General License Class

Chapter 9

Safety

Electrical Safety

- Basic Safety
  - Install a master ON/OFF switch for station & workbench.
    - Located away from station & workbench.
    - Clearly labeled.
    - Train family members & safety observers about location & proper use of switch.

Electrical Safety

- Basic Safety
  - Be aware of your surroundings.
    - Avoid placing yourself in harm's way.
      - Avoid locations or positions where likelihood of exposure to shock hazard.
      - Avoid locations or positions where hard to rescue.

Electrical Safety

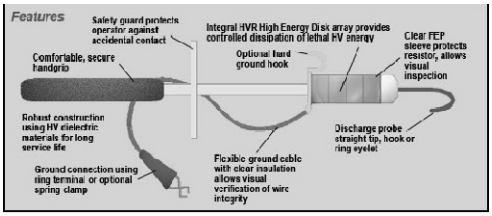
- Basic Safety
  - **Do NOT work on "live" circuits unless ABSOLUTELY necessary.**
    - If you must work on live equipment:
      - **ALWAYS** have a second person present to act as safety observer.
      - Keep one hand in pocket
      - Wear shoes with insulated soles.
      - Remove unnecessary jewelry.

Electrical Safety

- Basic Safety
  - **NEVER** assume equipment is off or circuit is de-energized.
    - Check with meter first.
  - When working on feedlines or antennas:
    - Turn off the transmitter.
    - Disconnect the feed line.

Electrical Safety

- Basic Safety
  - When working inside equipment:
    - Insulate or otherwise secure all loose wires.
    - Use bleeder resistor or grounding stick to make certain capacitors are discharged.



Electrical Safety

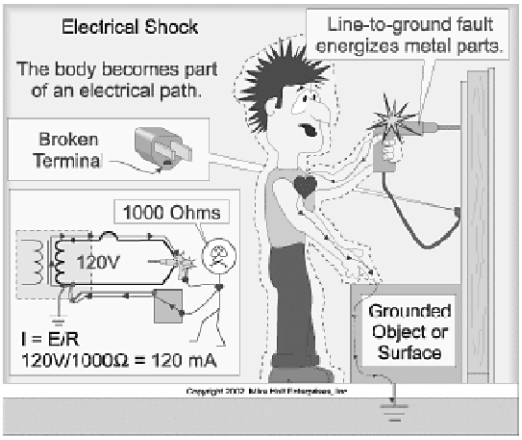
- Soldering and Lead
  - Standard solder is a mixture of tin & lead.
  - Heat of soldering is NOT enough to generate significant quanties of lead vapor.
    - Vapors are from rosin.
  - Main danger is from ingestion by not washing hands after handling solder.

Electrical Safety

- Soldering and Lead
  - The European Union adopted the Reduction of Hazardous Substances (RoHS) Directive in 2003.
    - Banned the use of lead containing solder in any electrical or electronic product manufactured or sold in the European Union effective July 1, 2006.
    - Manufacturers world-wide have switched to lead-free solder.
    - Printed circuit boards originally manufactured with lead-free solder should not be repaired with standard solder.

Electrical Safety

- Electrical Shock



Electrical Safety

- Electrical Shock
  - The National Safety Council estimates that nearly 300 people die in the United States each year from electric shocks on 120V or 277V circuits.
  - An electric shock from as little as 50VAC for as little as 1 sec can disrupt the heart's rhythm, causing death in a matter of minutes.

Electrical Safety

- Electrical Shock
  - The current does the damage.
    - High voltage is more dangerous ONLY because of Ohm's Law.
      - I = E / R means higher voltage → higher current.
    - Resistance of human body is 1 kΩ to 1.5 kΩ.
      - Can range from a few hundred ohms to tens of kilohms.
      - High voltages can penetrate skin, greatly reducing resistance.

Electrical Safety

- Electrical Shock
  - The current does the damage.

Description	Current Level	Physiological Effect
Threshold	1-5 mA	Tingling Sensation
Pain	5-8 mA	Intense or Painful Sensation
"Can't Let Go"	8-20 mA	Involuntary muscle contraction
Paralysis	>20 mA	Respiratory paralysis and pain
Fibrillation	**75-1000 mA**	**Ventricular fibrillation**
Defibrillation	>1000 mA	Sustained myocardial contraction and possible tissue burns

Electrical Safety

- Electrical Shock
  - Fibrillation level
    - Function of current over time.
      - 500mA over 0.2 sec → fibrillation.
      - 75mA over 0.5 sec. → fibrillation.
    - Immediate unconsciousness.
    - **Have safety observer who knows CPR!**

Electrical Safety

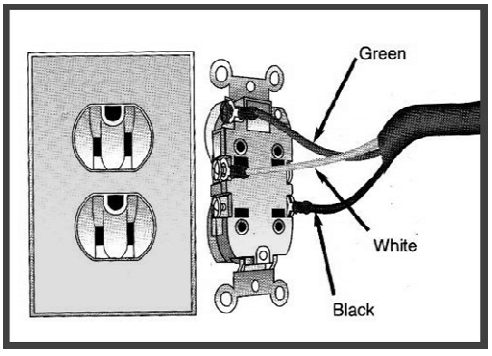
- Wiring & Safety Grounding
  - National Electrical Code (NEC).
  - Local building codes.
  - Wire size.
    - 15A circuit = #14 AWG.
    - 20A circuit = #12 AWG.
    - 30A circuit = #10 AWG.

Electrical Safety

- Wiring & Safety Grounding
  - Color codes.
    - Hot = Black or Red.
      - Brass-colored terminal or screw.
    - Neutral = White.
      - Silver-colored terminal or screw.
    - Ground = Green or uninsulated (bare copper).
      - Green-colored or bare copper terminal or screw.
      - ALWAYS connected to chassis.

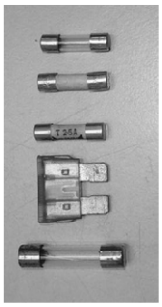
Electrical Safety

- Wiring & Safety Grounding
  - Color codes.



Electrical Safety

- Protective Components
  - Prevent equipment damage.
  - Prevent safety hazards.
  - Fuses & circuit breakers.
    - Fast-acting.
    - Time delay or slo-blo.



Electrical Safety

- Protective Components
  - Shock prevention.
    - Safety interlock.
      - Opens circuit if enclosure is opened.
      - Shorts high voltage to ground if enclosure is opened.

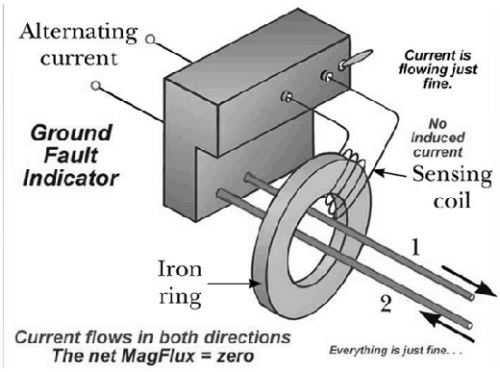
Electrical Safety

- Protective Components
  - Shock prevention.
    - Ground fault circuit interrupter (GFCI).
      - Opens circuit if currents in hot & neutral wires are not equal by more than a few mA.



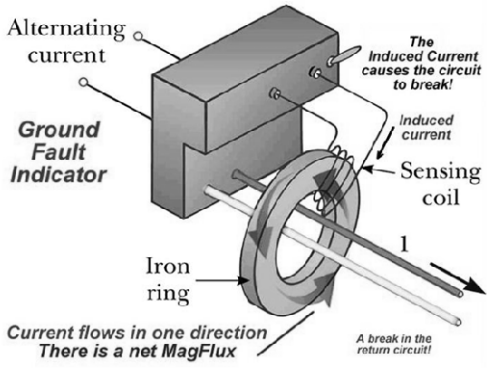
Electrical Safety

- Protective Components
  - Shock prevention



Electrical Safety

- Protective Components
  - Shock prevention



Electrical Safety

- Generator Safety
  - Installation.
    - Always use in an open, well-ventilated area.
      - Always outside.
      - Never in an enclosed space -- not even in a garage.
    - Locate fire extinguisher near generator but away from fuel.
    - Connect generator frame to a ground rod installed at the generator location.

Electrical Safety

- Generator Safety
  - Refueling.
    - Always shut down generator while refueling.
    - Always have 2nd person present with fire extinguisher.
    - Never store fuel near generator.
      - Especially near exhaust.

Electrical Safety

- Generator Safety
  - Connecting to house wiring.
    - Use an approved transfer switch.
      - Disconnects house wiring from power company wiring.
    - Open main breakers & connect generator on house side of breakers.

Electrical Safety

- Generator Safety
  - Connecting to house wiring.
    - If not disconnected from power company wiring:
      - Can back feed into power system & expose power line workers to lethal voltages.
      - When power is restored, can damage your generator.

Electrical Safety

- Lightning
  - Prevent fire.
  - Reduce or prevent damage to equipment.

Electrical Safety

- Lightning
  - Before the storm.
    - Disconnect all cables outside of the house.
    - Unplug equipment power plugs inside the house.
      - Also, disconnect telephone lines & PC connections.

Electrical Safety

- Lightning
  - When installing station.
    - Install grounded metal entry panel for all feedlines & control cables.
      - Connect to ground rod with short, heavy metal strap.
      - Install lightning arrestors on entry panel.
    - Bond ALL ground rods together & to AC wiring safety ground.
    - **NEVER** use soldered connections.

G0B01 -- Which wire or wires in a four-conductor connection should be attached to fuses or circuit breakers in a device operated from a 240-VAC single-phase source?

➡ A. Only the two wires carrying voltage

B. Only the neutral wire

C. Only the ground wire

D. All wires

G0B02 -- What is the minimum wire size that may be safely used for a circuit that draws up to 20 amperes of continuous current?

A. AWG number 20

B. AWG number 16

➡ C. AWG number 12

D. AWG number 8

G0B03 -- Which size of fuse or circuit breaker would be appropriate to use with a circuit that uses AWG number 14 wiring?

A. 100 amperes
B. 60 amperes
C. 30 amperes
➡ D. 15 amperes

G0B04 -- Which of the following is a primary reason for not placing a gasoline-fueled generator inside an occupied area?

➡ A. Danger of carbon monoxide poisoning
B. Danger of engine over torque
C. Lack of oxygen for adequate combustion
D. Lack of nitrogen for adequate combustion

G0B05 -- Which of the following conditions will cause a Ground Fault Circuit Interrupter (GFCI) to disconnect the 120 or 240 Volt AC line power to a device?

A. Current flowing from one or more of the voltage-carrying wires to the neutral wire

➡ B. Current flowing from one or more of the voltage-carrying wires directly to ground

C. Over-voltage on the voltage-carrying wires

D. All of these choices are correct

G0B06 -- Why must the metal enclosure of every item of station equipment be grounded?

A. It prevents blowing of fuses in case of an internal short circuit

B. It prevents signal overload

C. It ensures that the neutral wire is grounded

➡ D. It ensures that hazardous voltages cannot appear on the chassis

G0B09 -- Why should soldered joints not be used with the wires that connect the base of a tower to a system of ground rods?

A. The resistance of solder is too high
B. Solder flux will prevent a low conductivity connection
C. Solder has too high a dielectric constant to provide adequate lightning protection
➡ D. A soldered joint will likely be destroyed by the heat of a lightning strike

G0B10 -- Which of the following is a danger from lead-tin solder?

➡ A. Lead can contaminate food if hands are not washed carefully after handling the solder
B. High voltages can cause lead-tin solder to disintegrate suddenly
C. Tin in the solder can “cold flow” causing shorts in the circuit
D. RF energy can convert the lead into a poisonous gas

G0B11 -- Which of the following is good engineering practice for lightning protection grounds?

A. They must be bonded to all buried water and gas lines
B. Bends in ground wires must be made as close as possible to a right angle
C. Lightning grounds must be connected to all ungrounded wiring
➡ D. They must be bonded together with all other grounds

G0B12 -- What is the purpose of a power supply interlock?

A. To prevent unauthorized changes to the circuit that would void the manufacturer's warranty
B. To shut down the unit if it becomes too hot
➡ C. To ensure that dangerous voltages are removed if the cabinet is opened
D. To shut off the power supply if too much voltage is produced

G0B13 -- What must you do when powering your house from an emergency generator?

➡ A. Disconnect the incoming utility power feed

B. Insure that the generator is not grounded

C. Insure that all lightning grounds are disconnected

D. All of these choices are correct

G0B14 -- Which of the following is covered by the National Electrical Code?

A. Acceptable bandwidth limits

B. Acceptable modulation limits

➡ C. Electrical safety inside the ham shack

D. RF exposure limits of the human body

G0B15 -- Which of the following is true of an emergency generator installation?

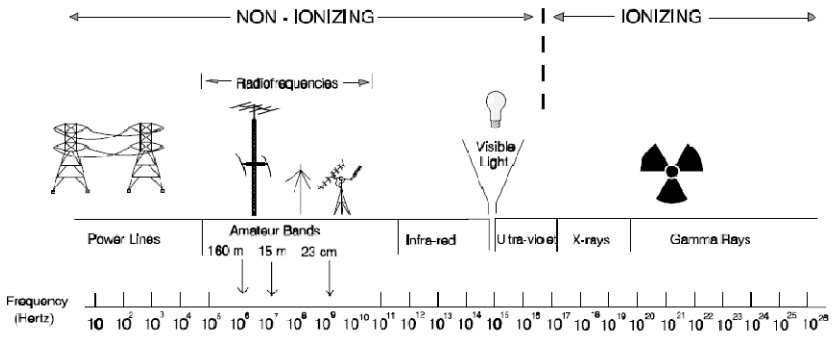
A. The generator should be located in a well-ventilated area
B. The generator must be insulated from ground
C. Fuel should be stored near the generator for rapid refueling in case of an emergency
D. All of these choices are correct

RF Exposure

- Do not confuse RF radiation with other types of radiation.
  - Two categories of radiation:
    - Non-ionizing radiation.
      - Only effect is heating of body tissues.
      - RF radiation.
    - Ionizing radiation.
      - Can cause genetic damage.
      - Ultra-violet light, x-rays, & nuclear radiation.

RF Exposure

- Ionizing and Non-Ionizing Radiation.



RF Exposure

- At low levels, RF energy is not dangerous.
- At higher levels, heating of body tissues can occur.
  - Depends on:
    - Frequency.
    - Power density.
    - Duty cycle.
    - Average exposure time.

RF Exposure

- Power Density.
  - Heating is caused by body absorbing RF energy.
  - Intensity of RF energy called power density.
    - Measured in mW/cm^2.
    - For example:
      - Power density = 10 mW/cm^2.
      - Hand = 75 cm^2.
      - Power absorbed = 750 mW.

RF Exposure

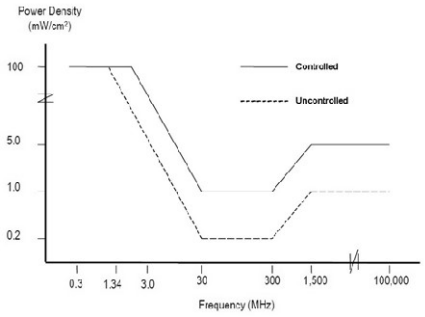
- Power Density.
  - Higher transmitter power → higher power density.
  - Higher antenna gain → higher power density.

RF Exposure

- Absorption and Limits.
  - Specific absorption rate (SAR).
    - Rate at which the body absorbs RF energy.
    - Varies with frequency & size of body part.
      - Range of highest SAR is 30 MHz to 1.5 GHz.
      - Torso & limbs -- Highest at VHF (30 MHz to 300 MHz).
      - Head – Highest at UHF (300 MHz to 3 GHz).
      - Eyes – Highest at microwave frequencies (> 1 GHz).

RF Exposure

- Absorption and Limits.
  - Maximum permissible exposure (MPE).
    - Highest level of exposure allowed by FCC regulations.
    - Varies by frequency.
    - Based on SAR & averaged over time.



Break

RF Exposure

- Averaging and Duty Cycle.
  - Exposure to RF is averaged over specified time periods.
    - Body responds differently to long duration and short duration exposure.
    - Different “environments” are averaged over different time periods.
      - Controlled environment.
      - Uncontrolled environment.

RF Exposure

- Averaging and Duty Cycle.
  - Controlled environment.
    - Areas where occupants are aware of and knowledgeable about RF exposure.
    - Exposure averaged over 6-minute period.
    - Higher MPE limits.

RF Exposure

- Averaging and Duty Cycle.
  - Uncontrolled environment.
    - Areas accessible to persons unaware of RF exposure.
    - Exposure averaged over 30-minute period.
    - Lower MPE limits.

RF Exposure

- Averaging and Duty Cycle.
  - Operating Duty cycle.
    - Ratio of transmitter on time to total time during the exposure.
    - Less talk time & more listen time allows higher power densities.

RF Exposure

- Averaging and Duty Cycle.
  - Emission Duty cycle.
    - Transmitter may not be at full output power all of the time depending on mode.
    - Typical duty cycles:
      - SSB (unprocessed) = 20% to 25%.
      - SSB (processed) = 40%.
      - CW = 40%.
      - FM & Digital = 100%.

RF Exposure

- Estimating Exposure & Station Evaluation
  - All amateur stations must evaluate RF exposure potential.
    - Mobile & portable stations are exempt.
    - Fixed stations are exempt if transmitter output power is below specified limits.
      - Limits vary by frequency.
      - Only have to evaluate transmitters that exceed the specified power output limits.

RF Exposure

- Estimating Exposure & Station Evaluation.
  - Power thresholds for RF Exposure Evaluation.

HF	
160m, 80m, 40m	500W
30m	425W
20m	225W
17m	125W
15m	100W
12m	75W
10m	50W

VHF/UHF/Microwave	
6m	50W
2m	50W
1.25m	50W
70cm	70W
33cm	150W
23cm	200W
13cm & up	250W

RF Exposure

- Estimating Exposure and Station Evaluation.
  - Methods of Evaluating RF Exposure.
    - Calibrated field strength meter.

RF Exposure

- Estimating Exposure and Station Evaluation.
  - Methods of Evaluating RF Exposure.
    - Calculate using formulas.
      - Use charts based on formulas.
      - Use software based on formulas.

RF Exposure

- Estimating Exposure and Station Evaluation.
  - Methods of Evaluating RF Exposure.
    - Calculate using formulas.
      - Need to know:
        - Transmitter output power.
        - Feedline loss.
        - Antenna gain.
        - Antenna height above ground.
        - Frequency.

RF Exposure

- Exposure Safety Measures.
  - Locate antennas where people cannot get near them.
    - Mount antennas as high as possible.
  - Don’t point antennas at occupied locations.
    - Use extra care with high-gain antennas used for VHF/UHF/microwave frequencies.
      - Long Yagi antennas.
      - Microwave dish antennas.

RF Exposure

- Exposure Safety Measures.
  - Carefully evaluate exposure from “stealth” antennas.
  - Locate VHF/UHF mobile antennas on roof of vehicle or on trunk lid.
  - Use external microphone with handheld radios.

RF Exposure

- Exposure Safety Measures.
  - Use a dummy load when testing transmitter.
  - Reduce power of your transmissions.
    - §97.313(a) An amateur station must use the minimum transmitter power necessary to carry out the desired communications.
  - Reduce duty cycle of your transmissions.
    - Listen more, talk less.

G0A01 -- What is one way that RF energy can affect human body tissue?

➡ A. It heats body tissue

B. It causes radiation poisoning

C. It causes the blood count to reach a dangerously low level

D. It cools body tissue

G0A02 -- Which of the following properties is important in estimating whether an RF signal exceeds the maximum permissible exposure (MPE)?

A. Its duty cycle

B. Its frequency

C. Its power density

➡ D. All of these choices are correct

G0A03 -- How can you 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

G0A04 -- What does "time averaging" mean in reference to RF radiation exposure?

A. The average amount of power developed by the transmitter over a specific 24 hour period
B. The average time it takes RF radiation to have any long-term effect on the body
C. The total time of the exposure
➡ D. The total RF exposure averaged over a certain time

G0A05 -- What must you do if an evaluation of your station shows RF energy radiated from your station exceeds permissible limits?

A. Take action to prevent human exposure to the excessive RF fields
B. File an Environmental Impact Statement (EIS-97) with the FCC
C. Secure written permission from your neighbors to operate above the controlled MPE limits
D. All of these choices are correct

G0A06 -- What precaution should be taken when installing a ground-mounted antenna?

A. It should not be installed higher than you can reach
B. It should not be installed in a wet area
C. It should limited to 10 feet in height
D. It should be installed such that it is protected against unauthorized access

G0A07 -- What effect does transmitter duty cycle have when evaluating RF exposure?

A. A lower transmitter duty cycle permits greater short-term exposure levels
B. A higher transmitter duty cycle permits greater short-term exposure levels
C. Low duty cycle transmitters are exempt from RF exposure evaluation requirements
D. High duty cycle transmitters are exempt from RF exposure requirements

G0A08 -- Which of the following steps must an amateur operator take to ensure compliance with RF safety regulations when transmitter power exceeds levels specified in FCC Part 97.13?

A. Post a copy of FCC Part 97.13 in the station
B. Post a copy of OET Bulletin 65 in the station
C. Perform a routine RF exposure evaluation
D. All of these choices are correct

G0A09 -- What type of instrument can be used to accurately measure an RF field?

A. A receiver with an S meter

➡ B. A calibrated field-strength meter with a calibrated antenna

C. An SWR meter with a peak-reading function

D. An oscilloscope with a high-stability crystal marker generator

G0A10 -- What is one thing that can be done if evaluation shows that a neighbor might receive more than the allowable limit of RF exposure from the main lobe of a directional antenna?

A. Change to a non-polarized antenna with higher gain

B. Post a warning sign that is clearly visible to the neighbor

C. Use an antenna with a higher front-to-back ratio

➡ D. Take precautions to ensure that the antenna cannot be pointed in their direction

G0A11 -- What precaution should you take if you install an indoor transmitting antenna?

A. Locate the antenna close to your operating position to minimize feed-line radiation

B. Position the antenna along the edge of a wall to reduce parasitic radiation

➡ C. Make sure that MPE limits are not exceeded in occupied areas

D. Make sure the antenna is properly shielded

Outdoor Safety

- Installing Antennas
  - **Place antennas well clear of power lines!**
    - At least 150% of height of antenna system from nearest power line.
      - 40 ft tower or mast with 10-ft antenna should be at least 75 feet from power lines.
    - If using sling-shot or bow & arrow to shoot support line into tree, make certain flight path beyond tree is clear of power lines.

Outdoor Safety

- Installing Antennas
  - **Place antennas well clear of power lines!**
    - **NEVER** run feedlines over or under power lines, including service drops.

Outdoor Safety

- Installing Antennas
  - Make certain people cannot come in contact with antenna after installation.
    - Put fence around ground-mounted antennas.
  - Follow manufacturer's instructions during installation.

Outdoor Safety

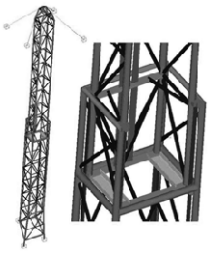
- Towers, Masts, & Hardware
  - Pipe masts.
    - Up to 20-30 feet.
    - Bracketed to side of building.
  - Push-up masts.
    - Up to 50 feet.
    - Must be guyed.

Outdoor Safety

- Towers, Masts, & Hardware
  - Fixed towers.
    - 8-ft or 10-ft sections.
    - Up to 200 feet or more.
    - Normally must be guyed.

Outdoor Safety

- Towers, Masts, & Hardware
  - Telescoping towers.
    - Up to 120 feet or more.
    - Normally self-supporting, but may be guyed.



Outdoor Safety

- Towers, Masts, & Hardware
  - Fold-over towers.
    - Fixed tower with special mounting base .

Outdoor Safety

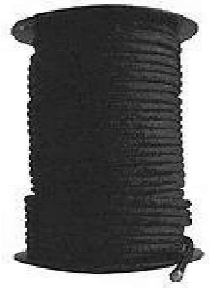
- Towers, Masts, & Hardware
  - Hardware.
    - Stainless steel.
      - Anti-seize compound.
    - Galvanized.

Outdoor Safety

- Towers, Masts, & Hardware
  - Hardware.
    - Coaxial cable should have UV-resistant jacket.
    - If burying coaxial cable, use conduit or PVC pipe.
      - Coaxial cable designed for direct bury.

Outdoor Safety

- Towers, Masts, & Hardware
  - Hardware.
    - Ropes should be UV-resistant.
      - Black.
      - Dacron.
      - Polyester.
      - Nylon.
      - Polypropylene. **(Yuck!)**



Outdoor Safety

- Performing Antenna & Tower Maintenance
  - Wear appropriate safety gear.

Outdoor Safety

- Performing Antenna & Tower Maintenance
  - Wear appropriate safety gear.
    - Climbing harness.
    - Safety helmet.
    - Boots or work shoes.
    - Safety goggles.
    - Gloves.
    - Don’t forget the sunscreen!

Outdoor Safety

- Performing Antenna & Tower Maintenance
  - Wear appropriate safety gear.
    - Not just climber.
    - Ground crew also.
      - Especially safety helmet.

Outdoor Safety

- Performing Antenna & Tower Maintenance
  - Handheld amateur or FRS radios for communications between climbers & ground crew.

Outdoor Safety

- Performing Antenna & Tower Maintenance
  - Before climbing:
    - Inspect all guy wires & hardware.
    - Crank-up towers all the way down.
    - Double check climbing gear -- belts, lanyards, & fasteners.
    - Inspect all ropes & pulleys.

Outdoor Safety

- Performing Antenna & Tower Maintenance
  - Before climbing:
    - Remove power from all circuits feeding the tower.
      - Lock-out / tag-out.
    - Disconnect transmitters & feedlines.

Outdoor Safety

- Performing Antenna & Tower Maintenance
  - While climbing:
    - **SLOW DOWN!** – Speed kills.
    - Carabiners completely closed.
    - Latch hooks with opening away from tower.
    - **ALWAYS** use safety lanyard or redundant lanyards.

G0A12 -- What precaution should you take whenever you make adjustments or repairs to an antenna?

A. Ensure that you and the antenna structure are grounded

➡ B. Turn off the transmitter and disconnect the feed line

C. Wear a radiation badge

D. All of these choices are correct

G0B07 -- Which of these choices should be observed when climbing a tower using a safety belt or harness?

A. Never lean back and rely on the belt alone to support your weight

➡ B. Confirm that the belt is rated for the weight of the climber and that it is within its allowable service life

C. Ensure that all heavy tools are securely fastened to the belt D-ring

D. All of these choices are correct

G0B08 -- What should be done by any person preparing to climb a tower that supports electrically powered devices?

A. Notify the electric company that a person will be working on the tower

➡ B. Make sure all circuits that supply power to the tower are locked out and tagged

C. Unground the base of the tower

D. All of these choices are correct

Questions?

Next Week Exam