RF Hazard Control Equipment

RICHARD R. STRICKLAND
RF Safety Solutions LLC
South Setauket, New York

INTRODUCTION

Radio frequency (RF) radiation, RF emissions, electromagnetic energy — whatever you choose to call it, the FCC regulations and an increased awareness of RF radiation are hot topics today.

Although the FCC adopted new regulations in 1997 and all companies were supposed to be fully compliant by September 2000, many organizations still have a long way to go. The FCC started to increase enforcement of RF safety early in 2002. It shut down broadcast operations at the big antenna farm on Mt. Wilson outside Los Angeles in July. It issued its first ever Notice of Apparent Liability and Forfeiture (NAL) in November, fining one broadcaster $10,000. Four days later another broadcaster was hit with a $10,000 fine. Insiders believe that there are many more to follow. The deputy head of the Enforcement Bureau is on record stating that enforcement of RF safety standards was one of her three main goals and that "the way they intend to achieve compliance is with large fines."

OBJECTIVES

Many broadcasters are giving more thought to what they should be doing to improve safety. The primary concerns for any company that works near high power RF sources should be to:

- Minimize the risk to all personnel
- Comply with all FCC Regulations
- Comply with all OSHA, and state, and local regulations
- Minimize liability risk

Many broadcasters have looked at only one aspect of compliance—satisfying the FCC Regulations in terms of public exposure. Today, there is a lot more to achieving compliance than just worrying about public areas. Putting up a high fence with barbed wire, locks, and signs around an antenna field is a good start. What about your employees and contractors? Employee safety is certainly important. Every time you hire a contractor, safety issues take on importance. To minimize your liability risk, you must transfer liability to your contractors. But, you cannot do that if you do not have an RF safety program in place. Then, you can make Contractor Requirements a component of your safety program. If the new tower regulations that are being proposed in several states become law at the national level, you will be ***required*** to have an RF safety program in place. The FCC Regulations almost force you to already. Consider that an FM station or VHF TV licensee must insure that nobody can enter an area with field levels exceeding 0.2 mW/cm² for even a moment without violating the Commission's regulations. If your station is operating under an RF safety program, you can allow employees in fields up to 1.0 mW/cm² on a continuous basis and even higher fields on an intermittent basis. This is because, not only are the Maximum Permissible Exposure (MPE) limits for Occupational/Controlled exposure five times higher above 3 MHz than they are for General Population/Uncontrolled exposure, they also allow time averaging. But if you do not have an RF safety program in place, you have an "Uncontrolled" exposure situation and the FCC does not allow time averaging.

RF HAZARD CONTROL EQUIPMENT

Hazard control equipment has been an essential tool of industrial hygiene and safety professionals in many areas for decades. But RF radiation (RFR) hazard control equipment has only been available for the broadcast industry for about 10 years. And, judging by the industry buzz, there is a lot of confusion about its application and use.

There are basically two types of RFR hazard control equipment available: RF personal monitors and RF protective garments. What are the important things to consider when selecting and using an RF personal monitor? What level of protection do RF "suits" provide? Can personal monitors be used with protective garments? These are important questions. Anyone who uses or is considering the use of RF hazard protection equipment should know the answers.

RF PERSONAL MONITORS

Personal monitors are designed to sound an alarm above a preset threshold. There are several factors that should be considered in selecting a monitor:

Frequency range

The first monitors developed for the military covered the microwave band only. The latest designs are very broadband. One design operates from 100 kHz to 100 GHz. A monitor should cover all the emitters where you are going to work.

Frequency response

Monitors can have a "flat" frequency response or a "shaped" response. The sensitivity of a shaped sensor varies with frequency.

For example, the FCC's Maximum Permissible Exposure (MPE) limit for Occupational/Controlled exposure at VHF frequencies (30-300 MHz), where the human body is most susceptible, is 1 mW/cm². Below 3 MHz, where the body does not heat very well, it is 100 mW/cm².

Take a simple site with one AM and one FM antenna, and you can see the advantage of a shaped sensor that responds in terms of "Percent of Standard." With a flat response, if the total field level from the two antennas is greater than 1 mW/cm², you cannot determine whether you are exposed above the MPE. If you are exposed to a 20 mW/cm² field, with 19.9 mW/cm² coming from the AM and 0.1 mW/cm² from the FM, you are only at about 30 percent of the MPE (19.9/100 + 0.1/1).

Of course, if half the field were coming from each antenna, then you would be at 1,010 percent of the MPE (10/100 + 10/1). Monitors are typically set to trigger at 50 percent of the MPE to allow for measurement uncertainty. Note that an average, ungrounded adult male makes a great Channel 6 or FM antenna, depending on his height.

Fields Detected

Monitors detect the E-field, the H-field, or both. At the lower frequencies, induced and contact currents are more of a threat than thermal affects. Both are related to the strength of the electric field.

That is why the most modern standards, such as IEEE C95.1-1999, allow much higher magnetic fields below 100 MHz. At AM frequencies, even a "heavy" magnetic field is never more than 10 dB higher than the electric field. Yet the IEEE limit is 10,000 times higher for the magnetic field at these frequencies. Yes, FCC MPE limits are the same for both fields, but the IEEE standard is biologically more correct. At 50 MHz to 100 MHz you might be in the near field 5-10 feet from the antenna.

So, unless you are essentially on top of one of these high-power broadcast antennas, an accurate E-field sensor works very well. But be careful, dipole electric field detectors do not work on the body below 50 MHz.

The Nardalert XT RF Personal Monitor operates on the body from 100 kHz to 100 GHz. Its frequency response is shaped to match the FCC MPE limits for Occupational/Controlled exposure.

Once you have your RF personal monitor, there are a few things to consider:

Where to wear the monitor

Monitors are directional and should be worn on the torso facing forward. Your eyes and testes are the most vulnerable parts of your anatomy. It is not possible to make an RF personal monitor that works isotropically *on the body*.

Although the monitors do not detect what is behind you, they are generally very effective, providing you do not stay motionless. The problem is heating, so as long as you move occasionally, the monitor should pick up the field.

Where ***not*** to wear the monitor

Wearing monitors on your belt over the back pocket brings new meaning to the concept of CYA, but it is not the correct place to wear a monitor. And RF personal monitors *do not work* underneath RF

protective garments. Wearing a RF personal monitor under a RF protective suit appears to make sense to those that are not familiar with the personal monitors and the suits. It would seem that the monitor would simply detect what is getting through to the wearer.

This approach — wearing the monitor under the protective suit — does not work, is potentially unsafe for the wearer and would never be recommended by the manufacturer of the personal monitor.

RF PROTECTIVE CLOTHING

Personal monitors can tell you where you cannot go or should not remain, but what if you need to work in an area with significant RF fields?

Protective garments are often a good solution to this problem. These suits can be considered Personal Protective Equipment (PPE). As with personal monitors, there is often confusion about protective garments. These garments provide a substantial amount of protection, 10 dB minimum and often more, and work above 50 MHz. But there are limitations and cautions, especially at lower frequencies, such as in the AM radio band:

Protection is limited

Putting on an RF protective garment should not be equated with Clark Kent changing into his Superman outfit in a phone booth.

The manufacturers of these garments stress that you should *know the intensity of the field that you are entering*. Yet, most survey instruments are not usable at these high field levels, which leaves computer modeling as the most common method used to determine the field levels. The conservative, recommended approach is to assume 10 dB of protection — restrict your work to areas that are no higher than 1,000 percent of the MPE limits.

Suits must be worn properly

Suits should never be used without the hood above 800-900 MHz due to the potential for eye and brain damage at those frequencies. Hoods are generally not required below 400-500 MHz. At frequencies in between, the suits can be used at levels of 300-500 percent of the MPE.

It is critical that the body of the suit makes intimate contact with the special conductive socks. The importance of making good contact between the main part of the suit and the conductive socks cannot be overemphasized, especially if you intend to work at lower frequencies, such as near an AM radio station.

The suits need to have a path to ground to work properly. If you leave the socks off, you not only do not have a good path to ground, but the currents into the suit pass through your ankles. The current density in the ankles can be very high due and can produce very high Specific Absorption Rates. If your ankles feel warm, something is wrong.

Other considerations

The coverall, gloves, socks and hood can impede mobility and add to heat stress, and the hood can limit visibility.

The NSP RF protective suit provides protection in fields up to 1000% of the FCC's MPE exposure limits. It is shown without the hood.

USING MONITORS WITH SUITS

The reason that you should never wear an RF personal monitor under and RF protective garment, or any garment for that matter, is that the monitor is not going to work properly. If you wear a monitor under regular clothing and the clothing is dry, a monitor will function properly. The disadvantages are that you will not be able to see the indicators and the audio alarms may be more difficult to hear. If the clothing is wet, the field strength that the monitor sees will be attenuated. Tests on monitors at microwave frequencies indicate as much as a 13 dB signal loss.

The attenuation is much less at broadcast frequencies but it is still very significant.

A monitor worn under an RF protective suit is affected in several ways. There are two important technical reasons for these problems that have been validated by tests.

1. The minimum measurement distance for RF sensors is either 20 cm or 5 cm, depending on the standard. In practice, many probes do not work with only 5 cm (about two inches) spacing. It is one of the reasons that the IEEE increased the distance to 20 cm. With a personal monitor worn under an RF protective garment, the conductive fabric is normally touching the monitor and within less than half a centimeter from the sensors. All types of abnormal reactions can occur with the sensor this close to a potential radiator (the conductive fabric can become a radiator). Capacitive coupling can occur which usually means that the levels are overestimated but they can also short out the field.
2. The strong currents that can flow through the conductive fabric, and the fields that can occur on the surface, can interfere with the control electronics. Under some conditions this will cause false alarms. However, under some conditions the monitor's ability to function properly will be disrupted in terms of electromagnetic compatibility (EMC) and the monitor will not alarm at all, regardless of the magnitude of the RF field.

A new high-power RF personal monitor is now available for use on the outside of RF protective garments. This combination of suit and monitor is the ideal solution to working in high-level RF fields. Just remember, if the monitor sounds an alarm at 1,000 percent, it is time to back off and get the power reduced before you proceed.

CONCLUSION

RF hazard protection equipment can be an important component of your overall RF safety program. It is very important that you educate yourself about the equipment, select the equipment that is best for your application, and use it properly. Used properly, both RF personal monitors and RF protective garments can be very useful for broadcasters. The wrong equipment, or even the correct equipment used improperly, can spell disaster.