Bob's TechTalk #7
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RF Exposure Evaluation (Part III of III):

Another Example:

Last month we evaluated two antennas, a 5/8 wavelength two-meter ground plane and a triband beam. This month we'll discuss a few more issues concerning Minimum Personal Exposure (MPE) levels; then we'll evaluate a club member's HF multi-band vertical antenna.

Before we begin, let me again suggest, for those who haven't already done so, that you purchase the $15 ARRL book *RF Exposure and You*, by Ed Hare, W1RFI [Clever call there Ed!] An alternative is to download the FCC document *OET Bulletin 65* along with Supplement 'B' *OET Bulletin 65 Amateur Supplement* from the FCC web site:

http://www.fcc.gov/oet/info/documents/bulletins/#65

The FCC Worksheet:

The two antenna evaluations last month were worked free form. To make your job easier the FCC and ARRL both publish an optional **worksheet** that will lead you step-by-step through an evaluation. The worksheet comes with eight pages of specific instructions and should be easy to complete if you've been following Tech Talk right along. The worksheet can be found in Supplement 'B' *OET Bulletin 65 Amateur Supplement*, or starting on page 7.37 of the ARRL Book. The worksheet is four pages in length and is of the "fill in the blanks" type of format. The instructions cover each line quite thoroughly and give generic values for many entries should you not be sure of what to enter. The instructions include tables to save you from some of the more difficult calculations. You should fill out a separate work sheet for each antenna and band.

When you're finished filling out the worksheets, sign and place them in a safe place (with your logbook possibly.) They make a good record of your compliance should the FCC come knocking at your door. You can bet that if you attract the FCC's attention enough to have them visit you, they will check that you are in compliance with the Exposure rules.

What If You Are Not In Compliance?:

You've completed a preliminary evaluation and it shows that your antenna field exceeds the MPE; what can you do? If you have not yet taken into account the emission type factor and transmit duty cycle, do so now. These concepts were covered in earlier columns but are repeated here. The worksheet allows you to include these factors.

Emission Type Duty Factor:

Since different types of modulation have different average to PEP power levels, certain modes such as SSB can reduce exposure distances significantly. For instance, if you're using SSB with 1500W of PEP power (and no speech processing) the average power you're using is just 20% times 1500 watts or 300 watts. You can use this power level and repeat your calculations. BUT BE CAREFUL – if you're using the full legal limit then you are probably chasing DX or trying to get through during bad conditions. This means

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you will probably have the speech processor on. When it is on, the average to PEP power is now in the 40% to 50% range, and you MUST USE 600 to 750 watts for your calculations. Also, tuning up with full carrier will exceed MPE levels. A table showing the ratio of PEP to average power was given last month in this column. The ARRL book and FCC document have more extensive tables. Remember that the emission type factor for FM is 100%.

Transmit Duty Cycle:

Unless you're from the "Dark Side" of amateur radio, you don't transmit continuously. You can use this fact to average the exposure level over either a 30 minute period (uncontrolled areas) or a 6 minute period (controlled areas). You must remember to use the maximum on time when calculating the duty cycle. If you repeatedly transmit for two minutes then listen for two minutes the average in a controlled area is 67% (not 50% nor 33%) since for a given six-minute period you can be transmitting for four minutes and receiving for only two. The same duty cycle would result in a 53% duty factor in an uncontrolled area (sixteen minutes transmitting and fourteen minutes receiving.)

If, after all this you are still over the MPE, there are certain additional actions you can take. The most obvious are to raise or move the antenna, or to reduce power. In the case of controlled areas you can also show that you have taken precautions to assure that no one is in that area when you are operating your station. If the field level is exceeded in an uncontrolled area where human presence is normally transient or not expected, such as a roadway or sidewalk or shrubbery, this can justify that the MPE would not normally be exceeded when people pass such areas. It would be a good idea to be able to view these areas while operating. The posting of signs in areas of transient human exposure warning people not to linger in the area is also acceptable. However, this might not be a good idea as it could cause more problems than it solves. The worksheet covers such possibilities.

What are the Exposure Limits?:

So far the actual minimum exposure level has not been quantitatively defined in Tech Talk. As a rule of thumb the uncontrolled area limit is five times higher than the controlled area limit, though this is not case below 3 MHz. The exposure limit varies with frequency. Currently, only frequencies between 300 KHz and 100 GHz have a defined MPE. Table one shows the current MPE levels for controlled and uncontrolled areas at the high end of the major HF amateur bands. Below 30 MHz the power density is separated into its two components (the electrical field strength - E and the magnetic field strength - H). Each component varies inversely with the frequency and thus the power density - S varies inversely with the square of the frequency. Between 30 and 300 MHz the MPE is fixed at 1.0 mW/cm2 (controlled) and 0.2 mW/cm2 (uncontrolled). Between 300 MHz and 1.5 GHz the MPE power density varies directly with the frequency. Above 1.5 GHz to 100 GHz the controlled and uncontrolled MPE levels are again fixed at 5.0 and 1.0 mW/cm2.

If you wish to calculate the MPE for particular frequencies between 1.34 MHz and 30 MHz or 300 MHz to 1.5 GHz see the side bar titled MPE Field Equations on page 6.

The R6000 Cushcraft Vertical:

Let's look at a Cushcraft R6000 (6 through 20 meters) vertical with a claimed gain of 3 dBi. The Yaesu FT757 radio runs 100 watts output (no 6-meters) and there is 100' of RG-8X feeding the antenna. The antenna is mounted along the side of the house between

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the ham's house and side fence that separates the neighbor's property. The antenna is mounted with its base 10 feet above ground. The distance to the house is 8 _ feet. The fence is five feet away. Shrubbery, about 5 feet deep, runs along the fence on the neighbor's side in the area of the antenna. The neighbor's house is 12 feet distant from the fence and the second story is back even further. Both houses are two story wood frame dwellings.

From table one in the ARRL book, the two dimensional safe distances for 100W key down (100% duty cycle) are:

Band (Meters)	Uncntled (Feet)	Cntrled (Feet)
6	14.8	6.6
10	14.6	6.5
12	12.3	5.5
15	10.6	4.7
17	9.0	4.0
20	7.1	3.2

This antenna, using the simple, highly conservative table, is in compliance with the controlled MPE limits. The uncontrolled levels are another story. Even though the power level on 15 through 20 meters is below the minimum required for an evaluation, since the antenna is so close to uncontrolled space, the amateur is responsible for assuring that the MPE is not exceeded. In this simple evaluation it is on all bands (at 100% key down). If it wasn't, we could stop right here.

Taking the evaluation one step further, table two in the ARRL book has an explicit chart for this type of antenna. Here is the data from that table for 100 Watts at different uncontrolled exposure heights above ground, assuming the antenna base is at 10 feet:

It is immediately obvious that someone walking on the ground is below the MPE level on all bands. Since the neighboring house is about 12' back from the fence and since the second story is back even further, the house is beyond the area of exposure. This radio is safe to operate as long as no one is climbing above the shrubs near the fence.

Band	Exposure Height		
	At 6'	At 12'	At 20'
(Meters)	(Feet)	(Feet)	(Feet)
6	0	8.0	6.0
10	0	6.5	8.5
12	0	6.0	7.5
15	0	5.5	6.5
17	0	5.0	5.0
20	0	4.5	3.5

While some liberties have been taken in this evaluation, it is very conservative. The duty factor of the modes used, time averaging over a 30 minute period and feedline loss (2.0 dB or 37% at 30 MHz), none of which were considered, will further reduce the minimum controlled safe distances substantially.

This ends the series on RF Exposure and the new FCC requirements. Next month we'll start a new topic. Perhaps coax and coax connectors.

	Controlled / Uncontrolled			
Band[A] Meters	E Field V/m	H Field A/m	S Field[B] mW/cm2	Avg. Time[C] Minutes
80	460.5 / 206.0	1.22 / 0.55	56.3 / 11.3	6 / 30
40	252.3 / 112.9	0.67 / 0.30	16.9 / 3.39	6 / 30
20	128.4 / 57.42	0.34 / 0.15	4.37 / 0.87	6 / 30
15	85.87 / 38.42	0.23 / 0.10	1.96 / 0.39	6 / 30
12	73.71 / 32.97	0.20 / 0.09	1.44 / 0.29	6 / 30
10	62.02 / 27.74	0.17 / 0.07	1.02 / 0.20	6 / 30

[A]: Upper band limit frequency is used for calculation
[B]: Equivalent plane-wave power density (far field)
[C]: Averaging period for MPE

Table One: MPE Levels For HF Ham Bands

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SIDEBAR:

MPE Field Equations:
Between 3.0 MHz (1.34 MHz uncontrolled) and 30 MHz, as well as between 300 MHz and 1.5 GHz the MPE levels vary with frequency (f in MHz). If you want to calculate the E or H or S fields in these regions you can use the following simple equations:

Controlled Exposure:
(3.0 MHz < f < 30 MHz)
E (V/m) = 1842 / f
H (A/m) = 4.89/ f
S (mW/cm2) = 900 / f^2

Controlled Exposure:
(300 MHz < f < 1.5 GHz)
S (mW/cm2) = f / 300

Uncontrolled Exposure:
(1.34 MHz < f < 30 MHz)
E (V/m) = 824 / f
H (A/m) = 2.19 / f
S (mW/cm2) = 180 / f^2

Uncontrolled Exposure:
(300 MHz < f < 1.5 GHz)
S (mW/cm2) = f / 1500

73, from AF6C

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