Amateur Radio General Class License Study Guide

Week 4

Element 0: ELECTRICAL AND RF SAFETY

October 24, 2023

Question pool sections: G0

Concepts covered:

G0A – RF safety principles, rules, and guidelines; routine station evaluation

G0B – Station safety: electrical shock, grounding, fusing, interlocks, and wiring; antenna and tower safety

Corresponding pages of ARRL *General Class license manual*:
9-3 through 9-16

Just because there are only two related questions on the General class exam, don't underestimate the importance of safety. One of the most important aspects of amateur radio is recognizing the hazards that may be present in the hobby, and following all appropriate safety rules to mitigate those hazards.

Electrical Safety:
A quick review of some electrical safety concepts from the Technician exam is a good starting place. The human body can be fatally injured by contact with electrical circuits. It is electrical current that does the damage. Electrical current causes heating of tissue, disrupts electrical functions of cells and causes involuntary muscle contractions. These disruptions are particularly dangerous to the heart. As little as 30 volts can be dangerous to humans, especially if the current flow is from one hand, through the chest, and out through the other hand. Ohm's law states that for a given resistance, current increases as the voltage increases, so higher voltages present a greater risk, as they can result in higher, more lethal current. The risk associated with high voltage is why *a power supply interlock is used to ensure that dangerous voltages are removed if the cabinet is opened.*

Many of the guidelines that relate to *electrical safety of the station are covered by the National Electrical Code* or NEC. A portion of the NEC specifies the minimum wire gauge for specified current carrying capacity. Wire size, or gauge, is expressed numerically as the AWG (American wire gauge). Note that a higher number indicates a smaller diameter wire, with lower current carrying capacity. *NEC specifies AWG #14 wire is appropriate for circuits up to 15 amperes, while a minimum of AWG #12 may be used safely for wiring with a 20-ampere circuit breaker*.

One question on the Technician exam specifies that home built equipment powered from a 120V AC power circuit should have a fuse or circuit breaker installed in series with the “hot” conductor only. The same applies to the use of *fuses or circuit breakers in a four-conductor 240 VAC circuit, which should be attached only the “hot” wires*. Note that there are two hot wires, a ground, and a neutral wire in a four-conductor 240 VAC circuit.

A ground fault circuit interrupter (GFCI) is another important safety device in AC power circuits. *Current flowing from one or more of the hot wires to the neutral wire will cause a ground fault circuit interrupter (GFCI) to disconnect AC power*.

There are two health related question on the General class exam. One relates to a *danger from lead-tin solder. Lead can contaminate food if hands are not washed carefully after handling the solder*. A good way to avoid this risk entirely is to use lead-free solder. To reduce the risk of carbon monoxide poisoning, when considering *an emergency generator installation, the generator should be operated in a well-ventilated area*. Other generator safety considerations include grounding of the generator, storing extra fuel away from the generator, and keeping a fire extinguisher nearby.

Lightning Protection:
Towers and antennas are a natural target for lightning strikes, which can cause severe injury and property damage. Coaxial *lightning arrestors should be located where the feed lines enter the building.* These should be attached to *the station’s lightning protection ground system, which should be as close to the station equipment as possible*. The *lightning*

protection ground rods must be bonded together with all other grounds. Remember that in grounding conductors used for lightning protection, sharp bends must be avoided, with connections as straight and direct as possible. The best way to protect your antenna system, station equipment, and home from lightning damage is to ground all antennas when not in use, and to disconnect station equipment from power lines and antenna cables if an electrical storm is nearby.

Antenna and tower safety: Amateur antennas bring another set of risks to you and your station. Many hams utilize towers to improve the location and performance of their antenna system, and towers come with serious risk. A tower climber is exposed to significant risk, so *when climbing a tower using a safety harness, confirm that the harness is rated for the weight of the climber and that it is within its allowable service life.* Falls are not the only risk that a climber may be exposed to. *Before climbing a tower that supports electrically powered devices, make sure all circuits that supply power to the tower are locked out and tagged* (LOTO). This may be accomplished by de-engergizing the circuit breaker and installing a lock or other barrier to prevent returning the circuit breaker to the “on” position.

RF Safety: This section was added to the question pool in 1997 to make amateurs more aware of the potential danger to themselves and others from RF energy radiated from antennas. Radio signals (RF energy), are a form of non-ionizing electromagnetic radiation. *One way that RF energy affects the human body is that it heats body tissue.* As noted in an earlier section, touching an antenna while the transmitter is on can cause painful RF burns.

The FCC has established RF exposure regulations, and you need to determine that your station complies with these regulations. These guidelines are not limited to amateur radio stations but *apply to all stations with a time-averaged transmission of more than one milliwatt. When when evaluating RF radiation exposure,* the term *“time averaging” means the total RF exposure averaged over a certain period.*

An amateur operator must take the following steps to ensure compliance with RF safety regulations: perform a routine RF exposure evaluation and prevent access to any identified high exposure areas. There are several ways can you determine that your station complies with FCC RF exposure regulations. These include *calculations based on FCC OET Bulletin 65, computer modeling, or by the measurement of field strength using calibrated equipment. (*all these choices are correct). One *type of instrument* that *can be used to accurately measure an RF field strength is a calibrated field strength meter with a calibrated antenna.*

Several factors *determine RF exposure from a transmitted signal.* These include *its duty cycle, its frequency, and its power density (*all these choices are correct). *The effect of modulation duty cycle on RF exposure* is *a lower duty cycle permits* greater power *levels to be transmitted.* Exposure limits vary with frequency because the human body absorbs more RF energy at some frequencies than at others. For example, the maximum permissible exposure value is lower on 50 MHz than it is on 3.5 MHz.

Most likely, *your station will fail to meet the FCC RF exposure exemption criteria*, in which case, *you'll need to perform an RF Exposure Evaluation in accordance with FCC OET Bulletin 65*. What happens if *an evaluation of your station shows that the RF energy radiated by your station exceeds permissible limits for possible human absorption?* You *must take*

action to prevent human exposure to the excessive RF fields. This could be in your own home or on the other side of your fence. *Precautions should be taken if you install an indoor transmitting antenn*a to *make sure that MPE limits are not exceeded in occupied areas.*

The same exposure rules apply on the other side of your neighbor's fence. *If evaluation shows that a neighbor might experience more than the allowable limit of RF exposure from the main lobe of a directional antenna,* you must *take precautions to ensure that the antenna cannot be pointed in their direction when they are present* (and you are transmitting).