



Chapter 8

Electrical and RF Safety

Electrical Safety

RF Exposure

Towers and Outdoor Safety



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Electrical Shocks

Table 8-1

Effects of Electric Current Through the Body of an Average Person

<i>Current (1 sec contact)</i>	<i>Effect</i>
1 mA	Just perceptible.
5 mA	Maximum harmless current.
10-20 mA	Lower limit for sustained muscular contractions.
30-50 mA	Pain.
50 mA	Pain, possible fainting. "Can't let go" current.
100-300 mA	Normal heart rhythm disrupted. Electrocution if sustained current.
6 A	Sustained heart contractions.



Electrical Safety – Wiring

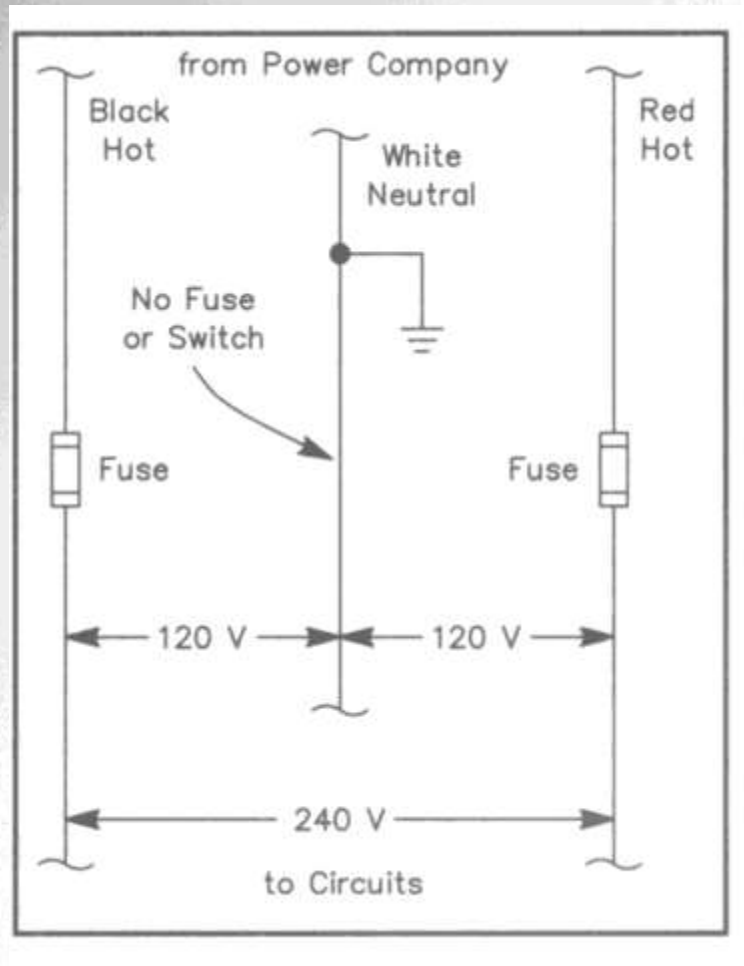
- National Electrical Code (NEC)
 - Detailed descriptions of safe wiring and practices
 - Covers residential and industrial
- Underwriters Laboratory (UL)
 - Tests and registers electrical devices for compliance
- Local Building Codes
- Proper grounding methods
- Proper wire size
 - 15 Amps ⇔ #14 AWG
 - 20 Amps ⇔ #12 AWG



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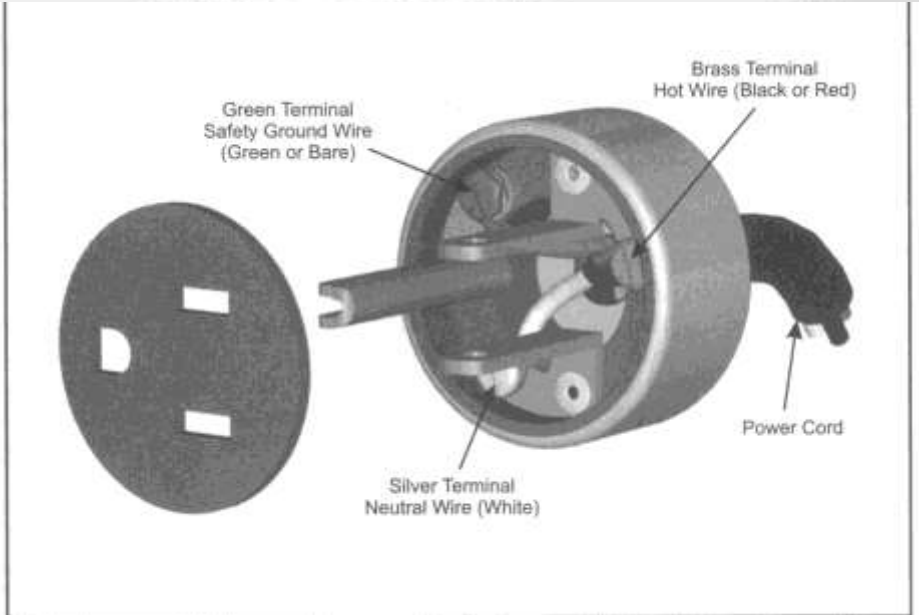
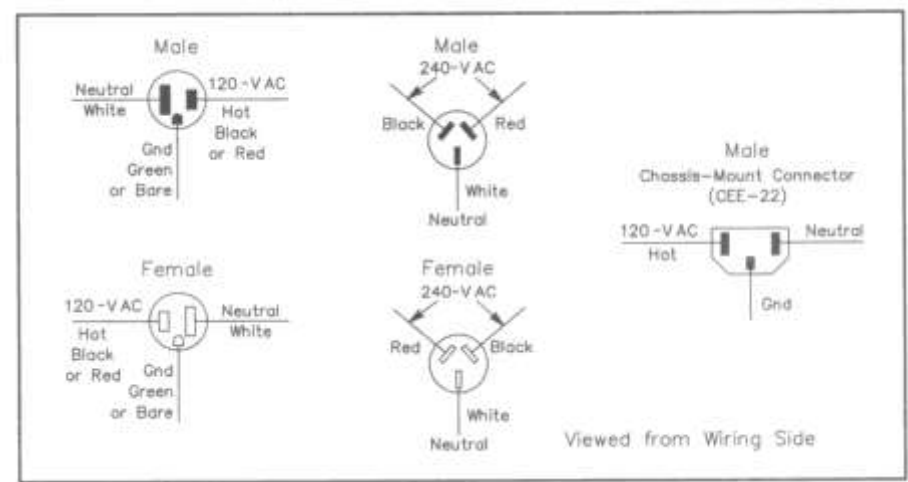
Electrical Safety – Power Source



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Electrical Safety – AC Connectors



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Electrical Safety – Wire Capacity

Table 8-2

Current Carrying Capacity of Some Common Wire Sizes

<i>Copper Wire Size (AWG)</i>	<i>Allowable Ampacity (A)</i>	<i>Max Fuse or Circuit Breaker (A)</i>
6	55	50
8	40	40
10	30	30
12	25 (20) ¹	20
14	20 (15) ¹	15

¹The National Electrical Code limits the fuse or circuit breaker size (and as such, the maximum allowable circuit load) to 15 A for #14 AWG copper wire and to 20 A for #12 AWG copper wire conductors.



Protective Components

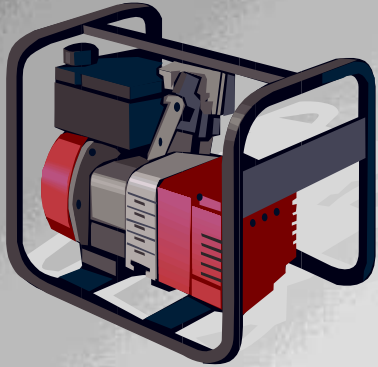
- Fuses and Circuit Breakers
 - Ampere rating determined by wire size
 - Voltage rating determined by line voltage
 - Install in Ungrounded (Hot) conductor, never in Neutral (Grounded) conductor.
 - Install in both Hot conductors of 240 Volt circuits
- Ground Fault Circuit Interruptor (GFCI)
 - Senses ground current as difference between Hot and Neutral current
 - Interrupts the circuit if ground current $> 6\text{mA}$



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Portable Power Plants



Generators convert mechanical energy to electrical energy. They actually consist of two devices: a gasoline engine and an electrical generator.

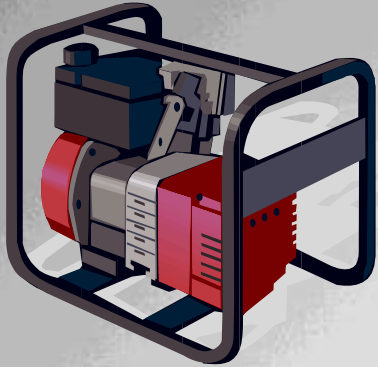
- A generator should be located in a well ventilated area.
- The metal and frame of the unit should be connected to a proper ground.
- Re-fueling supplies should be stored in a safe storage area away from the unit.



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Portable Power Plants



During a power outage, it is unsafe to connect the output of a generator into your home wiring without disconnecting the utility service

- It may present a hazard for electrical workers.
- You can draw too much current and overload the generator.
- When power is restored, the generator could be damaged.
- Automatic Bus Transfer switches may be used.



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Lightning Protection

Keep the voltage from lightning strikes outside the shack by disconnecting antennas outside.

- Keep all equipment in the shack at the same potential by bonding and grounding.
 - Cables enter shack at ground level through a grounded panel
 - Panel connected to a ground rod with wide strap.
 - Lightning arrestors mounted on panel
 - Panel and all ground rods bonded to building ground rod IAW NEC requirements



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RF Safety

It all boils down to common sense: Any radiation at high levels can cause physical harm.

- Solar rays
- X-rays
- Nuclear radiation
- Microwaves
- Amateur Radio Stations



RF Safety

Maximum Permissible Exposure (MPE)

- Thermal effects (getting cooked)
- Athermal effects (cellular and molecular damage)

Maximum Permissible Exposure

Table 8-3

Maximum Permissible Exposure (MPE) Limits

<i>Controlled Exposure (6-Minute Average)</i>		<i>Uncontrolled Exposure (30-Minute Average)</i>	
<i>Frequency Range (MHz)</i>	<i>Power Density (mW/cm²)</i>	<i>Frequency Range (MHz)</i>	<i>Magnetic Field Power Density (mW/cm²)</i>
0.3-3.0	(100)*	0.3-1.34	(100)*
3.0-30	(900/f ²)*	1.34-30	(180/f ²)*
30-300	1.0	30-300	0.2
300-1500	f/300	300-1500	f/1500
1500-100,000	5	1500-100,000	1.0

f = frequency in MHz

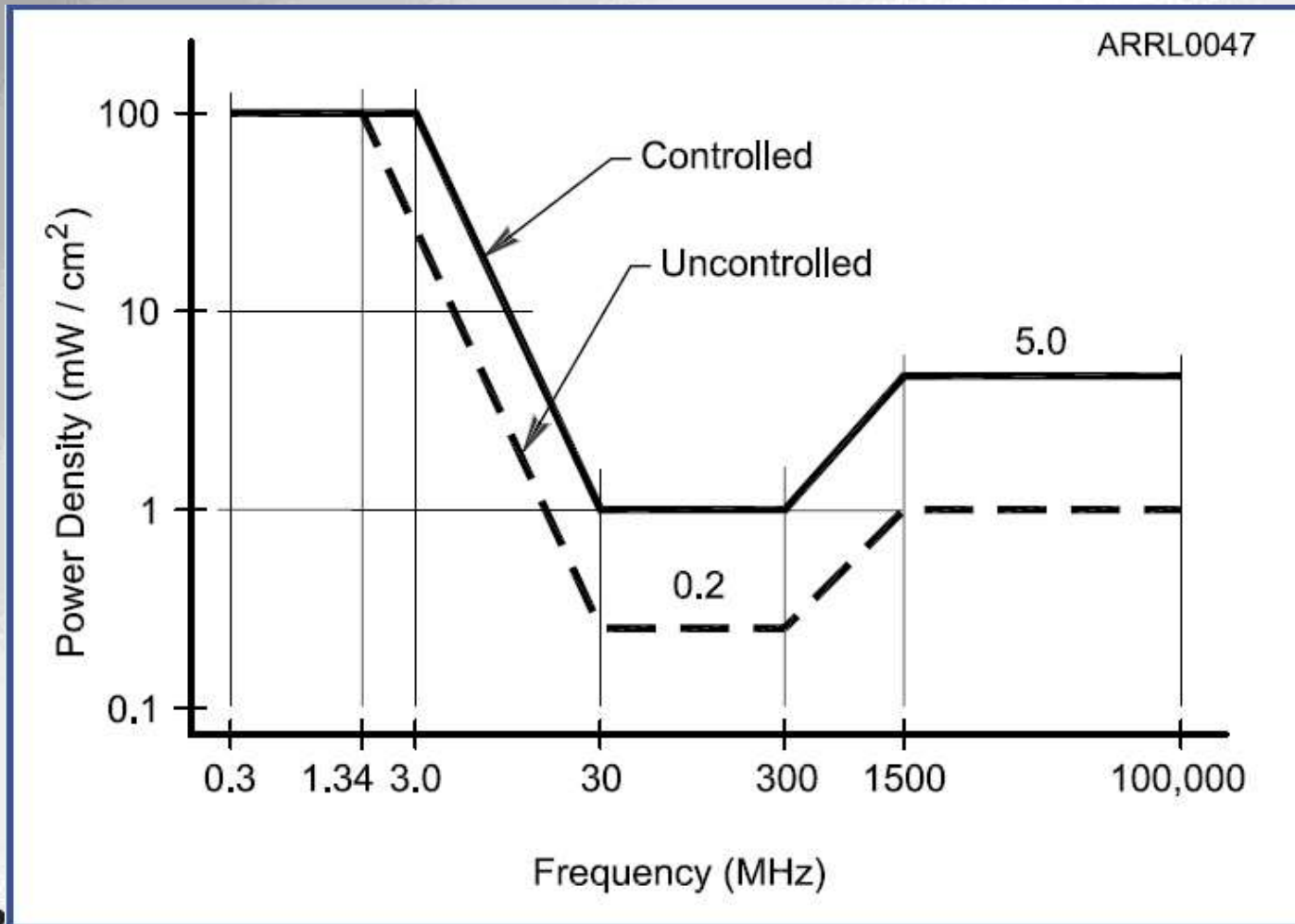
* = Plane-wave equivalent power density

Controlled – You are able to prevent access to the area

Uncontrolled – You can't prevent access to the area



MPE vs Frequency



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RF Safety

The power your body will absorb (and the heating) depends on the power density

- Power density depends on:
 - Power level of the source
 - Duty cycle of the wave



Duty Cycles of Modes

Table 8-4

Operating Duty Factor of Modes Commonly Used by Amateurs

<i>Mode</i>	<i>Duty Cycle</i>	<i>Notes</i>
Conversational SSB	20%	1
Conversational SSB	40%	2
SSB AFSK	100%	
SSB SSTV	100%	
Voice AM, 50% modulation	50%	3
Voice AM, 100% modulation	25%	
Voice AM, no modulation	100%	
Voice FM	100%	
Digital FM	100%	
ATV, video portion, image	60%	
ATV, video portion, black screen	80%	
Conversational CW	40%	
Carrier	100%	4

Notes

- 1) Includes voice characteristics and syllabic duty factor. No speech processing.
- 2) Includes voice characteristics and syllabic duty factor. Heavy speech processing.
- 3) Full-carrier, double-sideband modulation, referenced to PEP. Typical for voice speech.
Can range from 25% to 100% depending on modulation.
- 4) A full carrier is commonly used for tune-up purposes.



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RF Safety

You are required to know about the radiation environment that you create when transmitting.

- Power at the antenna
- Antenna gain
- Frequency
- Use a calibrated field strength meter, or
- Make calculations using a program or tables of data
 - Use the tables or online calculator at ARRL website



RF Power Thresholds

Table 8-5

Power Thresholds for RF Exposure Evaluation

<i>Band</i>	<i>Power (W)</i>
160 meters	500
80	500
40	500
30	425
20	225
17	125
15	100
12	75
10	50
6	50
2	50
1.25	50
70 cm	70
33	150
23	200
13	250
SHF (all bands)	250
EHF (all bands)	250

Exposure Safety Measures

Basic requirement is to prevent human exposure

- Keep antennas at a safe distance from people
- Keep people at a safe distance from antennas
- Orient directional antennas away from people
- Limit power when using indoor antennas to stay with MPE limits.
- Place mobile antennas as far as possible from passengers
- Use a Dummy Load for long testing.



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Outdoor Safety

Place antennas safely away from power lines

- At least 150% of tower and antenna height
- Make sure that a tower is used within the manufacturer's limits
- Obtain proper building permits and inspection
- Use materials which will stand up to exposure to weather and UV
- Keep overhead wires out of reach and above head height.



Towers and Climbing Safety

Have an adequate, equipped, and trained ground crew before climbing

- Checklist:
 - Inspect tower and support condition
 - Nest and block crank-up towers
 - Inspect climbing and support equipment
 - Turn off power to equipment and lock or tag switches
 - Check for bad weather and storms



Climbing Safely

- Ground and tower crew must have hard hats and safety glasses
- Have a way to communicate with ground crew
- Designate a safety observer and crew chief
- Take your time and be careful of safety
- Carabiners should be completely closed
- Latching hooks must close away from the tower
- Use a safety lanyard or lanyards to raise and lower tools and parts



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