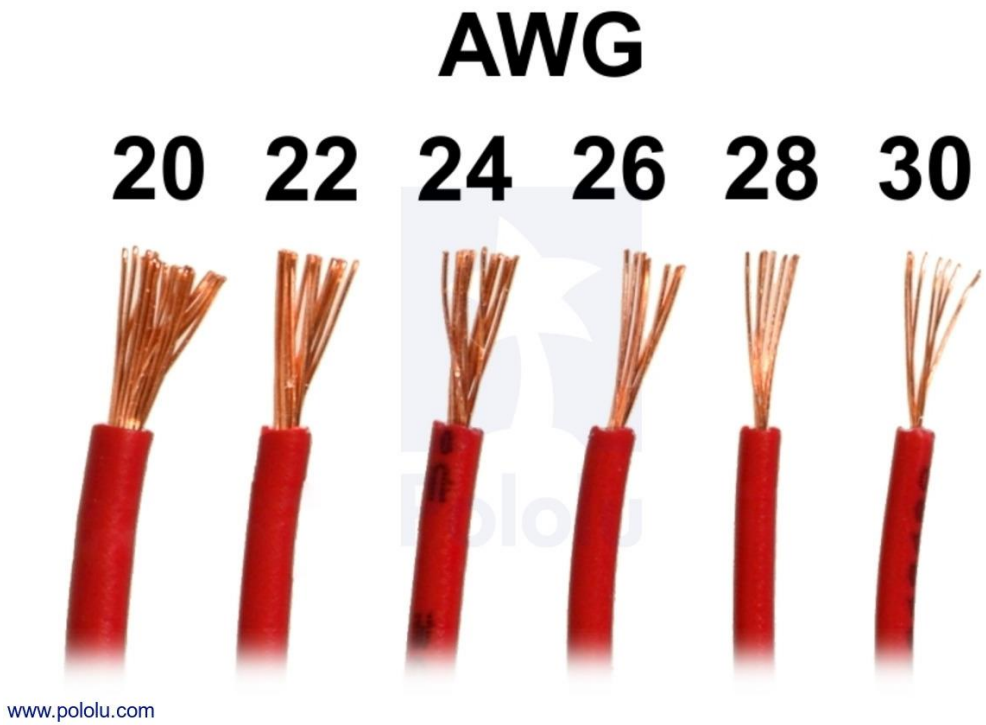
Knowledge Check 2

- A 20 AWG wire is larger than a 30 AWG wire



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Never's of Battery Safety

- NEVER connect the battery terminals with a low resistance connection
- NEVER try to recharge a non-rechargeable battery
- NEVER touch both the positive and negative terminal at the same time
- NEVER puncture a battery
  - This can cause explosion, fire and/or corrosive material to leak

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Don’ts of Battery Safety

- DON’T store unsealed lead acid batteries indoors
- DON’T combine batteries of vastly different voltages
- DON’T handle a leaky battery without gloves
  - Some batteries contain a strong acid
  - This applies to larger batteries
  - Wash your hands after handling a household battery

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Do's of Battery Safety

- DO dispose of all batteries properly at a disposal site
- DO replace batteries that are damaged immediately
- DO disconnect the battery terminals from the system before working on it
  - Remove the terminals one at a time
- DO use proper PPE while handling
  - Safety Glasses
  - Gloves
  - Face shield

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With Lithium Ion

- If the battery is “puffy” in any way – take it to a proper disposal facility immediately
- Never puncture a Li – Ion battery
- If it catches fire, do not use water to extinguish
- Never connect the two terminals together with a low resistance connection
  - This will create a fire!

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Arc Flash

- A phenomenon where a arc of current leaves its intended path and travels through the air and ignites the air around it

- Temperatures can reach 35,000 °F and will often vaporize everything including the metal conductors

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Arc Flash Boundaries

- This is the distance where the flash would cause curable second degree burns
  - Arc Flash boundaries are calculated to 1.2 cal/cm^2
- Sometimes the furthest distance, other times it is inward from the limited approach depending on the potential arc flash hazard
- This is usually calculated by a professional specific for the equipment

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Arc Flash Ratings

- Arc Flash is rated in cal/cm^2 or the amount of energy it can expel (calories) per square centimeter
- An exposure of between 1 and 2 calories can cause a second degree burn on human skin and arc flash releases anywhere from 5 to 30 calories
- Per NFPA 70E
- Arc Flash danger falls into 1 of 4 categories for PPE
  - CAT 1 - 4 cal/cm^2
  - CAT 2 - 8 cal/cm^2
  - CAT 3 - 25 cal/cm^2
  - CAT 4 - 40 cal/cm^2

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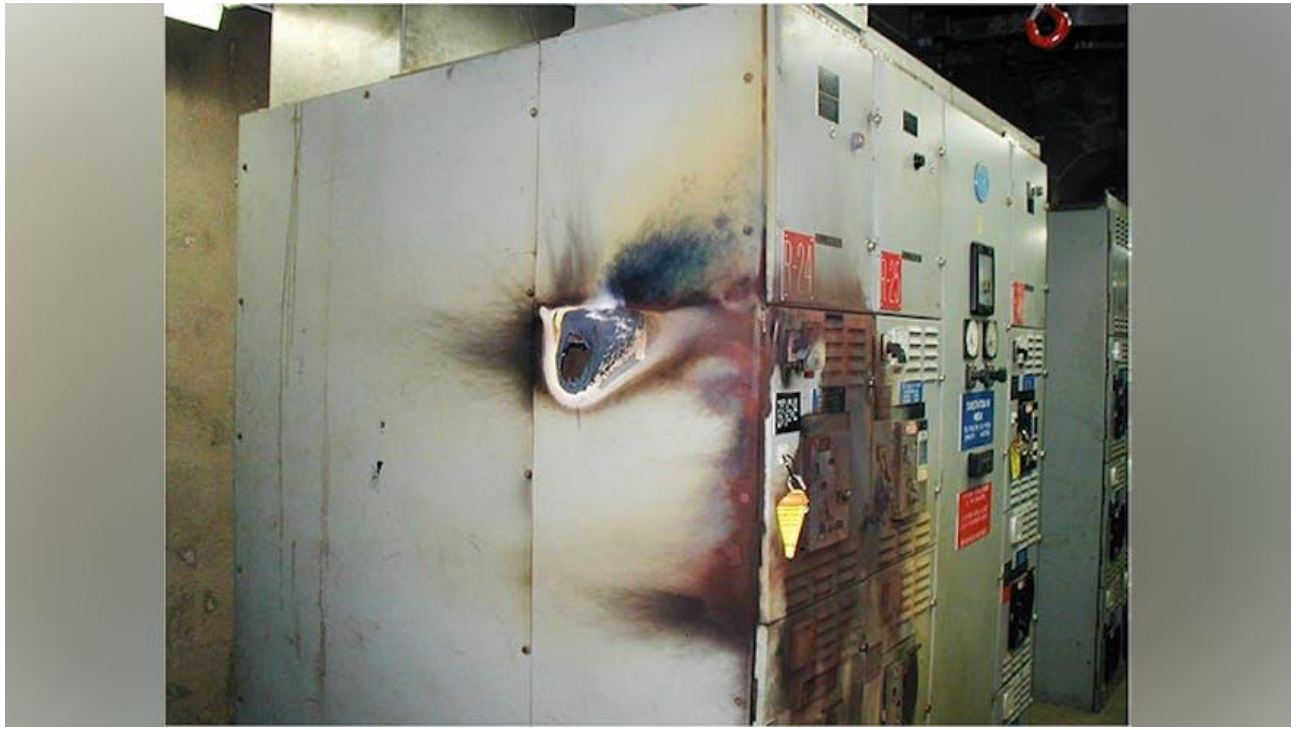
Arc Blast

- The resulting pressure wave from an Arc Flash that can result in damage
  - Collapsed lungs
  - Broken bones
  - Hearing loss



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Knowledge Check 3

- What is the value (in cal/cm^2) that causes curable 2nd degree burns?

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Knowledge Check 3

- 1.2 cal/cm^2 is the value that causes curable second degree burns
- (remember that arc flashes can expel up to 25 times that!)

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The Why of Electrical Safety

- Electricity can severely damage nerves, organs, skin and other parts of your body and even cause death
- It is important to take it seriously

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End of Show

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