

# Technician License Course

## Chapter 9

### Lesson Module 18 – Safety and Amateur Radio



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# Electrical Injuries

- Shocks and burns.
- Low voltages can cause enough current to create problems.
- Equipment today uses lower voltage than tube equipment but it can still cause burns.

## Effects of Electric Current in the Human Body

<i>Current</i>	<i>Reaction</i>
Below 1 milliampere	Generally not perceptible
1 milliampere	Faint tingle
5 milliamperes	Slight shock felt; not painful but disturbing. Average individual can let go. Strong involuntary reactions can lead to other injuries.
6-25 milliamperes (women) 9-30 milliamperes (men)	Painful shock, loss of muscular control*; the freezing current or "can't let-go" range.
50-150 milliamperes	Extreme pain, respiratory arrest, severe muscular contractions. Death is possible.
1000-4300 milliamperes	Rhythmic pumping action of the heart ceases. Muscular contraction and nerve damage occur; death likely.
10,000 milliamperes	Cardiac arrest, severe burns; death probable

\* If the extensor muscles are excited by the shock, the person may be thrown away from the power source.

Source: W.B. Kouwenhoven, "Human Safety and Electric Shock," Electrical Safety Practices, Monograph, 112, Instrument Society of America, p 93. November 1968.



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# Electrical Safety

- Avoiding contact is the most effective way of practicing electrical safety
- Unplug equipment before working on it
- Keep one hand in your pocket
- Make sure equipment is grounded
- Use power from GFCI-protected circuits



# Mitigating Electrical Hazards

- If working on live equipment is required:
  - Remove jewelry
  - Avoid unintentional touching of circuitry
  - Never bypass safety interlocks
  - Discharge high-voltage points and components to ground
  - Capacitors can store charge after power is off
  - Storage batteries are dangerous when shorted

# Responding to Electrical Injury

- **REMOVE POWER!**
  - Have ON/OFF switches and circuit breakers clearly marked.
  - Install an emergency master power switch and make sure your family knows how to use it.
- Call for help.
- Learn CPR and first aid.

# Electrical Grounding and Circuit Protection

- Make sure your station wiring meets code
- Most ham equipment does not require special wiring or circuits
  - Use 3-wire power cords
  - Use circuit breakers, circuit breaker outlets, or Ground Fault Circuit Interrupter (GFCI) circuit breakers or outlets
  - Use proper fuse or circuit breaker size
  - Don't overload single outlets or circuits



# Grounding & Bonding at RF

- RF burns from “hot spots” at high RF voltage
  - Do not cause serious injury at ham power level
  - Prevent by bonding (connecting) equipment together with heavy wire or strap – braided strap not recommended at RF
  - Prevent by keeping people away from antennas and radial or counterpoise wires
- Ground equipment for AC safety



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# Lightning Protection

- Ground antennas and towers to local code
  - Use 8-ft ground rod for each tower leg
  - Bond rods to tower leg and the other rods
- Ground connections should be as short as possible
- Use lightning arrestors on a single ground plate where cables enter the house
- Unplug and disconnect equipment (including telephones and computers) and feed lines if lightning is expected



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# RF Exposure

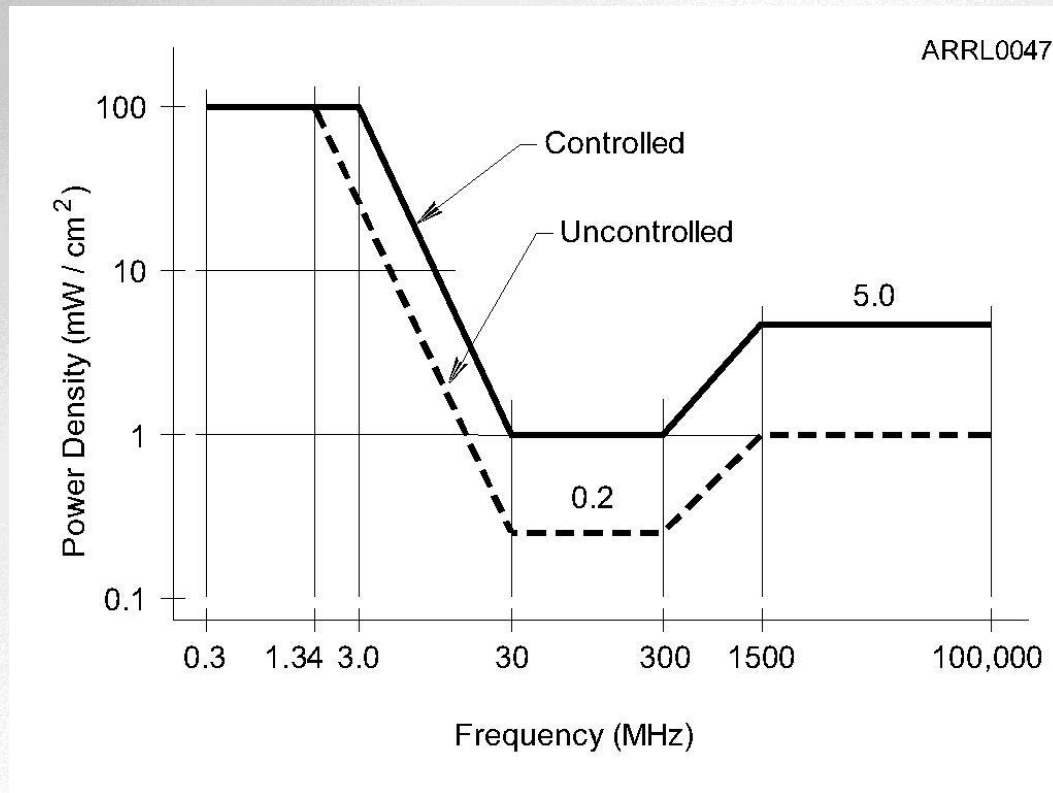
- Electromagnetic radiation (EMR) is not the same as radioactivity – much lower energy
- RF energy heats body tissues
  - Heating depends on the RF intensity and frequency.
  - If precautions are taken, RF exposure is minimal and not dangerous.

# RF Intensity

- Power Density
  - Watts per square centimeter ( $\text{w}/\text{cm}^2$ )
- Higher power density means higher RF exposure
- RF absorption varies with frequency because of body part size
- Safe exposure levels have been established by the FCC



# Maximum Permissible Exposure (MPE)



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# RF Environment

- **Controlled Environment.**
  - You know where people are standing in relation to your antenna and you can do something about it.
  - Higher power density is allowed because you can make adjustments if needed.
- **Uncontrolled Environment.**
  - You have no control of people near your antenna.
  - Lower power density is allowed because you cannot control or adjust the exposure of people.

# Duty Cycle and Duty Factor

- Duty cycle is the percentage of time that a transmitter is on during the evaluation period, from 0 to 100%
  - $\text{Duty cycle} = 100 \times (\text{time on} / \text{total time})$
- Duty factor is the same as duty cycle, but given as a number from 0 to 1.0
- Higher duty cycle or factor means higher average power density and exposure

# Mode Duty Cycle

- Accounts for the different characteristics of the transmitted signal's waveform

## Operating Duty Factor of Modes Common

<i>Mode</i>	<i>Duty Cycle</i>
Conversational SSB	20%
Conversational SSB	40%
SSB AFSK	100%
SSB SSTV	100%
Voice AM, 50% modulation	50%
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%



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# RF Exposure Evaluation

- All fixed stations must perform an exposure evaluation.
  - Use online calculator (easiest)
  - Model exposure with software (difficult)
  - Measure RF power density (most difficult)
- At lower power levels, no evaluation is required. Varies with frequency – example: below 50 W at VHF.
- Re-evaluate exposure when station equipment or operating frequencies change.



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# Reducing RF Exposure

- Relocate or reorient antennas
- Raise the antenna
- Reduce antenna gain
- Reduce RF power output
- Change to a lower duty cycle mode

# Mobile Safety

- Mobile Installations
  - Secure all equipment
  - Place equipment where you can operate it safely while driving
  - Know local rules for use of communications equipment while driving
    - May need hands-free microphone

# Power Line Safety

- Keep antennas well away from power lines
- Check for power lines before installing antennas in trees
- Provide a minimum of 10 feet of clearance if antenna falls
- Never attach antennas or guy lines to utility poles or structures

# Tower Work

- Basic tower safety
  - Proper clothing, hard hat and eye protection
  - Use a proper climbing harness, not a lineman's belt or rock-climbing gear
  - Don't climb a crank-up tower supported only by its lift cable – block and secure it first
  - Use a gin pole to lift heavy items
  - Don't work alone – use a ground crew

# Practice Questions



# Which of the following is a safety hazard of a 12 volt storage battery?

- A. Touching both terminals with the hands can cause electrical shock
- B. Shorting the terminals can cause burns, fire, or an explosion
- C. RF emissions from the battery
- D. All of these choices are correct

T0A01 HRLM (9-3)

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T0A01 HRLM (9-3)

# How does current flowing through the body cause a health hazard?

- A. By heating tissue
- B. It disrupts the electrical functions of cells
- C. It causes involuntary muscle contractions
- D. All of these choices are correct

T0A02 HRLM (9-2)

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T0A02 HRLM (9-2)

# What is connected to the green wire in a three-wire electrical AC plug?

- A. Neutral
- B. Hot
- C. Safety ground
- D. The white wire

T0A03 HRLM (9-4)

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T0A03 HRLM (9-4)

# What is a good way to guard against electrical shock at your station?

- A. Use three-wire cords and plugs for all AC powered equipment
- B. Connect all AC powered station equipment to a common safety ground
- C. Use a circuit protected by a ground-fault interrupter
- D. All of these choices are correct

T0A06 HRLM (9-3)

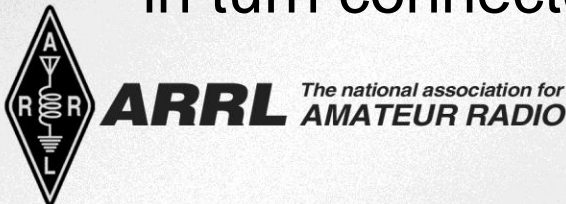
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T0A06 HRLM (9-3)

Which of these precautions should be taken when installing devices for lightning protection in a coaxial cable feed line?

- A. Include a parallel bypass switch for each protector so that it can be switched out of the circuit when running high power
- B. Include a series switch in the ground line of each protector to prevent RF overload from inadvertently damaging the protector
- C. Keep the ground wires from each protector separate and connected to station ground
- D. Ground all of the protectors to a common plate which is in turn connected to an external ground



T0A07 HRLM (9-5)

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T0A07 HRLM (9-5)

What safety equipment should always be included in home-built equipment that is powered from 120V AC power circuits?

- A. A fuse or circuit breaker in series with the AC "hot" conductor
- B. An AC voltmeter across the incoming power source
- C. An inductor in series with the AC power source
- D. A capacitor across the AC power source

T0A08 HRLM (9-4)



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T0A08 HRLM (9-4)



What kind of hazard might exist in a power supply when it is turned off and disconnected?

- A. Static electricity could damage the grounding system
- B. Circulating currents inside the transformer might cause damage
- C. The fuse might blow if you remove the cover
- D. You might receive an electric shock from the charged stored in large capacitors

T0A11 HRLM (9-3)



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T0A11 HRLM (9-3)

# When should members of a tower work team wear a hard hat and safety glasses?

- A. At all times except when climbing the tower
- B. At all times except when belted firmly to the tower
- C. At all times when any work is being done on the tower
- D. Only when the tower exceeds 30 feet in height

T0B01 HRLM (9-13)

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T0B01 HRLM (9-13)

# What is a good precaution to observe before climbing an antenna tower?

- A. Make sure that you wear a grounded wrist strap
- B. Remove all tower grounding connections
- C. Put on a climbing harness and safety glasses
- D. All of the these choices are correct

T0B02 HRLM (9-13)

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T0B02 HRLM (9-13)



# Under what circumstances is it safe to climb a tower without a helper or observer?

- A. When no electrical work is being performed
- B. When no mechanical work is being performed
- C. When the work being done is not more than 20 feet above the ground
- D. Never

T0B03 HRLM (9-14)



# Under what circumstances is it safe to climb a tower without a helper or observer?

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T0B03 HRLM (9-14)

Which of the following is an important safety precaution to observe when putting up an antenna tower?

- A. Wear a ground strap connected to your wrist at all times
- B. Insulate the base of the tower to avoid lightning strikes
- C. Look for and stay clear of any overhead electrical wires
- D. All of these choices are correct

T0B04 HRLM (9-12)



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T0B04 HRLM (9-12)



# What is the purpose of a gin pole?

- A. To temporarily replace guy wires
- B. To be used in place of a safety harness
- C. To lift tower sections or antennas
- D. To provide a temporary ground

T0B05 HRLM (9-14)

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T0B05 HRLM (9-14)

What is the minimum safe distance from a power line to allow when installing an antenna?

- A. Half the width of your property
- B. The height of the power line above ground
- C. 1/2 wavelength at the operating frequency
- D. So that if the antenna falls unexpectedly, no part of it can come closer than 10 feet to the power wires

T0B06 HRLM (9-12)



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T0B06 HRLM (9-12)



Which of the following is an important safety rule to remember when using a crank-up tower?

- A. This type of tower must never be painted
- B. This type of tower must never be grounded
- C. This type of tower must never be climbed unless it is in the fully retracted position
- D. All of these choices are correct

T0B07 HRLM (9-14)



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T0B07 HRLM (9-14)



# What is considered to be a proper grounding method for a tower?

- A. A single four-foot ground rod, driven into the ground no more than 12 inches from the base
- B. A ferrite-core RF choke connected between the tower and ground
- C. Separate eight-foot long ground rods for each tower leg, bonded to the tower and each other
- D. A connection between the tower base and a cold water pipe

T0B08 HRLM (9-13)

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T0B08 HRLM (9-13)

# Why should you avoid attaching an antenna to a utility pole?

- A. The antenna will not work properly because of induced voltages
- B. The utility company will charge you an extra monthly fee
- C. The antenna could contact high-voltage power wires
- D. All of these choices are correct

T0B09 HRLM (9-12)



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T0B09 HRLM (9-12)

# Which of the following is true concerning grounding conductors used for lightning protection?

- A. Only non-insulated wire must be used
- B. Wires must be carefully routed with precise right-angle bends
- C. Sharp bends must be avoided
- D. Common grounds must be avoided

T0B10 HRLM (9-4)

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T0B10 HRLM (9-4)

Which of the following establishes grounding requirements for an amateur radio tower or antenna?

- A. FCC Part 97 Rules
- B. Local electrical codes
- C. FAA tower lighting regulations
- D. Underwriters Laboratories' recommended practices

T0B11 HRLM (9-4)



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T0B11 HRLM (9-4)



Which of the following is good practice when installing ground wires on a tower for lightning protection?

- A. Put a loop in the ground connection to prevent water damage to the ground system
- B. Make sure that all bends in the ground wires are clean, right angle bends
- C. Ensure that connections are short and direct
- D. All of these choices are correct

T0B12 HRLM (9-4)

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T0B12 HRLM (9-4)



# What type of radiation are VHF and UHF radio signals?

- A. Gamma radiation
- B. Ionizing radiation
- C. Alpha radiation
- D. Non-ionizing radiation

T0C01 HRLM (9-5)

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T0C01 HRLM (9-5)

Which of the following frequencies has the lowest Maximum Permissible Exposure limit?

- A. 3.5 MHz
- B. 50 MHz
- C. 440 MHz
- D. 1296 MHz

T0C02 HRLM (9-7)



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T0C02 HRLM (9-7)



What is the maximum power level that an amateur radio station may use at VHF frequencies before an RF exposure evaluation is required?

- A. 1500 watts PEP transmitter output
- B. 1 watt forward power
- C. 50 watts PEP at the antenna
- D. 50 watts PEP reflected power

T0C03 HRLM (9-9)



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T0C03 HRLM (9-9)



# What factors affect the RF exposure of people near an amateur station antenna?

- A. Frequency and power level of the RF field
- B. Distance from the antenna to a person
- C. Radiation pattern of the antenna
- D. All of these choices are correct

T0C04 HRLM (9-9)

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T0C04 HRLM (9-9)

# Why do exposure limits vary with frequency?

- A. Lower frequency RF fields have more energy than higher frequency fields
- B. Lower frequency RF fields do not penetrate the human body
- C. Higher frequency RF fields are transient in nature
- D. The human body absorbs more RF energy at some frequencies than at others

T0C05 HRLM (9-6)

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T0C05 HRLM (9-6)

Which of the following is an acceptable method to determine that your station complies with FCC RF exposure regulations?

- A. By calculation based on FCC OET Bulletin 65
- B. By calculation based on computer modeling
- C. By measurement of field strength using calibrated equipment
- D. All of these choices are correct

T0C06 HRLM (9-9)



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T0C06 HRLM (9-9)



What could happen if a person accidentally touched your antenna while you were transmitting?

- A. Touching the antenna could cause television interference
- B. They might receive a painful RF burn
- C. They might develop radiation poisoning
- D. All of these choices are correct

T0C07 HRLM (9-6)



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T0C07 HRLM (9-6)



Which of the following actions might amateur operators take to prevent exposure to RF radiation in excess of FCC-supplied limits?

- A. Relocate antennas
- B. Relocate the transmitter
- C. Increase the duty cycle
- D. All of these choices are correct

T0C08 HRLM (9-10)



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T0C08 HRLM (9-10)



# How can you make sure your station stays in compliance with RF safety regulations?

- A. By informing the FCC of any changes made in your station
- B. By re-evaluating the station whenever an item of equipment is changed
- C. By making sure your antennas have low SWR
- D. All of these choices are correct

T0C09 HRLM (9-9)



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T0C09 HRLM (9-9)



# Why is duty cycle one of the factors used to determine safe RF radiation exposure levels?

- A. It affects the average exposure of people to radiation
- B. It affects the peak exposure of people to radiation
- C. It takes into account the antenna feed line loss
- D. It takes into account the thermal effects of the final amplifier

T0C10 HRLM (9-7)



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T0C10 HRLM (9-7)



# What is the definition of duty cycle during the averaging time for RF exposure?

- A. The difference between the lowest power output and the highest power output of a transmitter
- B. The difference between the PEP and average power output of a transmitter
- C. The percentage of time that a transmitter is transmitting
- D. The percentage of time that a transmitter is not transmitting

T0C11 HRLM (9-7)

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T0C11 HRLM (9-7)

# How does RF radiation differ from ionizing radiation (radioactivity)?

- A. RF radiation does not have sufficient energy to cause genetic damage
- B. RF radiation can only be detected with an RF dosimeter
- C. RF radiation is limited in range to a few feet
- D. RF radiation is perfectly safe

T0C12 HRLM (9-5)

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T0C12 HRLM (9-5)

If the averaging time for exposure is 6 minutes, how much power density is permitted if the signal is present for 3 minutes and absent for 3 minutes rather than being present for the entire 6 minutes?

- A. 3 times as much
- B. 1/2 as much
- C. 2 times as much
- D. There is no adjustment allowed for shorter exposure times

T0C13 HRLM (9-7)



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