Technician License Course

KE6HEC February 11, 2021

Technician License Course

Chapter 9

Lesson Plan Module – 18

Safety & Amateur Radio

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

Current	*Reaction*
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.

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

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

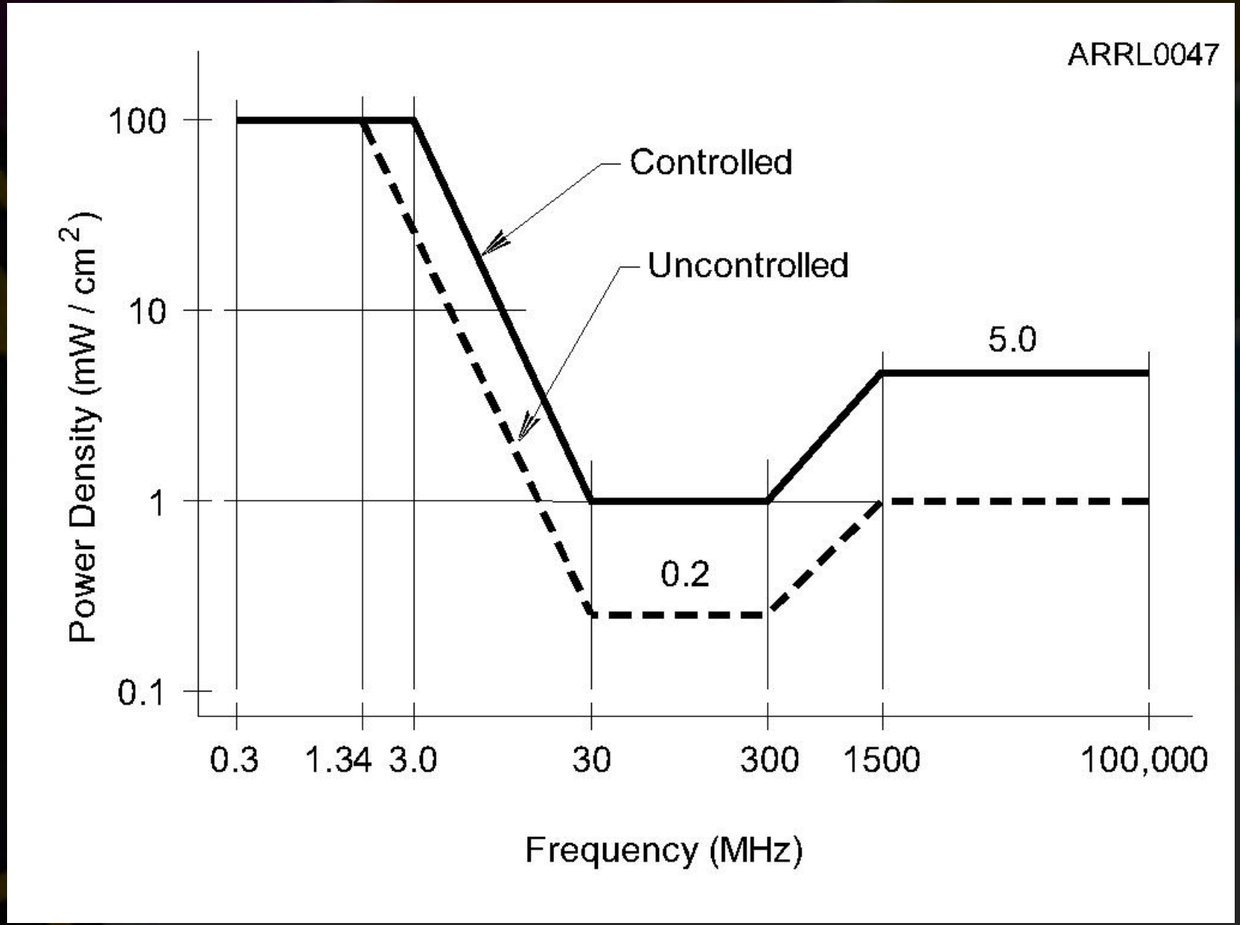
RF Exposure

- 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 (w/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)



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.

RF Environment

- 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%
  - Duty cycle = 100 x (time on / 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

Mode	*Duty Cycle*
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%

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)

RF Exposure Evaluation

- 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.

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

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Practice Questions

What is a safety hazard of a 12 voltage storage battery?

What is a safety hazard of a 12 voltage storage battery?

Shorting the terminals can cause burns, fire, or an explosion

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

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

By heating tissue
It disrupts the electrical functions of cells
It causes involuntary muscle contractions

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

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

Safety ground

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

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

- Use three-wire cords and plugs for all AC powered equipment
- Connect all AC powered station equipment to a common safety ground
- Use a circuit protected by a ground-fault interrupter

What precaution should be taken when installing devices for lightning protection in a coaxial cable feed line?

What precaution should be taken when installing devices for lightning protection in a coaxial cable feed line?

Ground all of the protectors to a common plate which is in turn connected to an external ground

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

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

A fuse or circuit breaker in series with the AC "hot" conductor

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

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

You might receive an electric shock from the charged stored in large capacitors

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

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

At all times when any work is being done on the tower

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

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

Put on a climbing harness and safety glasses

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

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

Never

What is an important safety precaution to observe when putting up an antenna tower?

What is an important safety precaution to observe when putting up an antenna tower?

Look for and stay clear of any overhead electrical wires

What is the purpose of a gin pole?

What is the purpose of a gin pole?

To lift tower sections or antennas

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

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

So that if the antenna falls unexpectedly, no part of it can come closer than 10 feet to the power wires

What is an important safety rule to remember when using a crank-up tower?

What is an important safety rule to remember when using a crank-up tower?

This type of tower must never be climbed unless it is in the fully retracted position

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

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

Separate eight-foot long ground rods for each tower leg, bonded to the tower and each other

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

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

The antenna could contact high-voltage power wires

What is true concerning grounding conductors used for lightning protection?

What is true concerning grounding conductors used for lightning protection?

Sharp bends must be avoided

What establishes grounding requirements for an amateur radio tower or antenna?

What establishes grounding requirements for an amateur radio tower or antenna?

Local electrical codes

What is good practice when installing ground wires on a tower for lightning protection?

What is good practice when installing ground wires on a tower for lightning protection?

Ensure that connections are short and direct

What type of radiation are VHF and UHF radio signals?

What type of radiation are VHF and UHF radio signals?

Non-ionizing radiation

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

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

50 watts PEP at the antenna

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

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

Frequency and power level of the RF field
Distance from the antenna to a person
Radiation pattern of the antenna

Why do exposure limits vary with frequency?

Why do exposure limits vary with frequency?

The human body absorbs more RF energy at some frequencies than at others

What is an acceptable method to determine that your station complies with FCC RF exposure regulations?

What is an acceptable method to determine that your station complies with FCC RF exposure regulations?

By calculation based on FCC OET Bulletin 65
By calculation based on computer modeling
By measurement of field strength using calibrated equipment

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

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

They might receive a painful RF burn

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

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

Relocate antennas

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

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

By re-evaluating the station whenever an item of equipment is changed

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

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

It affects the average exposure of people to radiation

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

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

The percentage of time that a transmitter is transmitting

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

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

RF radiation does not have sufficient energy to cause genetic damage

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?

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?

2 times as much

End of Module 18