Amateur Radio Technician Class License Study Guide

Week 2

SUBELEMENT T0 – SAFETY – [3 Exam Questions - 3 Groups]

March 14, 2023

Question pool sections: T0

Terms and concepts:

T0A – Power circuits and hazards: hazardous voltages, fuses and circuit breakers, grounding, electrical code compliance; Lightning protection; Battery safety

T0B – Antenna safety: tower safety and grounding, installing antennas, antenna supports

T0C - RF hazards: radiation exposure, proximity to antennas, recognized safe power levels, radiation types, duty cycle

Corresponding pages of Gordon West book
T0: 185 – 196

Electrical Safety: One of the most important parts of amateur radio is recognizing the hazards that may be present in the hobby, and following all appropriate safety rules to mitigate those hazards.

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. As such, *precautions should be taken when measuring high voltages with a voltmeter. Ensure that the voltmeter and leads are rated for use at the voltages to be measured.*

Although the 12-volt DC that is used to power most amateur equipment rarely presents a direct hazard, *a 12-volt storage battery that provides this power can cause burns, fire, or an explosion if the terminals are shorted. Charging or discharging a battery too quickly can cause overheating or out-gassing* (release of flammable gas, which could explode). In addition, some batteries release hydrogen gas when charging, so they must be vented to prevent collection of this explosive gas.

There are several additional rules for protecting your equipment and yourself. *Good ways to reduce the risk of electrical shock include using three-wire cords and plugs for all AC powered equipment, connecting all AC powered station equipment to a common safety ground, and installing mechanical interlocks in high-voltage circuits* that disconnect the high voltage when the compartment is opened*. In the United States,* the wires in *a three-wire 120 V*olt AC *cable* are color-coded. *Black wire insulation indicates the "hot" circuit,* the white wire indicates the "neutral" circuit, with the green wire used for the safety ground. All exposed metal in a station should be connected to a safety ground to reduce shock hazard. Good equipment design is also important to safety*.* Any home built equipment powered from a *120V AC power circuit should have a fuse or circuit breaker installed in series with the "hot"* (black) *conductor only.*

Even equipment that is turned off and disconnected can present a risk. *Charge stored in filter capacitors present a hazard from a power supply immediately after turning it off.* Remember, capacitors store energy in an electric field, and unexpected discharge of that energy could cause electric shock.

Fuses and circuit breakers protect equipment and property from potentially dangerous failure. *The purpose of a fuse in an electrical circuit is to remove power in case of overload* (excessive current). *A 5-ampere fuse should never be replaced with a 20-ampere fuse.* Doing so might allow *excessive current* to flow, which *could cause a fire.*

Antenna and tower safety: Amateur antennas bring another set of risks to you and your station. Care must be taken when installing antennas to avoid the dangers of power lines. *The minimum safe distance from a power line to allow when installing an antenna is enough*

that if the antenna falls unexpectedly, no part of it can come closer than 10 feet to the power wires. NEVER attach an antenna to an active *utility pole!* Doing so means *the antenna could contact high-voltage power wires.* In addition, the utility company does not allow such installations.

Many hams utilize towers to improve the location and performance of their antenna system, and towers come with serious risk. Hams often use tower work teams to construct or maintain towers. The tower climber is exposed to significant risk, so *it is <u>never</u> safe to climb a tower without a helper or observer. Requirements when climbing an antenna tower include having sufficient training on safe tower climbing techniques, use of an appropriate tie-off to the tower at all times and always wearing an approved climbing harness. An important safety precaution to observe when putting up an antenna tower is to look for, and stay clear of any overhead electrical wires.* Guy wires may be used to stabilize a tower. *Turnbuckles used to tension guy line should have safety wires installed to prevent loosening from vibration. An important safety rule to remember when using a crank-up tower is that this type of tower must not be climbed unless it is in the fully retracted position or mechanical safety locking devices have been installed.*

Towers and antennas are a natural target for lightning strikes, which can cause severe injury and property damage. *A lightning arrester may be installed in a coaxial cable feed line* to reduce the risk of damage to your station. These protectors should be *installed on a grounded panel near where feed lines enter the building. All external ground rods or earth connections should be bonded together with heavy wire or conductive strap.*

The grounding requirements for an amateur radio tower or antenna are established by local electrical codes. Proper grounding method for a tower is considered to be the installation of separate eight-foot long ground rod for each tower leg, bonded to the tower and each other. Good practice when installing ground wires on a tower for lightning protection is to ensure that connections are short and direct. When installing grounding conductors used for lightning protection, sharp bends must be avoided. 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.

<u>RF Safety</u>: 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 <u>non-ionizing</u>* electromagnetic *radiation. RF radiation differs from ionizing radiation (radioactivity), as RF radiation does not have sufficient energy to cause chemical changes in cells and damage DNA.* This does not mean that RF radiation is harmless!

The FCC has established RF exposure regulations, and you need to determine that your station complies with these regulations. *Acceptable methods of accomplishing this include calculations based on FCC OET Bulletin 65, computer modeling, or by the measurement of field strength using calibrated equipment.* Sometimes the *action to reduce exposure to RF radiation is* as simple as *relocating antennas. Once you know your station is in compliance, you can make sure your station stays in compliance with RF safety regulations by re-evaluating your station whenever an item of equipment is changed.*

The station licensee is responsible for ensuring that no person is exposed to RF energy above the FCC exposure limits. The FCC RF exposure regulations are most stringent over the 30 – 300 MHz frequency range. *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, 440 MHz or 1296 MHz.* This is because the human body absorbs energy more readily in the 50 MHz range. *The factors affecting the RF exposure of people near an amateur station antenna include the frequency and power level of the RF field, the distance from the antenna to a person, and the radiation pattern of the antenna.*

One definition which is important when discussing the technical aspects of RF exposure safety, is duty cycle. *The definition of duty cycle during the averaging time for RF exposure is the percentage of time that a transmitter is transmitting* (on).

The concept of *"duty cycle" is one of the factors used to determine safe RF radiation exposure levels because it affects the average exposure to radiation.* If the duty cycle (on time) is reduced, the permitted power density may be increased proportionally. Thus *the allowable power density for RF safety increases by a factor of 2 if duty cycle changes from 100 percent to 50 percent (*halved*).*

It is always a good practice to locate your station's antennas where no one can touch them while the transmitter is on. *Touching an antenna while the transmitter is on can cause painful RF burns to tissue*.