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RF Hazard Protection Equipment

RF personal monitors and RF protective garments are important tools for ensuring RF safety during site installation and maintenance activities. Managers and workers must understand the capabilities and limitations of RF hazard personal safety equipment to put it to the most effective use.

Radiofrequency (RF) radiation personal monitors are a common sight at both wireless and broadcast sites. Many tower climbers also use RF protective garments (RF suits). These two types of hazard-safety equipment, monitors and suits, can be valuable tools in reducing the amount of RF energy to which a person might be exposed.

As with any equipment, it is important to start by selecting the correct tool to do the job and then *use* it correctly. More often than not, monitors and suits are being purchased and used because the user was "told" to do so. Often, these tools are looked at as a quick fix or something to keep the FCC happy.

If you misuse a shop tool, like using a screwdriver to punch holes in a can, at worst you might be out $2 for a new screwdriver. The stakes are higher with tools used in RF environments. If you wear an RF suit incorrectly or in an environment with field levels that are too high, you can get *hurt*. If you use the wrong RF personal monitor, or misinterpret its indicators, you can also get hurt or, more likely, unnecessarily stop work activity when there really is no reason to do so.

Personal safety and MPE limits

The purpose of an RF personal monitor is to indicate when the wearer is being exposed to RF fields that *may* exceed the FCC's maximum permissible exposure (MPE) limits for an occupational/controlled (occupational, for short) RF environment. The purpose of an RF protective garment is to allow the wearer to work in areas where the RF field levels *substantially* exceed the MPE limits for occupational exposure.

Workers that use monitors and suits must be trained to work in RF environments. They must satisfy the FCC's criteria for being fully aware workers who are able to exercise control over their exposure. *(See "FCC Regulations," page 24.)*

Monitors and suits are not really complicated from the user's point of view. The user does not have to know how to design one or the other to use them successfully. Nevertheless, it is important to have a basic level of understanding about how this equipment works to recognize what is happening in potentially hazardous environments. I often find that people who wear monitors do not understand what the monitor is telling them. That is why I now ship out a training CD that I developed with each monitor order.

You should not simply "buy a monitor and wear it." You must also understand the device's limitations and know the requirements of the specific application when selecting and using an RF personal monitor. For protective garments, you must learn what level of protection RF suits provide and how this varies, depending on how they are used. There are proper ways to use RF personal monitors and RF protective garments in conjunction.

This article covers best practices for those who use, or are considering using,

by Richard Strickland

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Tower photography, Don Bishop. Product photography, Thomas Gibson. Art and design, Scott Dolash. RF safety equipment courtesy of, clockwise from top: UniTech Services Group, Narda Safety Test Solutions and Euclid Garment.

RF hazard protective equipment.

When should I use a monitor or suit?

This is an important question, to which there are many opinionated answers. Here is what I tell my clients:

First, only workers who satisfy the FCC's requirements for qualified workers who are *fully aware* and *able to exercise control* should be allowed to enter areas where the RF levels may exceed the MPE limit for general population/uncontrolled exposure. If a person is going to enter any area where there is a *chance* of exposure to RF field levels above the MPE limits for occupational/controlled exposure, a monitor is almost always the best solution. This includes any tower on which one or more television or FM radio antennas are located. It also includes work on towers within 500 feet of a broadcast antenna, such as at an "antenna farm." I would not recommend allowing anybody on a broadcast tower without a monitor, even when the systems are supposedly shut down.

There have been too many instances when systems have been accidentally turned back on while climbers were still on the towers. Consider one situation for which an FCC *Notice of Apparent Liability for Forfeiture* (NAL) was issued in 2005. A climber, wearing a suit, had been told that all three FM stations on the tower had been shut down. For some inexplicable reason, the climber shut off the monitor that he was wearing. When his legs got extremely warm and his RF suit started to smoke, he finally knew something was wrong.

In contrast, the field levels on most towers supporting only wireless services, such as cellular or PCS, are low. If all the antennas are directional (sector) antennas and they are arranged in the common triangular pattern, someone climbing the tower has nothing to worry about unless he or she somehow gets directly in front of one of these antennas. If there are any omnidirectional

The amount of stainless steel and the design of the yarns differ between manufacturers, ranging from 10 to 25 percent stainless steel. Both designs provide a minimum of a 10 to 1 reduction (10 dB) in energy absorbed by the wearer when the suit is worn properly.

Photograph courtesy of UniTech Services Group.

FCC Regulations

The FCC regulations provide for two sets of MPE limits, one for occupational/controlled (occupational) exposure and one for general population/uncontrolled (public) exposure. The MPE limits are frequency dependent, with the greatest restrictions occurring in the human resonance region from 30 MHz to 300 MHz, in which humans absorb the most energy. The public limits are only one-fifth of the occupational limits for all frequencies above 3 MHz. A common misconception is that the so-called "public" limits apply to the "general public." Nothing could be further from the truth.

Although this area could be the subject of an entire article, the basics are that a *controlled* environment is an area covered by an RF safety program. As part of an RF safety program, qualified workers are allowed to enter controlled areas. Qualified workers, per the FCC regulations, are *fully aware* and able to *exercise control*. Fully aware workers have received both written and verbal instruction in RF safety and are able to exercise control over their exposure by using appropriate equipment, such as RF personal monitors and RF protective garments.

Therefore, all the various tradespeople who might visit a rooftop RF environment—HVAC, elevator repair, window washer, building maintenance and even some electronics types—cannot possibly be classified as "fully aware and able to exercise control." In fact, it is difficult to control access to an entire roof, but it is fairly simple to control a tower. This is important to realize because this will influence the types and locations of RF safety signage that you should use. RF exposure is also an issue for the Occupational Safety and Health Administration (OSHA). There is an expectation that a company will have a program in place to manage these hazards. This means that you need a written policy, and your workers must receive training.

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antennas mounted on stub arms, offset a few feet from the tower, there is a chance of exposure to significant RF fields when the climber is at the same elevation as one of these antennas. However, one can usually climb past the antenna quickly so that the time-averaged exposure will not be significant. The key here is to train the workers so that they understand the radiation pattern of the antennas and know the basics of RF safety.

If the fields are known to be above the MPE occupational limits, workers must wear an RF suit in that area. Suits are primarily used on or near broadcast towers and have limited application on wireless towers or at rooftop sites.

Wearing a monitor on your belt, hanging over your back pocket, may bring new meaning to the phrase known by the acronym "CYA," but it is *not* the correct place to wear a monitor—unless you intend to climb backward. Also, RF personal monitors cannot do their job when worn *underneath* RF protective garments. Wearing an RF personal monitor under a RF protective suit might seem logical to those who are not familiar with the personal monitors and suits; they might think that the monitor would simply detect what is "getting through" to the wearer. This is simply untrue.

This approach—wearing the monitor under *the protective suit—does not work, is potentially unsafe for the wearer and is not recommended by the manufacturer of the personal monitor.* Unfortunately, some "safety consultants" have trained workers to do just that—wear a standard monitor under the suit.

There are two correct ways to determine whether the field levels might be too high for a person wearing a suit to enter. First: calculate the field levels using appropriate formulas and modeling techniques. One must still be careful, as the formulas have limitations, especially for on-tower applications. Second: Wear the Nardalert XT high-power model that is specifically designed to be worn with and outside of a suit.

Note: Be careful when using these special high-power monitors. One company that I know of bought a number of the high-power Nardalerts and issued them to personnel working on rooftops *without* RF suits, not realizing that these were not standard units. The high-power monitors are set to alarm at 10 times the field strength of standard monitors. That is, 500 percent of the MPE limit for occupational controlled exposure. High-power monitors are only appropriate when used with an RF suit that provides a factor of 10 protection. Fortunately, this error was discovered in a review of the company's training program, and I helped them get the monitors reprogrammed for normal use.

RF personal monitor design

Narda Safety Test Solutions, a division of Narda Microwave, supplies

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more than 95 percent of all the RF personal monitors sold worldwide. The first monitors, developed for the military, covered the microwave band only. The first generation of communications-band monitors covered the VHF and UHF bands. Today, the Nardalert XT accurately operates from 100 kHz to 100 GHz. The RadMan is rated up to 40 GHz, but in reality is only functional from about 40 MHz to 4 GHz. Its dipole sensor does not work on the body at lower frequencies, and it has extreme variations in sensitivity at higher frequencies. While this seems adequate for most applications in communications other than AM radio, the RadMan is far less accurate and offers fewer features than the Nardalert XT. Because equivalent models in each product series sell for exactly the same price, it is easy to see why the Nardalert XT outsells the RadMan by about three to one in the United States.

Photograph courtesy of Euclid Garment.

Both the Nardalert XT and the RadMan have a "shaped" frequency response whereby the sensitivity of the sensor is a function of frequency. The design technique is similar to designing a filter. The goal is to have the frequency response mirror one of the standards, such as the FCC regulations, as closely as possible.

For example, the FCC's MPE limit for occupational/controlled exposure at VHF frequencies (30–300 MHz) is 1 mW/cm², while the MPE limit below 3 MHz is 100 mW/cm². Take any simple site with one AM and one FM antenna, and you can see the advantage of a shaped sensor that responds in terms of percentage of the MPE, or "percent of standard." 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). The wireless industry faces the same type of problem where PCS systems are collocated with VHF two-way radios. In this case, the difference in exposure limits is only 5:1, but the issues are the same.

A shaped response monitor automatically weights each signal and determines the total exposure in terms of percent of standard. Users do not even need to know the operating frequency of the systems that they are working near. Monitors are typically set to alarm at 50 percent of the occupational MPE limit to allow for a measurement uncertainty margin of safety.

Although monitors employ the same sensor technology as the probes used in RF survey instruments, there

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is one important difference: Probes use three sensors arranged in a mutually orthogonal design so that they are omnidirectional. You cannot do that with a personal RF monitor because the human body functions as an RF absorber and as an RF reflector. So monitors use two sensors and detect fields in roughly the forward hemisphere but do not pick up energy from behind the wearer. Although the monitors do not detect what is behind you, they are generally effective, providing you do not stay motionless. The physical danger in RF fields is heating, so as long as you move occasionally, the monitor should pick up the field before you have had a significant time-averaged exposure.

RF protective garment design

RF protective garments supplied by the two companies serving the North American market both use a combination of Nomex and stainless steel. Nomex is a flame-proof, synthetic material also used by racecar drivers. Although Nomex may smoke under extreme conditions, it cannot burst into flame.

The amount of stainless steel and the design of the yarns differ between manufacturers, ranging from 10 to 25 percent stainless steel. Both designs provide a minimum of a 10:1 reduction (10 dB) in energy absorbed by the wearer when the suit is worn properly. This applies for all frequencies at the VHF range and higher. There is some question as to how effective the suits are at HF frequencies and the AM radio band.

For frequencies up to about 800 MHz, suits can be used without the hood, but the amount of attenuation drops to as little as 3:1. Although suits with more stainless steel provide more attenuation, it is this consultant's opinion that no one should ever *knowingly* enter an area with RF field levels that are higher than 1,000 percent of the MPE limit for occupational/controlled exposure. This limit is based on the minimum of a 10:1 reduction afforded by a full suit when properly worn. This conservative approach *allows for things to go wrong.* For example, the suits offer little attenuation unless they are worn properly and the wearer is well grounded. This means the coverall has to make good contact with the socks so that the energy drains to ground.

Worker competency is paramount

RF personal monitors and RF protective garments are useful tools for work performed in potentially high RF field levels. But you need to select the correct tool for the job and use it correctly. Anybody who uses monitors and suits must be a trained RF worker in accordance with the FCC criteria for workers who are *fully aware* and *able to exercise control.* agl

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