Wireless System Collocation Presents New Issues For Worker Protection

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As the number of subscribers to wireless communications services clicks past the 130 million mark in the U. S., base stations and their familiar towers continue to popup everywhere. As technologies change, the number of subscribers skyrockets, and demand for tower space increases, municipal governments are increasing their resistance to additional towers. With many of the most accessible, least controversial sites already taken, wireless service providers have broadened their search for potential base station locations. It hasn't taken long for their search to focus on electric utility towers, which are very nearly ready-made for collocation of wireless systems. Consequently, a remarkable percentage of new base station installations in the U. S. are sharing space with high-voltage transmission lines on these structures.

However, the juxtaposition of power transmission and wireless systems raises another issue: how to protect utility workers from being exposed to potentially harmful levels of radio frequency (RF) radiation. It might seem laughable that workers who routinely work in close quarters with hundreds of thousands of volts and hundreds of amperes should worry about exposure levels measured in milliwatts-per-square-centimeter. However, it is well known that RF radiation can have damaging effects on the human body. The Occupational Safety and Health Administration (OSHA) and other U. S. regulatory agencies have standards in place to protect workers and the general public against overexposure to RF radiation. However, the electricity transmission and distribution community has been unaffected by standards covering RF radiation—until now.

Manufacturers of instruments designed to measure RF energy have developed personal, wearable RF radiation monitors that activate their alarms in the presence of RF radiation at levels deemed potentially dangerous. The ability of these devices to function properly when worn by people in close proximity to high-intensity, power-line energy fields has been questioned.

It is well known that these fields can interfere with this type of detection equipment. As a manufacturer of these monitors, Narda Safety Test Solutions needed to determine the suitability of personal monitors for this application. The

company performed susceptibility tests both in the field and in its facilities. The results indicate that not all monitors (including some from Narda STS) are acceptable for use near power lines, while others are unaffected by low-frequency energy at field intensities well above those likely to be encountered by utility workers.

The issues

The electric power industry is all too familiar with medical, political, and financial issues related to safety in the presence of high-voltage electromagnetic fields. Just when one study finds a suspicious link between a deadly disease and exposure to low-frequency electromagnetic energy, another study refutes it. The general consensus appears to be that low-frequency energy probably causes little harm (although of course some disagree).

The same good study/bad study scenario exists in the area of RF radiation (300 kHz to 300 GHz). Heating of tissue caused by microwave energy is a proven fact and is fairly well understood, which is why the heating effect is the basis for exposure standards throughout the world. Although some researchers believe there may be some effect from minute levels of RF exposure, the theory has no basis in any standard. There is also some evidence to support the possibility that RF radiation causes chromosomal damage, but the limited data available are far from conclusive, and thus this theory too is not represented in any standard.

The body's physical size causes it to absorb more energy at some frequencies than others, making it more prone to heating at some frequencies -- the frequencies used for wireless communications and broadcasting are among them. In fact, a typical adult male appears as a perfect antenna to RF radiation at frequencies of about 85 MHz (TV channel 6).

The standards developed by both government, scientific, and industry groups feature frequency-dependent exposure limits. The acceptable levels of exposure contained in these standards are the foundation upon which the alarm thresholds of personal, wearable monitors are based.

Typical personal monitors

Personal wearable monitors are designed to provide a comfortable margin of safety, activating their alarm at RF radiation levels just below the values called out in the standard. These monitors are designed to be easy to use and require no technical knowledge, which is essential for a product used by people of widely varying technical backgrounds. The units are generally small and light (about twice the size of a pager) and operate for months on a single alkaline battery.

The simple outward appearance of personal monitors belies the technology inside. Some units employ detectors that sense true Root Mean Squared average electric fields (RMS fields sum the energy properly from multiple antennas), which is a desirable characteristic because the monitor's alarm is activated when the total energy from any number of antennas exceeds the preset threshold. In addition, monitors for this application should have response characteristics that are "shaped" to the requirements of the standards, in which maximum exposure levels vary with frequency (Figure 1). As a result, these monitors will alarm are different levels of RF radiation depending on the frequency at which they occur. Recent models of personal monitors allow the monitoring of RF exposure over a period time. Thus, the exposure of an individual can be examined after-the-fact, for example at the end of a work day or work week to help assure that proper safety precautions are being adhered to.

The cautionary indications consist of a variable audible alarm that increases in intensity with increasing radiation levels, and a bright flashing LED. The alarms occur conservatively at thresholds just below the levels specified in major standards. Newer models have also added features to allow indications at multiple exposure levels.

Do they work, and when

The high-voltage electricity transmission environment presents challenges to the operation of personal radiation monitors that are not encountered in their traditional applications. As a result, it was necessary to determine the potential for false alarms and other anomalies caused by the low-frequency energy generated by power lines.

It was initially thought that low-frequency fields of 30 kV/m were near the maximum level encountered by utility workers. Approximate field strength is determined by dividing the line voltage by the transmission line's height above ground (540 kV divided by 18 meters equals 30 kV/m), although the actual physics are more complex. Narda Microwave and a West Coast utility conducted tests using special fixtures constructed for this test situation. Monitors were subjected to a high-voltage field while simultaneously being exposed to RF fields at intensities of up to 40 kV/m.

The results of all tests indicated that detector design is extremely important. Some early models from all the manufacturers were not able to function properly anywhere near power line fields. In fact, many designs go into a constant alarm mode at levels below 2 kV/m. Other models functioned properly up to the limit of the test capabilities at 40 kV/m. In general, units that use electric field detection tended to false alarm, and models that use only magnetic field detection did not.

It has now been determined that personal monitors may require even more immunity from strong power frequency fields. Industry groups are proposing that

personal monitors be designed to operate in fields up to 100 kV/m. Another recent trend is the use of a much broader range of frequencies for wireless services. This presented a new challenge because it is essentially impossible to cover this range of frequencies with a single magnetic field sensor. Narda Safety Test Solutions solved this problem by designing ultra-broadband RF personal monitors that detect the electric field over virtually the entire RF spectrum and then added special shielding to block power line frequencies. It also improved its test facility to the 100 kV/m level. Today, Narda STS offers two families of "ELF Immune" personal monitors that meet this requirement. Not only have they passed tests in the lab, they have been field-tested by utilities.

It is imperative that the appropriate RF monitor be used. If a monitor is incapable of working in the expected environment, then the monitor is essentially ineffective, and essentially no protection from RF energy is then being given to the worker. Most units will give false "high" readings when they are malfunctioning in excessive electric field environments. When the incorrect unit is in real-world situations and not functioning properly, technicians often turn the unit off or ignore it, which is, effectively, not allow any RF protection. Narda, for example, manufactures personal monitors specifically designed for proper operation in fields in excess of 100 kV/m.

Maintaining consistent protection

Equipping field service organizations with personal monitors is easily done, once the need is identified. The task is made easier by the fact that electric utility engineers and technicians are generally well informed about the issues surrounding safety in the presence of low-frequency energy. However, it is quite likely that many utilities are unaware about the need to protect workers at collocated sites from RF radiation, have no knowledge of personal monitors or RF compliance programs, or both.

Information about non-ionizing radiation is relatively easy to find, and a massive amount of information exists concerning standards, basic principles of measurement, and virtually every technical aspect of non-ionizing radiation. In fact, it is quite possible to become immersed in a sea of conflicting information. As a result, it is generally safer to read a single standard (such as ANSI/IEEE C95.1-1992), since it will contain information and exposure levels nearly identical to other standards. An excellent resource is the FCC's Office of Engineering and Technologies (OET), "[OET Bulletin No. 65: Evaluating Compliance With FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields]," available at http://www.fcc.gov/oet/rfsafety.

Standards bodies throughout the world, as well as the World Health Organization (WHO), and U. S. regulatory organizations such as OSHA, the Federal Communications Commission (FCC), and the Food and Drug Administration (FDA), have detailed information on their respective web sites. Of primary

importance for any employer is adherence to the OSHA rules and regulations. OSHA has a web page dedicated to the issues of Non-Ionizing Radiation with additional information specifically related to development and adherence to Health and Safety Policies. The OSHA web page is http://www.osha-slc.gov/SLTC/radiofrequencyradiation.

Once an organization has made the decision to equip field service teams with monitors, to remain in compliance OSHA rules written health and safety policy, specifically detailing the application and use of any type of personal protective, of which RF personal monitors would apply, a written simple RF exposure compliance program to which each team must adhere needs to be created. A compliance program for a collocated wireless/electric power application need not be complex, but should contain the following elements:

- Make RF protection part of the organization's overall safety program.
- Assign an RF exposure compliance officer in each team, train that person, and make it part of his / her job description to ensure that the program is followed.
- Inform service people about the issues surrounding RF exposure, and why protection is important.
- Describe a typical co-located wireless/electric power site and how to find areas where high levels of radiation are likely to be found.
- Train every field service person to do the following:
    - Follow the organization's guidelines about working in close proximity to RF radiation.
    - Use a RF personal monitor.
    - Learn how to verify that transmitters are turned off and how to use lockout tags to ensure they remain that way.

While RF compliance programs vary with the organization they were created to serve, they should all adhere to these minimum guidelines. Additional information is available from many places, which has participated in the creation of RF compliance programs in many industries.

The first step – acceptance

The greatest step in maintaining RF safety in the co-located wireless/electric power environment is an awareness and recognition that a need exists. In the wireless communications, satellite, paging, and broadcast industries, awareness of the problem did not cause many industry decision makers to stand up and take notice – until media coverage and the potential for litigation provided the eye-opener.

Issues surrounding exposure to high-frequency RF energy sources are new to the electric power industry, so there is still time for appropriate preventative measures to be taken. The resources are immediately available.

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Captions

1. Photo of wireless site collocated on tower
1. Shaped response curve