**Bob's TechTalk #5**
***by Bob Eckweiler, AF6C***

**RF Exposure (Part I of III)**

**Evaluation:**

Since 1998 all radio amateurs are required to evaluate their stations for RF exposure. When you apply for or renew your license you must sign an RF Safety certification that is part of the application / renewal form. Over the next few months Tech Talk will be discussing RF exposure as it affects your operations and how to evaluate your station. In order to do the evaluation effectively a rudimentary understanding of power levels and decibels is necessary. If you've followed the past four Tech Talk columns you should have no problems!

Guidelines to RF exposure have been around for many years in the commercial radio world where power levels are high and directional aperture antennas can increase effective power many thousand-fold. As the guidelines became tighter and public concern grew; the FCC saw a need to have radio hams comply along with the commercial concerns. Some hams thought the requirement would blow a death knell to ham radio, but as you'll see, the evaluation of a station need not be that difficult. Actually there is one good thing that may come out of this; current antenna restrictions often lead to antenna placements that expose nearby occupants much more than they would be from an antenna up in the clear.

Why is the FCC suddenly concerned with RF exposure from amateur radio? During the past decade possible health hazards caused by exposure to electrical and magnetic fields have been brought to the attention of the public in numerous high profile articles. One, in The New Yorker magazine, looked into a possible correlation between a high rate of cancer and living near high tension power lines, and was widely read. The jury is still out on health problems created from electrical and magnetic fields at lower levels; studies vary almost as regularly as the "what foods are good and bad for you this week" articles. However, it is already known that at higher levels, RF fields are damaging to the human body due to heating of internal organs. An extreme example would be sticking your hand in an operating microwave oven. The big question is; at what levels do these fields become a health hazard? It is even more complex than that. The frequency of the energy is also important because certain parts of the body are like tuned circuits and are resonant at a particular frequency. There is also a question of the effects of long time exposure. The primary effect of the fields is a heating of organs, but other accumulative effects may also cause damage over long periods. The FCC, in conjunction with health and safety organizations, has published maximum permissible exposure (MPE) levels. Keeping electromagnetic exposure at or below the conservative MPE levels significantly reduces any health risks.

There are three separate but related MPE level criteria. Above 30 MHz there is a maximum field power density measured in watts per square meter (W/m2). Below 30 MHz the two components that make up a

field must be considered separately, and each must be below the given MPE for the frequency in question. The magnetic field is measured in amperes per meter and the electrical field is measured in volts per meter (V/m).

**Ohm's law says volts times amperes equal watts, so if the two field components are multiplied together you get watts per square meter:**

$$V/m * A/m = (V * A) / (m * m) = (W/m^2)$$

The reason the field components are measured separately at lower frequencies is because their longer wavelengths make the near field around the antenna more apt to be accessible by humans. (See side bar on The Square Law).

The immediate question is; "How do I know if I have to evaluate my station?" The first place to look is in a table published by the FCC, and partially reproduced here as Table 1. If the power level **into the antenna** is equal or greater than published in the table for your band of operation then you must do an evaluation. However, even if the power level is below that published **you are still responsible for meeting the exposure criteria**. Unless your station is unusual, you probably will. Special consideration needs to be given if you're using a high-gain antenna, a room or attic antenna, or if your antenna is mounted immediately adjacent to a neighbor's or public property.

The power you should use is the output power of your rig or power amplifier, (keyed on CW, FM and digital modes. PEP on SSB and AM) corrected for any feedline or tuner losses. To be conservative, these losses can be assumed to be zero.

Mobile and portable stations are exempt. However, that should not stop you from doing an evaluation if you are running high power in your mobile. Poor antenna placement, fiberglass bodied cars, and high power can lead to exposure above the MPE to the passengers in the car.

**Evaluation required if Power* (watts)**

| Band: | Exceeds: |
|---|---|
| 160 m – 40 m | 500 w |
| 30 m | 425 w |
| 20 m | 225 w |
| 17 m | 125 w |
| 15 m | 100 w |
| 12 m | 75 w |
| 10 m – 1.25 m | 50 w |
| 70 cm | 70 w |
| 33 cm | 150 w |
| 23 cm | 200 w |
| 13 cm & smaller | 250 w |

*PEP input to the antenna. (Repeater rules differ.)

**Table One**

My suggestion is you evaluate each transmitter / antenna combination for each band even if your power limit is below the published table and evaluate what the safe power level is for each antenna / band combination. That way you won't have to re-evaluate should you change radios and increase your power level.

When doing your evaluation there are two types of area that must be considered: controlled and uncontrolled area. Definitions of these are given in the references listed later

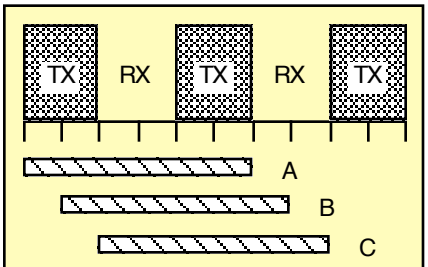
in this article. Briefly, controlled areas are spaces that you have immediate control over and can limit access – such as your property and the inside of your home. Uncontrolled areas are your neighbor's property, sidewalks and public property adjacent to your antennas. The two areas have different MPE limits, the uncontrolled area being the more stringent.

So where do you begin? Theoretically, the easiest solution would be to make actual measurements while in operation. Unfortunately, current equipment to do this is complex and expensive. A more difficult solution would be to calculate the field around your antenna. The complexity of this solution grows quickly since still and moving obstacles that will reflect energy usually surround the antenna. A much simpler solution is to use tables published by the FCC and ARRL.

The original document published by the FCC Office of Engineering and Technology (OET) is titled *Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields (Edition 97-01)*. In cooperation with the ARRL the FCC OET also published a supplement 'B' to the document, *Additional Information for Amateur Radio Stations*. These bulletins are available on the FCC web site. There is also a supplement 'A', confined to commercial broadcast radio. The ARRL has published a manual titled *RF Exposure and You* which includes copies of the two FCC documents listed above, additional tables and lots of useful articles and information.

Next month we'll actually evaluate some stations using the FCC and ARRL tables. Before starting on that task here are a few more evaluation criteria that need to be discussed.

Exposure limits are based on time averaging. In a controlled area the average is taken over a six-minute period. In an uncontrolled area the average is taken over a 30 minute period. In either case you must consider the period when the maximum exposure occurs. For example: You transmit two minutes, followed by two minutes receiving and repeat this numerous times. Over any six minute period you would be transmitting between two and four minutes, depending when you start the time measurement. You must use the **largest number**, four minutes. See Figure one. Since you are transmitting only a maximum of four out of six minutes, the MPE can safely be 1.5 times the published value for that frequency for continuous exposure.




Each division is one minute. TX = transmit, RX = receive. The bars are each a six-minute period.
Bar A: 67% transmit duty cycle
Bar B: 50% transmit duty cycle
Bar C: 33% transmit duty cycle

You must use A, 67% for your calculations

**Figure One**

Exposure limits are also depend on the duty cycle of the mode you're operating. FM, SSTV, AFSK have a duty factor of 100%. SSB is between 20% and 40%. CW is 40% and a carrier is 100%. Again you can find the duty cycle for your mode in tables provided by the FCC and ARRL.

Next month, when we begin evaluating station antennas, we'll look at these criteria in more depth. Meanwhile, I strongly suggest you obtain a copy of the ARRL book *RF Ex-*

*posure and You* ($15). The ARRL has done a good job expanding on the FCC tables and even converts the table distances from meters to feet for easier use.

### The Square Law, Near and Far Fields

The energy surrounding a transmitting antenna obeys the principle of the square law. The energy of the field diminishes as the square of the distance from the antenna to the measurement point. This law is true only after you get far enough from the antenna that the antenna's size is small and appears as a point source. Space beyond this distance is referred to as the far field; here the electrical and magnetic fields are perpendicular and the field voltage and current relate to an intrinsic impedance of about 377 ohms (assuming no obstacles are in proximity.) Electromagnetic fields in the far field are known as plane-waves.

The near field is the field close to the antenna. Here field intensities are complex and can vary greatly. Hot spots are possible especially if signals are reflected off nearby conductors.

***73, from AF6C***

*This article is based on the TechTalk article that originally appeared in the May 2001 issue of RF, the newsletter of the Orange County Amateur Radio Club - W6ZE.*