RF Emissions Safety and Today's Regulations

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Present

RF emissions, radio frequency radiation, electromagnetic energy – whatever you want to call it, the new FCC regulations and increased awareness of non-ionizing radiation is a hot topic today. The new FCC regulations seemed to have caught many organizations by surprise, although it has taken years to get to where we are. And where are we? Well, we have some reasonable regulations that are soundly based on well-documented biological hazards. At least some of the confusion is due to the conflicting messages sent out by OSHA – messages that only now appear to agree with he FCC and other regulatory agencies. But before we go into details, perhaps it is better to review how we arrived at the place where RF safety is making headlines.

Past

Although there were some indications of the heating effects from the energy emitted by radio transmitters in the late 1930's, the phenomena became well known with the development of radar during the Second World War. Quite simply, people noticed that they got warm when they stood in front of radar antennas. Dr. Percy Spencer of Raytheon took note and ultimately developed the *radar range* – today's microwave oven. My company, Narda, got involved at the very beginning – back in 1969 – when two representatives of the Food and Drug Administration knocked on our door and asked for help. Public Law 90-602 that regulated the amount of RF energy leaking out of a microwave oven was about to be passed and there weren't any instruments to measure the leakage. The only thing that existed were some extremely crude instruments to measure field strength. My colleague, Ed Aslan, invented the first instrument to measure microwave oven leakage and received a patent and an IR100, or Industrial Research, award as one of the top 100 new inventions. Today, I am lucky to have Ed in the office next door – still inventing. In fact, he now has 47 patents in this field. The rest of the world has ***four***!

The first human exposure guidelines were developed by the U.S. military in the 1950's. The military funded most of the research in those days because they were the ones with most of the high power emitters. The first general RF exposure standard was issued by ANSI – the American National Standards Institute – in 1966. It was only four pages long and suggested limiting human exposure to levels no higher than 10 mW/cm^2 from 10 MHz to 100 GHz.

Other than the military, broadcasters were the only ones who faced concerns over RF radiation. But most broadcasters focused on the concerns of the public. In reality, RF radiation is ***almost*** exclusively an occupational problem. It is rare for someone to be exposed to significant RF field levels outside of work, although the proliferation of wireless antennas is making public exposure more of a concern than ever. We'll get back to that point later. Now, a concerned public can impact broadcast operations and must be dealt with, even if the fears are almost always unwarranted. But I have always found it ironic that those dealing with some of the most dangerous RF exposure situations –

broadcasters – almost totally ignored occupational exposure issues. Until recently, that is.

As biological research continued, it became apparent that three primary questions needed to be answered:

1. How do various RF fields affect the body?
2. At what levels does the body suffer adverse effects?
3. At what levels are the effects permanent?

Well, early on we knew that the primary concern was thermal – quite simply the body heats up in the presence of significant RF energy. The first ANSI standard was a best guess and suggested limiting exposure to the same 10 mW/cm^2 field level at all frequencies. But, as research continued, it became apparent that many factors impact how much the body heats up. The concept of Specific Absorption Rate, or SAR, evolved. SAR designates heat absorbed into the body in units of Watts per kilogram. Ultimately, it was determined that much of this follows basic antenna theory. In an ungrounded situation, the body represents a fat, lossy dipole. When well grounded, the body represents a grounded quarter wave antenna. Researchers consider the "standard man" to be 1.75 meters tall, about 5 foot 9 inches. That makes him resonant at about 86 MHz. So the average adult makes a perfect antenna for channel six television!

The biology is certainly more complicated than that – but height, grounding, and polarization are the most important factors in determining SAR level.

The next question is: How much heat can the body tolerate? It was determined that the most heat the human body can deal with is approximately 4 W/kg. Much of this research was based on exercise levels rather than on actual exposure experiments. And these levels are averaged over the body since our circulatory systems function much like a radiator. For this reason, an arm exposed to a strong RF field from a satellite uplink dish can tolerate about twenty times as much energy as the whole body. The eyes and a male's testes are particularly vulnerable, however, since the limited blood flow of these organs limits the benefits of the circulatory system. Time is also a factor – most standards average exposure over time, which only makes sense since we are dealing with heat. Six minutes is the averaging period for most occupational exposure limits.

How can RF energy hurt me? Moderate level exposures cause heat stress and behavioral changes. The effects are often mistaken for the flu because the symptoms are often similar. And as the level of exposure increases, the potential for harm increases. Human cells die at 107 degrees Fahrenheit. This is the reason that doctors get concerned if anyone's temperature goes above 105 degrees. The body is constantly replacing cells so the amount of damage that is done depends on how many cells are killed and what kind of cells are killed. Kill off some cells and the effects may pass in minutes or hours. Cook off a lot of cells – liver cells for instance – and you will have liver damage.

Back to the Present

Today, we understand the biology fairly well. We have reasonable standards in place. And both the public and workers are much more aware of the issue of RF safety. Industry is still trying to come to grips with how to deal with the new FCC regulations, OSHA, and a host of state and local government agencies.

Today, most of the RF exposure standards from around the world are remarkably similar because they are based on the same biological data. All the U.S. standards are most restrictive from 30 MHz to 300 MHz. The 300 MHz represents a newborn infant in a crib. At the other end, the standards are designed to protect a well-grounded NBA center. The exposure limits are set for one tenth of known limits for healthy young adults – a SAR level of 0.4 W/kg. The safety factor can be greater than 10:1, depending on the polarization. However, several factors can chip away at that safety factor.

1. Not everyone fits the category of athletically fit, healthy young adult.
2. The standards were all developed at room temperature – high heat and humidity lead to a severe erosion of what can be considered your "heat budget" before one even factors in the RF energy.
3. Workers are often engaged in strenuous activity, such as climbing a tower, which also produces heat.

So, the standards and the FCC regulations make sense. Now, you should be asking "What does my company need to do to satisfy all these standards and regulations?" The first question really should be: What do we need to do to keep anyone from getting overexposed? And most of this is common sense once you understand the biology and the standards.

What the FCC Regulations Require

The new FCC regulations have a single objective – to prevent people – all people – from being overexposed to potentially harmful RF energy. The regulations are concerned with human exposure, not emission levels.

There are basically two ways to achieve compliance:

1. Make a site compliant by design.
2. Develop and follow an RF safety program to insure that personnel do not risk exposure.

One common misconception is that low power wireless systems that are *categorically excluded* somehow relieve the operator from all responsibility for RF safety issues. Categorical exclusion does eliminate the *legal* need for an *engineering evaluation*. So, you do not need to complete an engineering evaluation. But you still need to protect your personnel. First, what is an engineering evaluation (EE)? Well, there is no exact structure to this document. Basically, it is a written document that defines how you came to the conclusion that your facility was compliant with the FCC regulations. It might

include a copy of a measurement report or a computer model that was completed. Or it may include some manual calculations. Someone who has the necessary skills and knowledge to do this work must complete the EE. While we are on the subject, what about an Environmental Assessment (EA) or an Environmental Impact Statement (EIS)? Well, these are very formal, structured documents. And while some consulting firms offer to complete Environmental Assessments for you, there is absolutely no reason to ever file an Environmental Assessment or an Environmental Impact Statement with the FCC. The FCC tells me that they have received a few environmental assessments but never an environmental impact statement. Both of these documents always put your violation in writing. But since you are not going to get any relief, why declare it. And it would probably cost more to file these reports than to fix the problem anyway.

It is possible to achieve *compliance by design* for many wireless sites. To be compliant by design, the antennas must be located such that the field levels are below the FCC General Population/Uncontrolled environments limits anywhere that a person could reasonably be expected to go. Since even a low power PCS antenna creates fields above the Maximum Exposure Limits (MPE) close to the antenna, typically within two feet, it is not possible to be compliant by design on a rooftop unless omni-directional antennas are elevated above your head and sector antennas are located either on the edge of the roof or overhead. It is possible to relocate antennas at many sites to achieve compliance. At other sites, economics or local ordinances – for example, antenna height – may preclude this type of solution.

For many sites the only way to be compliant is to operate under a RF safety program.

Safety programs are often misunderstood by those in the communications industry. Yet, to health and safety professionals, all good safety programs follow a common template, regardless of the physical or chemical hazard that they are designed to protect against. In many ways they are similar to the quality control programs that most of you are familiar with. The common threads are:

- Someone has to be in charge with the resources and authority to carry out the program.
- The program must be communicated to and understood by the personnel that are affected, which usually involves some form of training.
- Hazard areas must be identified and marked.
- Standard work practices and controls must be established.
- The program should be reviewed, or audited, periodically to make sure that it is achieving the desired results.

A complete safety program for an operating company should have three similar, related components:

A corporate safety program document
A contractor or customer safety program document
A site-specific safety program document

Every safety program needs the basic corporate document that contains all the key elements previously described. In addition, a thorough safety program will include:

A Mission Statement
Various Appendices with needed reference and background material

If your organization hires subcontractors or leases space, these organizations are required to follow your safety program. Typically, the subcontractor or tenant is given a copy of the safety program contractor/customer document. They must sign a form acknowledging that they understand the requirements of your safety program and promise to operate under its rules.

A site-specific document is useful at a complicated or particularly hazardous site. This document will call out any site-specific work rules and typically will include a site plan with hazard areas indicated.

Operating companies should try to totally characterize all their sites and use this information to achieve a safe work environment. At shared sites, where conditions change constantly, this is a difficult – if not impossible – task. The problem with many sites – especially rooftop sites – is the surprising number of organizations and people that need to access the site. Not only do you have all the communications people involved in installing and maintaining the electronic equipment, there are service personnel for elevators and HVAC equipment, window washers, building maintenance people, exterminators, painting and roofing contractors, and often a surprising number of other visitors. At many rooftop sites, RF energy is often not just an occupational problem. And although many of the typical visitors I have just described are there to perform work, those from occupations outside the communications industry rarely have any knowledge of RF radiation.

Service organizations have little control over their environment. Personal monitors are the only practical way for service organizations to protect their personnel. And many operating companies use monitors also since it is difficult to characterize all their sites and keep up with the inevitable changes.

Future

Now that many companies are in a mad rush to achieve compliance, what is next? First, there is often a big difference between what companies may do and what they should do. First and foremost, the goal should be to protect both a company's own personnel and all others who may visit a site. Doing that also greatly reduces a company's liabilities. And since we are all business people, the goal should be to accomplish this at minimum cost with the least amount of impact on operations.

Well, some things are a given. Most companies today would not even consider letting workers climb a tower without adequate fall protection equipment. Years ago, this was not the case. The very communications industry that we are working to build is enlightening more and more people. So their tolerance of anything less than an RF safe environment is continually decreasing. In the coming years I would expect that the safety programs become more rational and less reactive. There will be less of "let's do it so we can satisfy the FCC and OSHA" and more of "What works best for us?" Training issues will be resolved and annual refresher courses will become the norm. Employees will become more involved in developing and maintaining RF safety programs, much like they have become more involved in quality assurance issues.

In a few years, RF safety policies and procedures will be the norm, not a disruptive annoyance!