General License Class

1

General Class

Chapter 9

Safety

2

Electrical Safety

Preventing 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 short a time as 1 second can disrupt the heart's rhythm, causing death in a matter of minutes.

3

Electrical Safety

Preventing Electrical Shock

- It is the current that does the damage.
  - High voltage is more dangerous **ONLY** because of Ohm's Law.
    - I = E / R
    - Higher voltage → higher current.

4

Electrical Safety

Preventing Electrical Shock

- Typically, the resistance of the human body is 1 kΩ to 1.5 kΩ.
  - The resistance can range from a few hundred ohms to tens of kilohms.
  - High voltages can penetrate the skin more easily, thereby greatly reducing the resistance.

5

Electrical Safety

Preventing Electrical Shock

- It is the current that 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

6

Electrical Safety

Preventing Electrical Shock

- Fibrillation level
  - The amount of electrical shock necessary to cause ventricular fibrillation is a function of current over time.
    - 500mA over 0.2 sec → fibrillation.
    - 75mA over 0.5 sec. → fibrillation.
  - Fibrillation causes immediate unconsciousness.
  - **Have a safety observer who knows CPR!**

7

Electrical Safety

Preventing Electrical Shock

- 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.

8

Electrical Safety

Preventing Electrical Shock

- 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.

9

Electrical Safety

Preventing Electrical Shock

- **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.

10

Electrical Safety

Preventing Electrical Shock

- **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.

11

Electrical Safety

Preventing Electrical Shock

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

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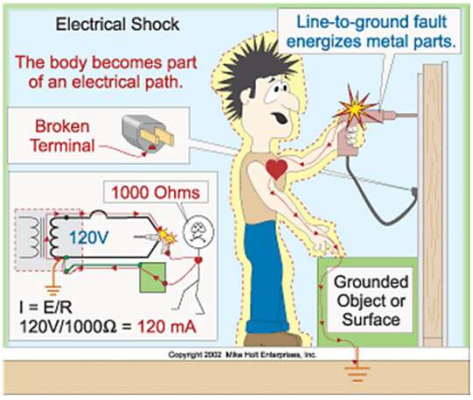
Electrical Safety

Preventing Electrical Shock



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Electrical Safety

Soldering Safety

- Standard solder is a mixture of tin & lead.
- The heat of soldering is **NOT** enough to generate significant quantities of lead vapor.
  - The vapors produced are from heating the rosin.
- The main danger is from the ingestion of lead by not washing your hands after handling solder.

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Electrical Safety

Soldering Safety

- The European Union adopted the Reduction of Hazardous Substances (RoHS) Directive in 2003.
  - This directive banned the use of solder that contains lead in any electrical or electronic product manufactured or sold in the European Union effective July 1, 2006.

15

Electrical Safety

Soldering Safety

- Manufacturers world-wide have switched to using lead-free solder.
- Printed circuit boards that were originally manufactured with lead-free solder should not be repaired using standard solder.

16

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

17

Electrical Safety

Wiring Practices

- Power wiring circuits in your station should comply with:
  - The National Electrical Code (NEC).
  - Local building codes.

18

Electrical Safety

Wiring Practices

- You should **ALWAYS** adhere to the standard color codes when installing power circuits.
  - 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.

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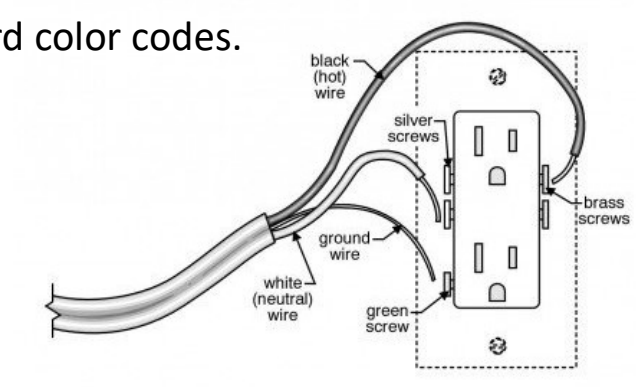
Electrical Safety

Wiring Practices

- Standard color codes.



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Electrical Safety

Wiring Practices

- The minimum wire sizes that should be used for power circuits and extension cords are:
  - 15A circuit = #14 AWG.
  - 20A circuit = #12 AWG.
  - 30A circuit = #10 AWG.

21

Electrical Safety

Protective Components

- Protective components prevent equipment damage & safety hazards.
- Common types of protective components are:
  - Fuses.
  - Circuit breakers.
  - Ground fault circuit interrupters.

22

Electrical Safety

Protective Components

- Fuses have a small piece of metal which melts when the current exceeds the rated value.
  - Most fuses are fast-acting.
  - Some fuses have a time delay (Slo-Blo).

23

Electrical Safety

Protective Components

- Circuit breakers interrupt the current by opening a switch when the current exceeds the rated value.
  - Circuit breakers are re-useable.

24

Electrical Safety

Protective Components

- A fuse or a circuit breaker **MUST** be installed in the hot wire of a 120-volt circuit or piece of equipment.
- Fuses or circuit breakers **MUST** be installed in **BOTH** hot wires of a 240-volt circuit or piece of equipment.

25

Electrical Safety

Protective Components

- **NEVER** install a fuse or circuit breaker in the neutral or ground wires.

26

Electrical Safety

Protective Components

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



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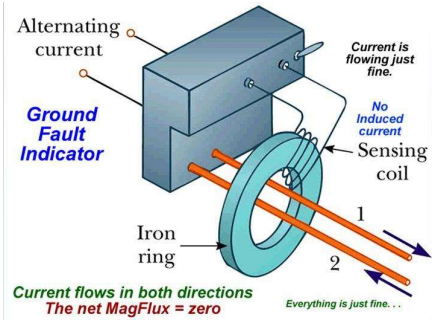
Electrical Safety

Protective Components

- Shock prevention



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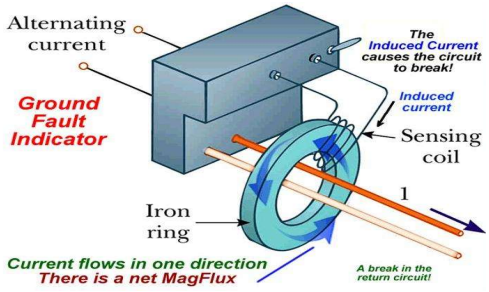
Electrical Safety

Protective Components

- Shock prevention



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Electrical Safety

Protective Components

- Shock prevention.
  - A common way to prevent shock is the use of a safety interlock.
    - Removes power if the enclosure is opened.
    - Shorts the high voltage circuit to ground if the enclosure is opened.

30

G0B01 -- Which wire or wires in a four-conductor 240 VAC circuit should be attached to fuses or circuit breakers?

A. Only the hot wires
B. Only the neutral wire
C. Only the ground wire
D. All wires

31

G0B02 -- According to the National Electrical Code, what is the minimum wire size that may be used safely for wiring with a 20-ampere circuit breaker?

A. AWG number 20
B. AWG number 16
C. AWG number 12
D. AWG number 8

32

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

A. 30 amperes
B. 25 amperes
C. 20 amperes
D. 15 amperes

33

G0B05 -- Which of the following conditions will cause a ground fault circuit interrupter (GFCI) to disconnect AC power?

A. Current flowing from one or more of the hot wires to the neutral wire
B. Current flowing from one or more of the hot wires directly to ground
C. Overvoltage on the hot wires
D. All these choices are correct

34

G0B06 -- Which of the following is covered by the National Electrical Code?

A. Acceptable bandwidth limits
B. Acceptable modulation limits
C. Electrical safety of the station
D. RF exposure limits of the human body

35

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

36

Electrical Safety

Generator Safety

- Installation.
  - Always use in an open, well-ventilated area to prevent carbon monoxide poisoning.
    - **ALWAYS** outside.
    - **NEVER** in an enclosed space -- not even in a garage.

37

Electrical Safety

Generator Safety

- Installation.
  - Locate a fire extinguisher near the generator but away from the fuel.
    - **NEVER** store the fuel near the generator.
  - Connect the generator frame to a ground rod installed at the generator location.

38

Electrical Safety

Generator Safety

- Refueling.
  - **ALWAYS** shut down the generator while refueling.
  - **ALWAYS** have a 2nd person present with a fire extinguisher.
  - **NEVER** store fuel near the generator.
    - Especially near the exhaust.

39

Electrical Safety

Generator Safety

- Connecting to house wiring.
  - Always use an approved transfer switch.
    - Disconnects the house wiring from the power company wiring.
  - Open the main breakers & connect the generator on the house side of breakers.

40

Electrical Safety

Generator Safety

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

41

G0B09 -- Which of the following is true of an emergency generator installation?

A. The generator should be operated 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 these choices are correct

42

Electrical Safety

Lightning

- The purposes of lightning protection are to:
  - Prevent fire.
  - Reduce or prevent damage to equipment.



43

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.

44

Electrical Safety

Lightning

- When installing your station.
  - Install a grounded metal entry panel for all feedlines & control cables.
    - Connect to a ground rod with a short, heavy metal strap.
    - Install lightning arrestors on the entry panel.
  - Bond **ALL** ground rods together & to the AC wiring safety ground.

45

Electrical Safety

Lightning

- **NEVER** use soldered connections in the lightning protection system.
  - The extremely high currents generated by a lightning strike will melt the solder and cause the connection to fail.

46

G4C07 -- Why should soldered joints not be used in lightning protection ground connections?

A. A soldered joint will likely be destroyed by the heat of a lightning strike
B. Solder flux will prevent a low conductivity connection
C. Solder has too high a dielectric constant to provide adequate lightning protection
D. All these choices are correct

47

G0B04 -- Where should the station's lightning protection ground system be located?

A. As close to the station equipment as possible
B. Outside the building
C. Next to the closest power pole
D. Parallel to the water supply line

48

G0B11 -- Which of the following is required for lightning protection ground rods?

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

49

G0B13 -- Where should lightning arrestors be located?

A. Where the feed lines enter the building
B. On the antenna, opposite the feed point
C. In series with each ground lead
D. At the closest power pole ground electrode

50

RF Exposure

Do not confuse RF radiation with other types of radiation.

- There are two categories of radiation:
  - Non-ionizing radiation.
    - RF radiation, infrared light, & visible light.
    - The only effect is heating of body tissues.
  - Ionizing radiation.
    - Ultra-violet light, x-rays, & nuclear radiation.
    - Can cause genetic damage.

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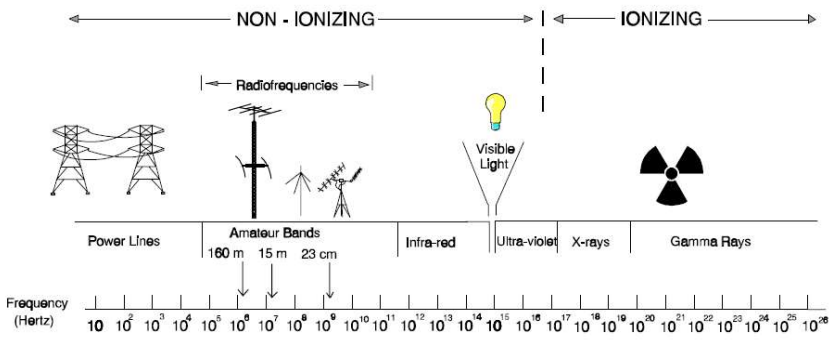
RF Exposure

Ionizing and Non-Ionizing Radiation.



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RF Exposure

Danger from RF Exposure

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

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RF Exposure

Power Density

- Heating is caused by the body absorbing RF energy.
- The intensity of the RF energy is called *power density*.
  - Power density is measured in mW/cm^2.
  - For example:
    - If the power density is 10 mW/cm^2, and the size of your hand is 75 cm^2, then the power absorbed is 750 mW.

54

RF Exposure

Power Density.

- Higher transmitter power → higher power density.
- Higher antenna gain → higher power density.
- Closer to the antenna → higher power density.

55

RF Exposure

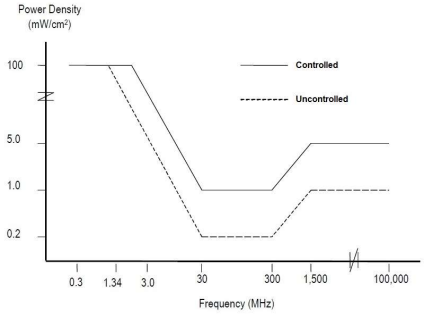
Absorption and Limits

- 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).

56

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.



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Break

58

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.

59

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.

60

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.

61

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.

62

RF Exposure

Averaging and Duty Cycle.

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

63

RF Exposure

Averaging and Duty Cycle.

- Antenna system.
  - The antenna gain and transmission line losses are also included in the calculations.
    - Antenna gain increases the power density.
    - Transmission line losses decrease the power density.

64

RF Exposure

Estimating Exposure and Station Evaluation

- **All** amateur stations must evaluate RF exposure potential if the time-averaged power level of the transmitter is greater than 1 mW.

65

Estimating Exposure and Station 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

66

RF Exposure

Estimating Exposure and Station Evaluation

- Methods of Evaluating RF Exposure.
  - Calibrated field strength meter & antenna.
    - **VERY** expensive.
  - Hand-held power density meter.
    - < $150

67

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.

68

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.

69

RF Exposure

Estimating Exposure and Station Evaluation

- Multi-transmitter environments.
  - If there are multiple transmitters at a location, every transmitter that produces 5% or more of the MPE must be included in the calculations for that location.
    - e.g. - Repeater systems sharing a site with transmitters in other services.

70

RF Exposure

Exposure Safety Measures.

- If your transmitter exceeds the MPE for a location, you must take steps to reduce the power density at that location.
  - Reduce transmitter power.
  - Relocate antennas.
  - Any other steps that will reduce the power density to a level below the MPE.

71

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.

72

RF Exposure

Exposure Safety Measures.

- Carefully evaluate exposure from “stealth” antennas.
  - Antennas inside your house.
- Locate VHF/UHF mobile antennas on the roof of the vehicle or on the trunk lid.
- Use an external microphone with handheld radios.

73

RF Exposure

Exposure Safety Measures.

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

74

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

75

G0A02 -- Which of the following is used to determine RF exposure from a transmitted signal?

A. Its duty cycle
B. Its frequency
C. Its power density
D. All these choices are correct

76

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 these choices are correct

77

G0A04 -- What does “time averaging” mean when evaluating 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 period

78

G0A05 -- What must you do if an evaluation of your station shows that the RF energy radiated by your station exceeds permissible limits for possible human absorption?

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 these choices are correct

79

G0A06 -- What must you do if your station fails to meet the FCC RF exposure exemption criteria?

A. Perform an RF Exposure Evaluation in accordance with FCC OET Bulletin 65
B. Contact the FCC for permission to transmit
C. Perform an RF exposure evaluation in accordance with World Meteorological Organization guidelines
D. Use an FCC-approved band-pass filter

80

G0A07 -- What is the effect of modulation duty cycle on RF exposure?

A. A lower duty cycle permits greater power levels to be transmitted
B. A higher duty cycle permits greater power levels to be transmitted
C. Low duty cycle transmitters are exempt from RF exposure evaluation requirements
D. High duty cycle transmitters are exempt from RF exposure requirements

81

G0A08 -- Which of the following steps must an amateur operator take to ensure compliance with RF safety regulations?

A. Post a copy of FCC Part 97.13 in the station
B. Notify neighbors within a 100-foot radius of the antenna of the existence of the station and power levels
C. Perform a routine RF exposure evaluation and prevent access to any identified high exposure areas
D. All these choices are correct

82

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

A. A receiver with digital signal processing (DSP) noise reduction

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

83

G0A10 -- What should be done if evaluation shows that a neighbor might experience 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. Use an antenna with a higher front-to-back ratio

C. Take precautions to ensure that the antenna cannot be pointed in their direction when they are present

D. All these choices are correct

84

G0A11 -- What precaution should be taken 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

85

G0A12 -- What stations are subject to the FCC rules on RF exposure?

A. All commercial stations; amateur radio stations are exempt

B. Only stations with antennas lower than one wavelength above the ground

C. Only stations transmitting more than 500 watts PEP

D. All stations with a time-averaged transmission of more than one milliwatt

86

Outdoor Safety

Installing Antennas

- **Place antennas well clear of power lines!**
  - The antenna and its support must be at least 150% of the height of the antenna system from the nearest power line.
    - A 40 ft tower or mast with a 10-ft antenna should be at least 75 feet from power lines.

87

Outdoor Safety

Installing Antennas

- **Place antennas well clear of power lines!**
  - If using a sling-shot or bow & arrow to shoot a support line into a tree, make certain that the flight path beyond the tree is clear of power lines.
  - **NEVER** run feedlines over or under power lines, including service drops.

88

Outdoor Safety

Installing Antennas

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

89

Outdoor Safety

Towers, Masts, & Hardware

- Pipe masts.
  - Up to 20-30 feet.
  - Should be guyed or bracketed to side of a building.
- Push-up masts.
  - Up to 50 feet.
  - Must be guyed.

90

Outdoor Safety

Towers, Masts, & Hardware

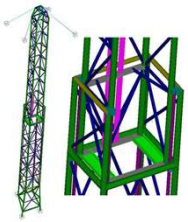
- Fixed towers.
  - 8-ft or 10-ft sections.
  - Up to 200 feet or more.
  - Normally must be guyed.

91

Outdoor Safety

Towers, Masts, & Hardware

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



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Outdoor Safety

Towers, Masts, & Hardware

- Fold-over towers.
  - Fixed tower with special mounting base .

93

Outdoor Safety

Towers, Masts, & Hardware

- Hardware.
  - For best results, use stainless steel bolts, nuts, & washers.
    - May use galvanized bolts, nuts, & washers.
  - Use an anti-seize compound on all hardware and where tower sections are joined.

94

Outdoor Safety

Towers, Masts, & Hardware

- Hardware.
  - Coaxial cable should have a UV-resistant jacket.
  - If burying coaxial cable:
    - Use coaxial cable designed for direct bury, or
    - Use conduit or PVC pipe.

95

Outdoor Safety

Towers, Masts, & Hardware

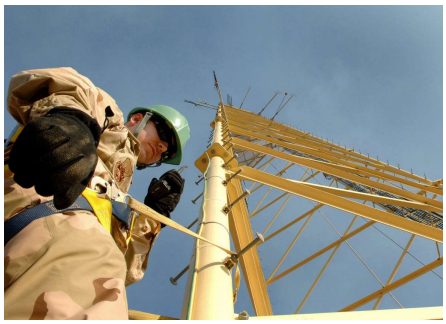
- Hardware.
  - Ropes should be UV-resistant.
    - Black.
    - Dacron.
    - Polyester.
    - Nylon.
    - **NEVER** use polypropylene.

96

Outdoor Safety

Good Maintenance Practices

- **ALWAYS** wear appropriate safety gear.



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Outdoor Safety

Good Maintenance Practices

- Wear appropriate safety gear.
  - Climbing harness.
  - Safety helmet.
  - Boots or work shoes.
  - Safety goggles.
  - Gloves.
  - Don't forget the sunscreen!

98

Outdoor Safety

Good Maintenance Practices

- Wear appropriate safety gear.
  - Not just climber.
  - Ground crew also.
    - Especially safety helmet.
- **ALWAYS** inspect all safety gear before use.
  - Is it within the recommended service life?
  - Is it adequately rated for the intended use?

99

Outdoor Safety

Good Maintenance Practices

- Have handheld amateur or FRS radios for communications between climbers & ground crew.

100

Outdoor Safety

Good Maintenance Practices

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

101

Outdoor Safety

Good Maintenance Practices

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

102

Outdoor Safety

Good Maintenance Practices

- While climbing:
  - **SLOW DOWN!** – Speed kills.
  - Make certain that carabiners are completely closed.
  - Latch hooks with opening away from tower.
  - **ALWAYS** use a safety lanyard or redundant lanyards.

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

A. Always hold on to the tower with one hand

B. Confirm that the harness 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 harness

D. All these choices are correct

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G0B08 -- What should be done before climbing 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 these choices are correct

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Questions?

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