To calculate average power, multiply PEP by the duty factor for the mode being used. The duty factors for various modes are shown in Table 2. Multiply that result by the percentage of time the transmitter could be in use during the appropriate averaging period—6 minutes for controlled exposure, 30 minutes for uncontrolled. A few examples are shown elsewhere in this article under the sidebar, "Step by Step."

Tables Developed from Formulas

Most amateurs will use the tables in Supplement B to estimate their compliance with the MPE levels. These tables show the distances people must be from any part of the antenna to avoid being exposed at levels exceeding the MPE limit. They have been calculated with a ground-reflection factor, which includes the ground gain of an antenna over typical ground. This allows hams to use manufacturer's antenna gain figures in dBi with confidence that the result represents a conservative real-world estimate. This model, although simplified, has been verified by the ARRL Laboratory staff using *NEC* antenna-modeling software with a number of antennas modeled over ground. These tables do not necessarily apply to all antenna types, though. *NEC* models of small HF loops, for example, give fields near the antenna that are much higher than the power-density formula predicts. A more accurate method was used to develop the small-loop table in the supplement.

The tables derived from formulas do have advantages: they generally offer conservative estimates and they are easy to use. If a ham "passes" using these conservative tables, the evaluation is complete. Doing a station evaluation can be just that simple!

Supplement B contains a number of these tables. Select the ones that best apply to your station, calculate your average power, then determine if your antenna is far enough away for each band and mode that you use. (One shortcut is to use the highest PEP you use on each band.) Figure 1 shows how this worst-case estimate applies to the main beam of the antenna. Figure 2 shows how to calculate the actual distance to the points you are evaluating.

Table 4

Estimated distances from transmitting antennas necessary to meet FCC power-density limits for Maximum Permissible Exposure (MPE) for either occupational/controlled exposures ("Con") or general-population/uncontrolled exposures ("Unc"). The estimates are based on typical amateur antennas and assuming a 100% duty cycle and typical ground reflection. (The figures shown in this table generally represent worst-case values, primarily in the main beam of the antenna.) The compliance distances apply to average exposure and average power, but can be used with PEP for a conservative estimate.

		Distance from antenna (feet)							
Frequency	Gain	100 W		500 W		1,000 W		1,500 W	
(MHz)	(dBi)	Con	Unc	Con	Unc	Con	Unc	Con	Unc
2	0	0.5	0.7	1.0	1.6	1.5	2.2	1.8	2.7
	3	0.7	1.0	1.5	2.2	2.1	3.1	2.6	3.8
4	0	0.6	1.4	1.4	3.1	2.0	4.4	2.4	5.4
	3	0.9	2.0	2.0	4.4	2.8	6.2	3.4	7.6
7.3	0	1.1	2.5	2.5	5.7	3.6	8.1	4.4	9.9
	3	1.6	3.6	3.6	8.0	5.1	11.4	6.2	13.9
	6	2.3	5.1	5.1	11.4	7.2	16.1	8.8	19.7
10.15	0	1.6	3.5	3.5	7.9	5.0	11.2	6.1	13.7
	3	2.2	5.0	5.0	11.2	7.1	15.8	8.7	19.4
	6	3.2	7.1	7.1	15.8	10.0	22.4	12.2	27.4
14.35	0	2.2	5.0	5.0	11.2	7.1	15.8	8.7	19.4
	3	3.2	7.1	7.1	15.8	10.0	22.4	12.3	27.4
	6	4.5	10.0	10.0	22.3	14.1	31.6	17.3	38.7
	9	6.3	14.1	14.1	31.6	20.0	44.6	24.4	54.7
18.168	0	2.8	6.3	6.3	14.2	9.0	20.1	11.0	24.6
	3	4.0	9.0	9.0	20.0	12.7	28.3	15.5	34.7
	6	5.7	12.7	12.7	28.3	17.9	40.0	21.9	49.0
	9	8.0	17.9	17.9	40.0	25.3	56.5	31.0	69.2
21.45	0	3.3	7.5	7.5	16.7	10.6	23.7	13.0	29.0
	3	4.7	10.6	10.6	23.6	15.0	33.4	18.3	41.0
	6	6.7	14.9	14.9	33.4	21.1	47.2	25.9	57.9
	9	9.4	21.1	21.1	47.2	29.8	66.7	36.5	81.7
24.99	0	3.9	8.7	8.7	19.5	12.3	27.6	15.1	33.8
	3	5.5	12.3	12.3	27.5	17.4	39.0	21.3	47.7
	6	7.8	17.4	17.4	38.9	24.6	55.0	30.1	67.4
	9	11.0	24.6	24.6	55.0	34.8	77.7	42.6	95.2
29.7	0	4.6	10.4	10.4	23.2	14.7	32.8	18.0	40.1
	3	6.5	14.6	14.6	32.7	20.7	46.3	25.4	56.7
	6	9.2	20.7	20.7	46.2	29.3	65.4	35.8	80.1
	9	13.1	29.2	29.2	65.3	41.3	92.4	50.6	113.2
		50 W		100 W		500 W		1,000 W	
		Con	Unc	Con	Unc	Con	Unc	Con	Unc
50, 144, 222	0	3.3	7.4	4.7	10.5	10.5	23.4	14.8	33.1
	3	4.7	10.5	6.6	14.8	14.8	33.1	20.9	46.8
	6	6.6	14.8	9.3	20.9	20.9	46.7	29.5	66.1
	9	9.3	20.9	13.2	29.5	29.5	66.0	41.7	93.3
	12	13.2	29.5	18.6	41.7	41.7	93.2	59.0	131.8
	15	18.6	41.6	26.3	58.9	58.9	131.7	83.3	186.2
	20	33.1	74.0	46.8	104.7	104.7	234.1	148.1	331.1
420	0	2.8	6.3	4.0	8.8	8.8	19.8	12.5	28.0
	3	4.0	8.8	5.6	12.5	12.5	28.0	17.7	39.5
	6	5.6	12.5	7.9	17.7	17.7	39.5	25.0	55.8
	9	7.9	17.6	11.2	24.9	24.9	55.8	35.3	78.9
	12	11.1	24.9	15.8	35.2	35.2	78.8	49.8	111.4
	15	15.7	35.2	22.3	49.8	49.8	111.3	70.4	157.4
1240	0	1.6	3.6	2.3	5.2	5.2	11.5	7.3	16.3
	3	2.3	5.1	3.3	7.3	7.3	16.3	10.3	23.0
	6	3.2	7.3	4.6	10.3	10.3	23.0	14.5	32.5
	9	4.6	10.3	6.5	14.5	14.5	32.5	20.5	45.9
	12	6.5	14.5	9.2	20.5	20.5	45.8	29.0	64.8
	15	9.2	20.5	13.0	29.0	29.0	64.8	41.0	91.6

Repeaters

The power levels shown in Table 1 are in peak-envelope power (PEP) input *to the antenna*. FCC rules specify amateur power in PEP and most transmitters are rated in PEP. However, you must consider feed line losses to determine power to the antenna.

There is a little wrinkle in the rules when it comes to repeaters. The evaluation exemption for amateur repeater operation is determined by the *effective radiated power* (ERP) of the repeater. ERP is referenced to the gain of a half-wave dipole in free space (unlike equivalent isotropically radiated power, EIRP, which is referenced to an isotropic source). Supplement B describes how to calculate feed line losses and determine ERP for an amateur repeater.

All amateur repeaters using 500 W ERP or less generally do not need to be evaluated. Those that operate with more than 500 W ERP need to be evaluated if they have an antenna mounted on a building, or if any part of a nonbuilding-mounted antenna is less than 10 meters (32.8 feet) above ground. (This is another example that higher antennas generally create less field strength on the ground than lower antennas!)