ARRL Amateur Radio Education & Technology Program

Unit 7 Safety

What does safety mean to you? I'm sure you have heard your mother or father telling you to "be careful." Unfortunately, we don't always heed these warnings and something happens. It might be painful or embarrassing, but by then, it's too late. So whose responsibility is it to see we play and work safely? When you were small, you were continually watched by an adult to make sure your basic needs were met. This included providing you with a safe environment. As you got older, you were allowed to venture out on your own around the neighborhood. Now you are in school, the school takes some responsibility for your safety but you take a large part of the responsibility yourself. So to answer the question, "whose responsibility is it?" The ultimate responsibility lies with each of us.

Safety, all safety, comes down to each person's knowledge, common sense and attitude. For you to make good decisions about safety requires you to know your environment, to know your personal limitations and to be familiar with any devices you are working with.

This section on safety is divided into three areas.

1. *General Safety:* Common sense situations. Use of ordinary tools and items found around the house, school or in public places.
2. *Electrical Safety:* Specific safety suggestions while working around electrical equipment.
3. *RF Radiation & Electromagnetic Field Safety:* The least understood of the three. RF safety involves more detailed understanding or radio frequency and its effect of the human body.

The following information is intended to help you develop your personal safety program at your school. Please remember, these are only guidelines and should not be considered a complete set of safety rules. The school principal and teachers are the final authority on safety and should decide the level of training required for the students at your school.

General Safety

All the information in the following sections is from ARRL publications: *The ARRL Operating Manual, The ARRL Handbook, The ARRL Antenna Book and RF Exposure and You.* It is important that you as a student using Amateur Radio as an instructional tool, maintain a safe environment for yourself and other students.

To equip yourself with basic safety knowledge, you need to learn as much as possible about what could go wrong so you can avoid factors that might result in accidents. Amateur Radio activities are not normally dangerous, but like many things in modern life, it pays to be informed. Stated another way, while we long to be creative and have fun, there is still the need to act responsibly. Safety begins with our attitude.

One very important aspect of safety is to keep your work area clean. Amateur Radio operators often joke about having the "messiest shack" in town. Part of that comes from the amount of activity taking place in the shack. The operating position is often used for equipment repair and kit building, so there is often equipment and tools left on the bench. This can be a dangerous situation so it is a good idea to regularly clean the work space/operating position to keep it clear of tools, sharp object and liquid spills. Keep all tools in a toolbox or drawer so you can get to them but are still out of the way.

Here is a list of some general safety rules to help you work safely around Amateur Radio equipment.

- Keep you work area clean and free of unnecessary materials.
- Wear appropriate eye protection when working with tools.
- Wear appropriate foot protection when working with tools.
- Store sharp objects (screwdrivers etc.) with sharp points pointed away from you. When handing sharp objects to another person, hand it handle first.
- Only turn on a switch if you know what it operates.
- When lifting heavy objects, lift with your legs, not your back.
- Wipe up all liquids immediately.
- Remove rings and other jewelry when working on electronic equipment
- Keep a fire extinguisher in an accessible location.

Fires in Amateur Radio equipment are rare but do happened. It is important that you are aware of the types of fire extinguishers available and which type to use around electrical equipment. Quick action can make the difference of a small fire or the loss of an entire building, not to mention loss of life.

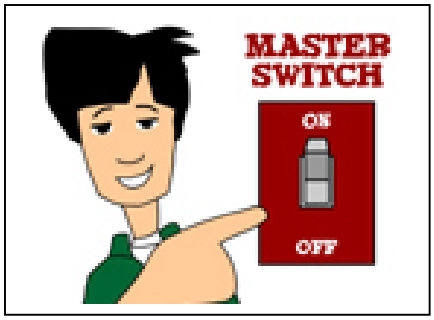
So which fire extinguisher should you use? There are two types of fire extinguishers appropriate to use on electrical fires: The dry chemical or "ABC" type and CO_2 type. The ABC type extinguishers contain a solid powder that does not conduct electricity, and is safe for electrical equipment. The CO_2 type extinguishers use carbon dioxide to smother the fire. They also do not conduct electricity. CO_2 types are heavy, difficult to handle, and are relatively expensive. ***Water extinguishers should never be used on an electrical fire.*** Why? Ground water is a conductor of electricity and is an electrical shock hazard.

Electrical Safety

Although the RF, and ac and dc voltages in most amateur stations can be dangerous, common sense and knowledge of safety practices will help you avoid accidents. Building and operating an Amateur Radio station can be, and is for most amateurs, a perfectly safe hobby. However, carelessness can lead to severe injury, or even death. Remember there is no substitute for common sense.

Here are some general things to think about with working around electricity:

- When working with electricity it is important to understand electrical theory. How electricity flows through conductors and basic circuitry.
- When working with commercial (store bought) equipment, it's a good idea to read the owners manual to become familiar with the voltage and current requirements for that piece of equipment. Make sure the electrical circuit can supply the voltage and current needed to operate the equipment. Overloading the circuit (drawing too much current) can cause the circuit to overheat and possibly cause a fire.
- It's a good idea to have a "master switch" in the ham shack. This switch can shut off the power to all equipment in the shack at one time. Should there be an emergency, all you need to do is turn off one switch.



- It's not a good idea to use extension cords in the ham shack. They are often handy and are fine for a temporary connection but should not be used for a permanent connection. Extension cords can become frayed or cut and cause electrical shock or possibly start a fire, should the wires become shorted together.
- You should NEVER plug anything into an electrical outlet except an approved electrical plug (How's that for common sense?).
- NEVER use electrical equipment around water. That includes Amateur Radio equipment as well. Water is a conductor. A little water on the floor or bench is an invitation for disaster. This includes soft drinks also. So it's not a good idea to drink soda or water while operating a ham radio station. And as mentioned above, NEVER use a water fire extinguisher to put out an electrical fire.
- All wires carrying power around the ham shack should be of the proper size for the current to be drawn and should be insulated for the voltage level involved.
- All equipment in the ham shack should be connected to a good ground. Should you somehow touch a wire in the circuit, most of the electricity will flow to ground through the ground wire instead of you.

RF Radiation and Electromagnetic Filed Safety

Operating a Amateur Radio station is basically a safe activity. In recent years, however, there has been a lot of discussion about the possible dangers of *electromagnetic radiation* (EMR). This includes both *radio-frequency* (RF) energy, and *power-frequency* (50-60 Hz) energy, which comes form electrical power lines. FCC regulations set limits on the *maximum permissible exposure* (MPE) allowed for the operation of radio transmitters. These regulations do not take the place of RF-safety practices, however.

All life on Earth has adapted to survive in the weak, low-frequency electromagnetic fields found in nature. These natural low-frequency EMR fields come form two main sources: the sun, and thunderstorm activity (lightning). But in the last 100 years, man-made fields at much higher levels and wider frequency ranges have altered this natural EMR background in ways we still don't fully understand. Much more research is needed to determine the long term effects of EMR. So what are the effects of RF that we know of?

Thermal Effects of RF Energy

Scientists have found that body tissues that are exposed to very high levels of RF energy may suffer serious thermal (heat) damage. Do you have a microwave oven at home? Microwave ovens use RF energy to cook food, right? That gives you an idea of what concentrated RF energy can do. The effects, however, depend upon the frequency of the energy, the power density (strength) of the RF field that strikes the body, and even such factors as the polarization of the wave. So does that mean you will become a "crispy critter" if you operate a ham radio? Not! Thermal effects should not be a major concern for most radio amateurs because of the low RF power we normally use (100 watts). That's the same amount of power it takes to light a 100 watt light bulb. We are only exposed to these low RF power levels when transmitting a signal. Amateurs spend more time listening than talking and we are not always transmitting a signal. This limits our exposure to RF. So the combination of low power and short transmitting time put ham radio in the lower margins of RF exposure. Some suggestions for avoiding too much exposure to RF will be listed later.

Athermal Effects of EMR

Research about possible health effects resulting from exposure to the lower level energy fields – the athermal effects- has been of two basic types: epidemiological research and laboratory research. In laboratory research, scientist study how EMR may affect animals, including humans. Epidemiologists look at the health patterns of large groups of people. In the area of RF and EMR effects, the results of both methods of research have proven inconclusive. What does that mean? Scientists still have not been able to show that exposure to low-level RF and EMR is dangerous to our health. It is also important to note they have not been able to show that it isn't, as well. If you, your

teacher or parents are interested in doing further reading about RF safety, I suggest reading the ARRL publication "RF Exposure and You."

Safe Exposure Levels

How much EM energy is safe? Scientist and regulators have devoted a great deal of effort deciding upon safe RF-exposure limits. This is a very complex problem, involving difficult public health and economic considerations. The recommended safe levels have been revised downward several times in recent years – and not all scientific bodies agree on the question even today.

Because these fields dissipate rapidly with distance, "prudent avoidance" would mean staying perhaps 12 to 18 inches away from most Amateur Radio equipment (and 24 inches from power supplies and 1-kW RF amplifiers) whenever an ac power is turned on. There are currently no non-occupational US standards for exposure to low-frequency fields.

General Safety Recommendations

There are a few additional RF safety points that you should be aware of when operating your Amateur Radio station. This section includes some general guidelines to help keep you and anyone near your station safe while it is being operated.

Hand-held radios are very popular for VHF and UHF operation, especially with FM repeaters. They transmit with less than 7-watts of power, which is generally considered safe. Because the radios are designed to be operated with an antenna that is within 20 centimeters of your body, they are classified as *portable devices* by the FCC. Some special considerations are in order to ensure safe operation. This is especially true because hand-held radios generally place the antenna close to your head. Try to position the radio so the antenna is as far from your head (and especially your eyes) while transmitting. An external speaker microphone can be helpful.

A *mobile radio* is a transceiver that is designed to be mounted in a car. Mobile radios are normally intended to be operated with an antenna that is at least 20 cm from any person. Mobile operations also require some special considerations. For example, you should try to mount the antenna in the center of the metal roof of your car, if possible. This will use the metal body of the vehicle as an RF shield to protect people inside the car. Glass-mounted antennas can result in higher exposure levels, as can antennas mounted on a trunk lid or front fender. Glass does not form a good RF shield.

Although mobile radios usually transmit with higher power levels than hand-held radios, the mobile unit often produces less RF radiation exposure. This is because an antenna mounted on a metal car roof is generally well shielded from car occupants.

Don't operate RF power amplifiers or transmitters with the covers or shielding removed. This practice helps you avoid both electric shock hazards and RF safety hazards.

Another area you should pay attention to is the feed line connecting your transmitter to your antenna. If you are using poor-quality coax, or if there are other causes leading to signals radiating from your feed line, you should consider replacing it (use only good-quality coax and be sure your connectors are installed properly). Improper grounding can also lead to a condition known as RF in the shack. This can be a problem with stations installed on the second or third floor (or higher) where the ground lead begins to act more like an antenna. If you notice that the SWR reading changes as you touch your equipment, or if you feel a tingling sensation in your fingers when you touch the radio or microphone, these may be indicators or RF in the shack. You will have to take some steps to correct these conditions to ensure a safe operating environment.

As stated at the beginning, safety comes down to each person's knowledge, common sense and attitude. For you to make good decisions about safety requires you to know your environment, to know your personal limitations and to know the equipment you are working with.