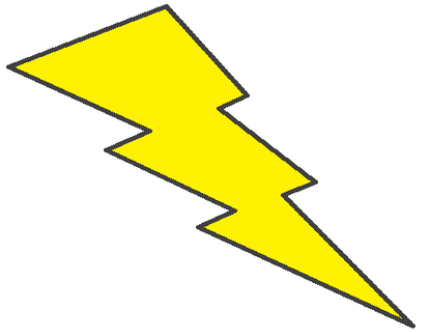


Understanding RV Electrical Hazards

“Do you really want to plug in here?”

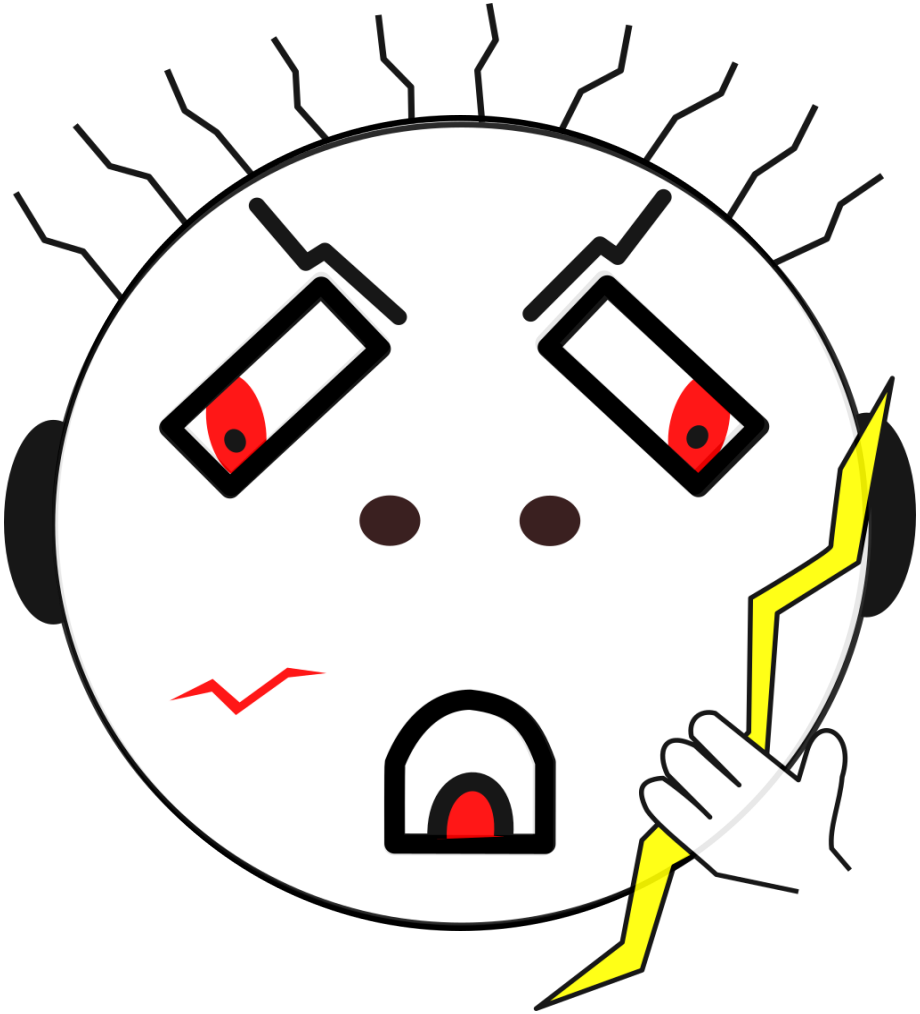
John Slaughter

- RV owner for 12 years, 150,000 miles of travel.
- Electrical Engineer
- Full disclosure, I am not a safety expert.

Takeaways

- Don’t just assume everything is fine
- Don’t become a victim when trying to help someone else.
- The difference between a tingle and a deadly shock can be very subtle. Don’t ignore the tingle.
- Don’t circumvent safety systems either intentionally or accidentally
- Safety devices are not perfect protection
- Don’t get fooled by your instruments
- Importance of good mechanical connections, proper wire size and physical protection

Looks Innocuous



Hazards

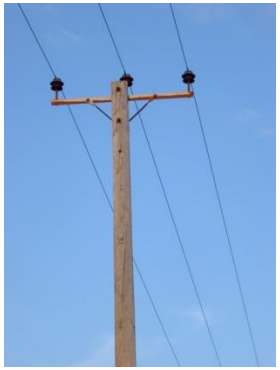
- Electrical Shock
  - Painful
  - Burns
  - Death
- Fire
  - Your coach will burn
- Latent Damage
  - Equipment failure
- Batteries
  - Explosion
  - Corrosion

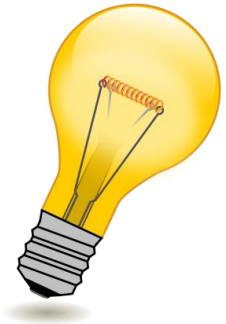
What is Electricity Anyway?

- **Electricity** is the set of **physical** phenomena associated with the presence and motion of **electric charge**.
- What we usually associate with electricity are the secondary effects, heat, light, sound and motion.
- Unless it's doing work, it's invisible and unseen.

Three Categories

- Utility or electrical distribution
- Household power
- Low voltage
  - Signaling
  - Power

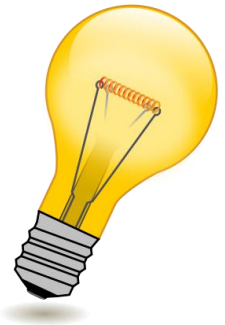




Utility or electrical distribution

- High voltage Typically 7,200 volts and higher.
- Even a momentary contact will usually kill and or maim.
- No second chances
- Don’t even get near a downed wire. If you are in a vehicle don’t get out.

Household power



- Typically 120 / 240 volts AC
- Can be lethal, but not always.
- Normally kills by, ventricular fibrillation. This causes the heart to either stop beating or beat inefficiently.
- Once your heart goes into fibrillation, a counter shock with a defibrillator is usually required. Seconds count!

- Get medical attention with any severe shock.

Low voltage

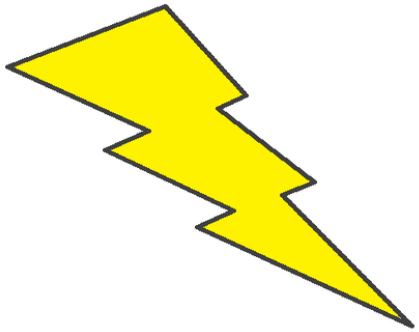
- Typically below 48 volts AC or DC
- Examples are your 12/24 volt RV circuits and most electronics.

- Rarely lethal, but not always.
- With high energy systems, burns and fire can be a problem.

- Danger with rings, tools etc.
  Having a wedding ring turn white hot in an instant will ruin your day!

Specific Hazards

- Electrical Shock
- Injuries suffered due to violent muscular contraction. Lacerations even broken bones.
- Burns
- Fire
- Equipment Damage
- Storage Batteries
  - Acid
  - Explosive gases
  - Even sealed batteries can vent



Shock Prevention

- Park equipment will have agency certifications.
- Park electrical systems are usually inspected
- Physical barriers, separation and or insulation.
- Protective conductors / enclosures which provide a return path preventing shock. Often act by allowing enough current to flow and open a breaker. Ground or green wire.
- Active devices like GFCI (Ground Fault Circuit Interrupters) which sense abnormal current flow and shut off power to the circuit.

Estimated effects of 60 Hz AC currents

- 1 mA (0.001 amp) Barely perceptible
- 16 mA (0.016 amp) Maximum current an average man can grasp and “let go”
- 20 mA Paralysis of respiratory muscles
- 100 mA Ventricular fibrillation threshold
- 2 A Cardiac standstill and internal organ damage
- 15/20 A Common circuit breaker rating

How Much Current Will Flow

- Dry exposed calloused skin can have quite high resistance. You might not even feel line voltage under the right conditions.

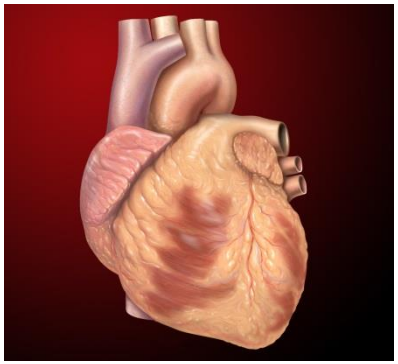
- Wet conditions, cuts and abrasions can go from not being able to feel it to a deadly shock.
- Some people are better "insulators" than others.

Rescue

- Electrocutions often come in pairs. Don't become a victim.
- Before assisting a victim, determine what happened.
- Be very sure that power is removed.
- Call 911, administer CPR and use a Automated external defibrillator (AED) if available.
- Even if victim seems to be okay, after a severe shock, get medical attention. Effect can be delayed.

Bottom Line

- It takes current, but a small amount of current to cause problems
- The minimum let-go-current is well below the deadly 100 ma range. (Very low energy!)
- If you can't let go, you may well die because you can't breathe or as your body warms, the current will increase to the danger level where ventricular fibrillation occurs.

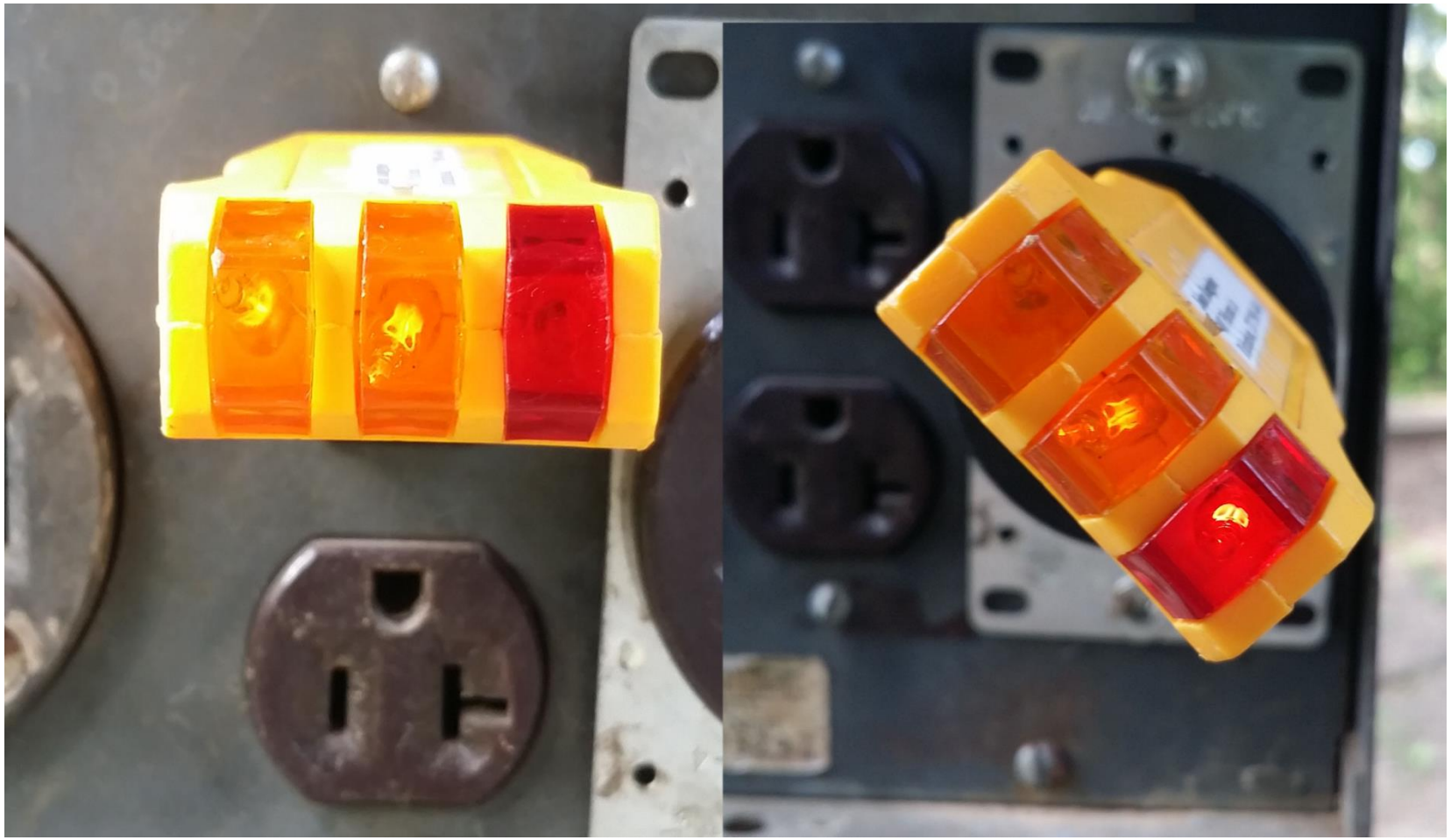


Park Electrical Systems

Is it safe?

- Yes, very likely! Don't be paranoid!
- Use your eyes first!
- Check for proper wiring

Hot Neutral Fault



Danger of Hot Neutral

- The body or chassis of your entire RV may become “hot” if the safety or green wire is compromised.
- If you constantly trip a breaker when plugging into some parks, you have probably encountered a hot neutral and have a connection between your neutral and ground connection.
- Some sensitive electronics may be damaged with a hot neutral.

Before You Plug In

- Shoddy workmanship in park wiring?
- New connection? Be particularly cautious! Many electricians are unfamiliar with RV connections.
- Test the outlet for proper wiring
  - Ground
  - Neutral on Correct Pin
  - Hot on Correct Pin(s)

- Check 30 amp with 3 light Tester and a 30 to 15 amp adapter. Will not detect all faults!
- Procedures and testers available for 50 amp
- If you don’t know how, learn.


Underwriters Laboratories Inc.
LISTED
POWER OUTLET

Before You Plug In (cont.)

- Power Pedestal Breaker off
- Be extra cautions under wet conditions.
- Use one hand.
- Major Loads in Rig like AC off
- Snug fit when plugging in?
- Turn on Power Pedestal Breaker
- Check voltage under no load and then under load.

Park Safety Ground Connection

- Like a vehicle safety belt it does nothing in a normal situation.
- If you have an failure and the conductor comes into contact with the grounded chassis, the return path through the safety wire will normally trip a circuit breaker.
- If the safety ground is missing, then the you are at risk.

50 amp Hazards

- Missing Safety Ground
- Missing neutral
- A 50 amp connection is really
- two 120 volt circuits, yes there is 240 volts between the hot legs, but your equipment runs on 120 volts not 240. A missing neutral can create serious problems due to in-balanced voltages.
- The shared neutral reduces the number of required wires and normally carries less current.

Generators

- Don’t even think of using a home made cable to connect the generator. (suicide cord)
- Grounding considerations vary depending on the unit. Do your homework.
- Carbon Monoxide poisonings are often the result of generator use.

Is it Really Off?

- RV's have multiple energy sources!
- Battery disconnect, know where it is and how to use it.
- Solar Panels produce power in the sun, there is no "off" switch. Become familiar with this system and how disconnect the panels.
- AC outlets may be powered from an inverter running off your batteries when not plugged in to shore power.
- You can't tell by looking if a circuit is hot, always check even when you think it's dead.

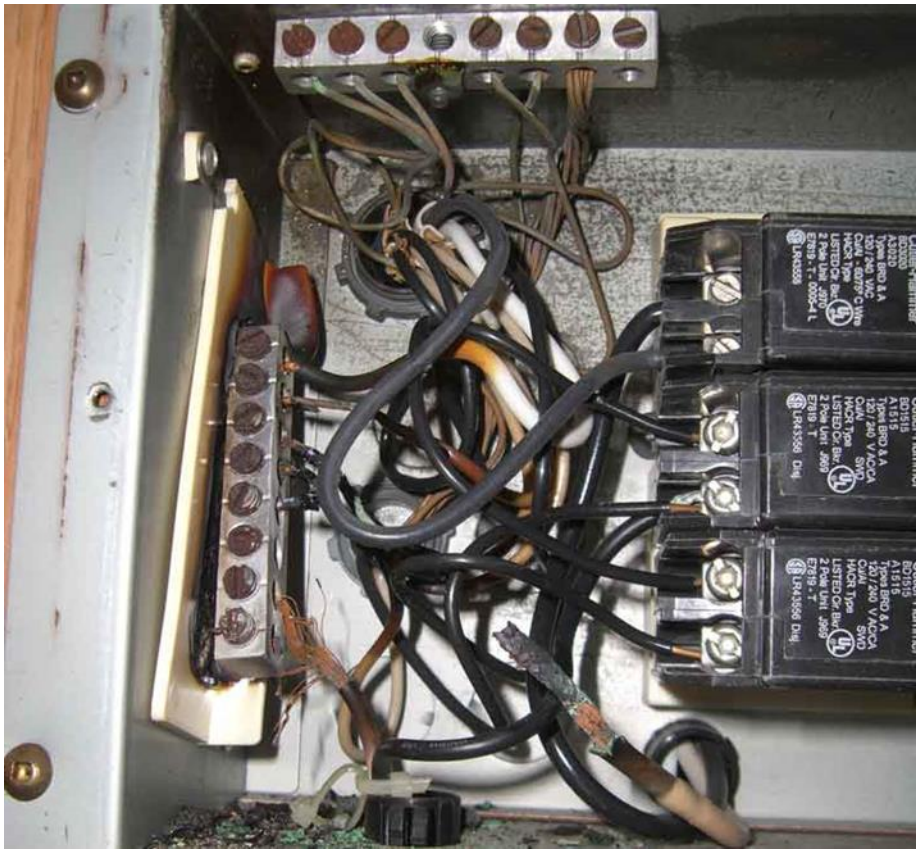
Power Limitations

- Much less power than at home.
- In our RV's we are limited.
- 3.6KW maximum with a 30 amp service.
- Two or three high current devices maximum like microwaves, toasters, AC units.
- 12KW maximum with a 50 amp service.
- Much more flexibility, but it can add up quickly.
- Even though the rating is 30 or 50 amps, this does not mean the park system can deliver this much power, watch the voltage.
- You have to manage the load, your RV won't do it for you

Overloaded Circuits

- Don’t demand more power than the park system and your rig are designed to handle.
- Circuit breakers in your rig and in the pedestal are not precise, so you could be well above the rating a long time.
- Excessive current will heat connections and eventually you will have bigger problems.
- Just because it seems to be working does not mean that everything is okay.

Poor Connections Hurt



This RV panel damage was due to poor connections on the neutral bus bar, it got hot and melted the wires! The breaker did not trip!

Protection Devices Are Not Perfect

- A circuit breaker is not a precise device, it may not trip with even a 50% overload.
- A breaker will be very slow to trip under overload conditions. Will trip fast under fault conditions.
- A circuit breaker will not prevent fire due to a poor connection. The fire may eventually cause a short circuit or fault which will trip a breaker.
- Don’t depend on a breaker to keep you from overloading your electrical system.
- GFCI devices work well and save lives, but the trip threshold may be above the let go value. Have you tested your devices?

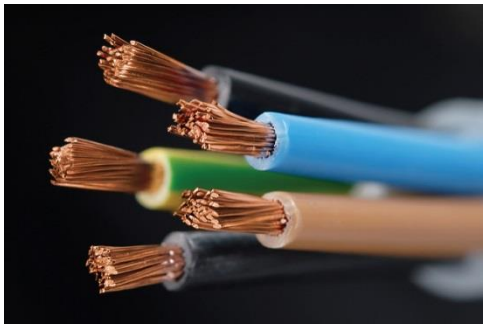
Electrical Work in Your RV

- Many of us do some of our own work.
- RV service centers vary dramatically in quality.
- Good practice will minimize risk of problems.
- Be aware
- Ask questions
- Challenge poor workmanship
- Place unsealed batteries in vented locations outside of living space.

DIY Electrical

- What you don’t know may bite in the future.
- Proper wire gauge and insulation
- Branch circuit protection
- Proper abrasion protection
- Water and electricity don’t mix well, RV’s get wet, both inside and out.
- Under your coach is a nasty place
- There are sharp edges everywhere and your coach moves and vibrates.

Wire Gauge & Insulation



- Wire gauge is more than just safe current rating.
- In low voltage DC circuits the wire resistance can be critical.
- Mechanical durability of wire may be an issue. Solid vs stranded wire for example.
- Insulation needs to be appropriate for the operating temperature, chemical resistance and abrasion resistance.

Branch Circuit Protection

- Many a vehicle fire has occurred because an installer did not fuse the circuit correctly.
- Protect the wire at the source. Fusing a wire at the point of use ignores the wire between the device and the energy source.
- Use no larger a fuse than necessary for normal operation.
- Enormous current available from a battery.

Support and Protect Wires

- Use auxiliary sleeves, physical barriers, grommets and fasteners to protect wires from abrasion and damage.
- Think, “can this become a problem over time?”
- Cheap components may quickly become brittle and fail.
- Line voltage wiring requires more care.
- No hidden or buried splices.

Water Damage

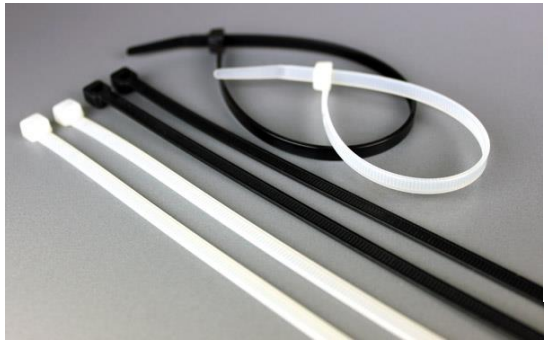
- Water is a fact of life in RV's
- When routing wires, consider how water may be a problem.
- Particularly important with line voltages
- Water promotes corrosion in addition to being conductive.
- Connectors and connections may need to be sealed or not made in these environments.

Batteries

- Locate unsealed batteries in a vented space outside of the living area.
- Properly secure batteries, they are heavy!
- Provide for service access

Connections

- Common failure point.
- Wire nuts are not well suited for RVs.
- Crimped connections are much better. Use the correct size!
- Mechanically test your connections! TUG!
- Use high quality materials.
- Heat shrink tubing is wonderful stuff, easy to use.
- Plastic cable ties work well



Instrumentation

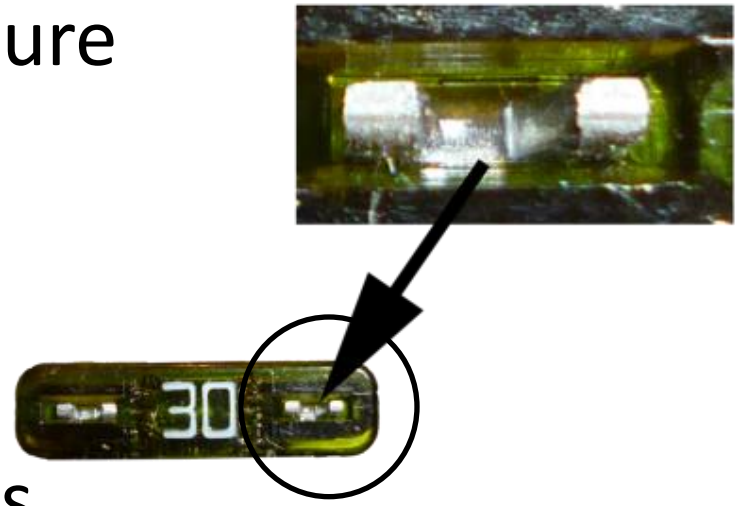
- Modern digital voltmeters are wonderful tools, but be aware that they do not “load” the circuit and you might not have what you think.
- Clamp on AC/DC ammeters can tell you about the current. It takes both current and voltage to do useful work.
- Be careful with high voltages

Instrumentation

- A DC test light is a powerful simple troubleshooting tool. (Don’t use on line operated circuits.)
- A voltage sniffer can tell you if a wire it hot, but always test the instrument on a live circuit first. It is very sensitive and may indicate a hazard where none exists!
- Never grab a wire, touch with the back of the hand first.

Useful Fact: Fuses

Automotive style fuses usually have built in test points. You can probe with a meter or a test light. Measure the voltage between the points and you can measure current! Look up the resistance of the fuse on the internet and you can estimate how much!

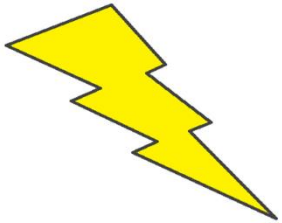


30 amp about 0.002 ohms.
15 amp about 0.005 ohm
10 amp about 0.008 ohm

$I = V/R$

Summary

- ✓ Be aware of potential problems, pay attention.
- ✓ Don’t become a second victim
- ✓ The difference between a tingle and a deadly shock can be very subtle.
- ✓ Don’t re-engineer the system.
- ✓ Safety devices are not perfect protection
- ✓ Understand the limitations of your instruments
- ✓ Good mechanical connections, proper wire size and physical protection



Questions