W5YI REPORT

America's Oldest Ham Radio Newsletter

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Vol. 19, Issue #24 **$1.50** PUBLISHED TWICE A MONTH **December 15, 1997**

FCC Releases RF Safety Supplement for Amateur Radio Stations!

"As of January 1, 1998, amateur licensees and grantees will be expected to routinely evaluate their stations for potential human exposure to RF fields that may exceed the FCC-adopted limits for maximum permissible exposure (MPE). If such an evaluation shows that potential exposure will exceed the MPE limits, the amateur licensee must take appropriate corrective action to bring the station into compliance before transmission occurs (see 47 CFR § 97.13(c), as amended."

In August, the Commission issued a revised version of *OET Bulletin 65, "Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields."* This revised bulletin, Edition 97-01, provides assistance in determining whether FCC-regulated transmitters comply with limits adopted by the Commission in 1996 for human exposure to radiofrequency (RF) electromagnetic fields. *(Report and Order,* ET Docket 93-62, adopted August 1, 1996.)

The new guidelines replaced the 1982 RF protection guides of the *American National Standards Institute,* ANSI, which had been used by the FCC since 1985. For amateur stations, the new policy requires that the station be subject to *"routine evaluation"* when it will be operated above certain threshold power levels. A routine evaluation is a formal determination as to whether the station conforms to the RF exposure requirements. In the past, although amateur stations were expected to comply with the FCC's guidelines, routine station evaluation was not required.

On November 18th, the FCC released *Supplement B* to *Bulletin 65* which provides specific guidance for use by amateur radio applicants and licensees in evaluating their stations for compliance with the RF safety limits. This addendum is entitled, *"Additional Information for Amateur Radio Stations,"* and is the second supplement to be released in connection with *Bulletin 65. Supplement A,* issued earlier, provides additional compliance information for radio and television broadcast stations.

Supplement B contains information, tables and figures that can be used by amateur station licensees in determining whether a station must be evaluated for RF compliance, and, if so, how that evaluation can be accomplished. The publication was developed in consultation with amateur licensees and organizations, including the American Radio Relay League and the W5YI Group.

It was Dr. Wayne Overbeck, N6NB (a professor at California State University, Fullerton) who suggested that the FCC should develop an additional RF safety bulletin aimed at amateur radio operators. He pointed out that vast numbers of amateurs are neither members of the ARRL nor subscribers to any amateur service magazines and consequently these educational sources are not sufficient to ensure adherence to the RF safety guidelines.

He felt that a special version of *OET Bulletin No. 65* for radio amateur operations could supplement Part 97 rules and be used by amateurs to certify compliance with the RF exposure safety guidelines. It would include charts and tables which would

THE W5YI REPORT [Pub. No. 009-311] is published twice monthly by The W5YI Group, Inc., 2000 E. Randol Mill Road # 608-A, Arlington, TX 76011
SUBSCRIPTION RATE: (U.S., Canada and Mexico) One Year (24 issues) $24.50 • Two Years: $45.00 • Three Years: $64.00. • Tel. 817/461-6443
Foreign Subscriptions via Air Mail: $39.50 per year. (Payment may be made by Check, Money Order, VISA or MasterCard payable in U.S. funds.)
Periodicals Postage paid at Arlington, TX. **POSTMASTER:** Send address changes to THE W5YI REPORT, P.O. Box 565101, Dallas, TX 75356

assist amateurs in determining the required separation distances between antennas and inhabited areas for various power levels.

N6NB prepared many excellent tables for *Supplement B* that give estimated distances to meet RF power density limits in the main beam of typical antenna installations. Overbeck also suggested that amateurs be tested on this topic as part of operator license examinations. The FCC adopted both of his suggestions.

The Commission also incorporated the proposal of the American Radio Relay League (ARRL) that amateurs should be required to certify, as part of their license application process, that they have read and understand the RF safety bulletins and the relevant FCC rules.

The complete text of *OET Bulletin 65* and the new *Supplement B* (about 150 pages total) can all be viewed and downloaded from the FCC's OET Wide World Web site at: http://www.fcc.gov/oet/.

Follows is a highly capsulized version of the new RF Safety rules contained in *Supplement B.*

Section 1: What it Radiofrequency Radiation?

contains definitions of radiofrequency (RF) energy - and electromagnetic "radiation", "waves" and "fields. The relationship of wavelengths to frequency is also discussed. "The RF part of the electromagnetic spectrum can generally be defined as that part of the spectrum where electromagnetic waves have frequencies that range from about 3 kilohertz (kHz) to 300 gigahertz (GHz)."

Section 2: FCC Exposure Guidelines and Their Application

covers the exposure environments and time and spatial averaging. The FCC guidelines incorporate two separate tiers of exposure limits that are dependent on the situation in which the exposure takes place and/or the status of the individuals who are subject to exposure.

Occupational/controlled exposure limits apply to situations in which persons who are exposed have been made fully aware of the potential for exposure and can exercise control over their exposure. Occupational/controlled exposure limits also apply where exposure is of a transient nature as a result of incidental passage through a location where exposure levels may be above general population/ uncontrolled limits (see below), as long as the exposed person has been made fully aware of the potential for exposure and can exercise control over his or her exposure by leaving the area or by some other appropriate means.

Occupational/ controlled exposure limits apply to amateur licensees and members of their immediate household (but not their neighbors - see below). In general, a controlled environment is one for which access is controlled or restricted. In the case of an amateur station, the licensee or grantee is the person responsible for controlling access and providing the necessary information and training as described above.

General population/uncontrolled exposure limits apply to situations in which the general public are not be made fully aware of the potential for exposure or cannot exercise control over their exposure. Therefore, members of the general public always fall under this category. Neighbors of amateurs and other non-household members would normally be subject to the general population/uncontrolled exposure limits.

For purposes of applying these definitions, awareness of the potential for RF exposure in a controlled or similar environment can be provided through specific training. Warning signs and labels can also be used to establish such awareness as long as they provide information, in a prominent manner, on risk of potential exposure and instructions on methods to minimize such exposure risk. For example, a sign warning of RF exposure risk and indicating that individuals should not remain in the area for more than a certain period of time could be acceptable.

Time Averaging - A feature of the exposure guidelines is that exposures may be averaged over certain periods of time with the average not to exceed the limit for continuous exposure. The averaging time for occupational/controlled exposures is six minutes, while the averaging time for general population/ uncontrolled exposures is thirty minutes.

It is important to note that for general population/uncontrolled exposures it is usually not possible or practical to control access or otherwise limit exposure duration to the extent that averaging times can be applied. In those situations, it would normally be necessary to assume continuous exposure to RF fields that would be created by the on/off cycles of the radiating source.

As an illustration of the application of time-averaging to occupational/controlled exposure (such as would occur at an amateur station) consider the following. The relevant interval for time-averaging six minutes. This means, for example, that during any given six-minute period an amateur could be exposed to two times the applicable power density limit for three minutes as long as he or she were not exposed at all for the preceding or following three minutes.

Power-averaging consists of both the time of full exposure during any six (or thirty) minute period (i.e. the on-and-off transmitting time of the signal) and the "duty factor" of the transmitting mode being used.

Section 3: Methods of Predicting Human Exposure

This section discusses the many ways of predicting exposure and estimating compliance distances. These include using tables developed from field strength equations and antenna modeling. Compliance distances can also be estimated by using calibrated field-strength measurements.

Most amateurs will use various tables to estimate compliance distances for MPE limits. The simplest of these tables was developed using a far-field equation and assuming ground reflection of electromagnetic waves from the RF source. This model, although simplified, has been verified to be a reasonable approximation against a number of dipole, ground-plane and Yagi antennas, based on computer modeling carried out by the ARRL. In most cases, however, the tables derived from this far-field approximation give conservative results that over-predict exposure levels. The W5YI Tables (see page 9 and 10) are probably the easiest of the tables to use. They are followed by a number of tables based on specific antenna types.

The first step an amateur should take is to select the simple table that best applies to your station and determine the estimated compliance distances for the relevant operating bands. If a compliance distance is less than the actual distance to an exposure location, the station "passes" and the evaluation is complete. It can be that simple. Remember that these distances are for the absolute distance from the antenna at any angle.

Section 4: Estimating Compliance Distances from Typical Transmitting Antennas

These section contains a number of tables for amateurs who desire a more accurate estimate of the RF fields expected near their antennas. In many cases, a station that may not pass based on "worst-case" predictions could easily be shown to be in compliance using these tables. The ARRL tables offered in this supplement are only a few examples of a large number of tables prepared by that organization using this method.

There are also several based on use of far-field power density equations assuming the reflection factor used by the EPA. These tables represent "worst case" estimates of the far-field equivalent power density. These tables should be used unless the exposure situation of interest is in the main beam or lobe of the antenna being considered. In the latter case, surface reflection would not necessarily be of major concern.

Section 5: Controlling Exposure to RF Fields

In order for an amateur to perform an evaluation of his or her station for RF compliance, the following questions should first be asked:

(1) *Which category of exposure applies at the location(s) in question? (i.e. "controlled" or "uncontrolled." environment.)*

(2) *What type(s) of transmitting antenna is/are being used?*

(3) *What transmitting power levels will be used?*

(4) *How far is the area being evaluated from the antenna(s) in question?*

The tables in *Supplement B* can then be used to help determine compliance with exposure guidelines. If this supplement does not contain a table that is relevant to the particular station parameters, *Bulletin 65* should be consulted for alternative methods of determining compliance (e.g., calculations, measurements, etc.)

After an evaluation is performed, if a determination is made that a potential problem exists, Section 4 of *Bulletin 65* should be consulted for a discussion of recommended methods for reducing or controlling exposure. Such methods could include one or more of the following:

1. *Restricting access to high RF-field areas*
2. *Operating at reduced power when people are present in high RF-field areas*
3. *Transmitting at times when people are not present in high RF-field areas*
4. *Considering duty factor of transmissions*
5. *Time-averaging exposure*
6. *Relocating antennas or raising antenna height*
7. *Incorporating shielding techniques*
8. *Using monitoring or protective devices*
9. *Erecting warning/notification signage*

Limiting access may be the easiest method to reduce exposure. If an antenna is in an area where access is generally restricted (such as a fenced-in yard) it may be sufficient to simply control access to the yard when transmissions are in progress (assuming exposure levels exceed the guidelines in the yard). An antenna could also be placed high enough on a tower or mast so that access to high RF levels is generally impossible.

Reducing transmitting power can also significantly reduce exposure levels. The power output of a transmitter has a linear relationship with the power density exposure level that could be experienced by a person near the transmitting antenna. For example, if power output is reduced by 20% then power density at a given location will also be reduced by 20%.

An often overlooked method of reducing exposure is by utilizing the inherent duty factor of the transmissions from an amateur station. The worst-case duty factor, 100%, occurs during continuous or "key down" transmissions. However, most amateur service two-way transmissions are more likely to be of the "key on, key off" type, resulting in more typical duty factors of, say, 50%.

Conclusion:

The Commission has always relied on the skills and demonstrated abilities of amateurs to comply with its technical rules, and it will continue to do so. The Commission believes that amateur licensees and applicants should be sufficiently qualified to conduct their own evaluations and act accordingly. In *OET Bulletin 65* and in *Supplement B*, the FCC attempts to provide the amateur community with as much information as possible to accomplish these tasks. In addition, Commission staff will continue to be available to answer questions and provide further information if requested. The Commission will also continue to work with amateur organizations such as the ARRL to improve the usefulness, accuracy and inclusiveness of this supplement.

Future editions of *Supplement B* (as well as of *Bulletin 65)* may be issued as needed to update the data and information provided here or to make any major corrections that may be necessary. In that regard, the Commission invites amateurs to provide input to FCC staff relating to evaluating RF exposure and the contents of the *Bulletin 65* and its supplements.

The FCC encourages the amateur community to continue its activities in developing its own methods and information for performing RF environmental evaluations. "We believe that these efforts will result in an improved and safe amateur service that will benefit both amateur licensees and those persons residing or working near amateur facilities," the FCC said.

Optional Worksheet and Record of Compliance

Supplement B also contains an excellent fill-in-the-blank worksheet that takes you step-by-step through an evaluation of your station. It was prepared by the FCC's Barnett C. "Jay" Jackson, Jr., W3VG.

During the early 1980's, Jackson worked in the Private Radio Bureau and for at least a couple of years, his primary duty was developing the ham radio license exam questions. As fast as Jay would develop them, Dick Bash (KL7IHP -remember him?) would have his "henchmen" (i.e. test takers who returned the "feed back" cards he stitched in the back of his "Final Exam" training books send them to him for republishing to the amateur community. Bash's thievery of Jackson's questions led to the question pool system which was already in use by the FAA in the aviation licensing field. Jackson now works with the FCC's Common Carrier Bureau (Cellular Division.)

This optional worksheet can be used to determine whether routine evaluation of an amateur station is required by the FCC's rules. It also can be used as an aid in determining compliance. However, use of this worksheet is not required by the FCC. Once you determine what your output power to your antenna, you can easily determine the needed separation distance to the controlled and uncontrolled environment by using the W5YI Tables. For 99% of all amateur stations, these are the only two tools that you will need.

Optional Worksheet and Record of Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields for Amateur Radio Stations

Instructions

Introduction. This optional worksheet is intended to be helpful when determining whether any particular combination of transmitting apparatus at an amateur radio station ("a setup") is in compliance with the FCC rules *[47 C.F.R. § 1.1310]* concerning human exposure to radiofrequency (RF) electromagnetic fields.

The purpose of the first section of this worksheet is to help determine, for any given setup of the amateur station, whether the routine RF evaluation prescribed by FCC rules *[47 C.F.R. § 1.1307(b)]* must be performed before the setup can be used for transmitting. In the event that a routine RF evaluation must be performed, that requirement may be satisfied by completing the second section of the worksheet, by using methods outlined in *OET Bulletin 65* or by employing another technically valid method.

The person responsible for making the determination is the person named on the data base license grant as the primary station licensee or as the club, military recreation or RACES station license trustee, and any alien whose amateur radio station is transmitting from a place where the service is regulated by the FCC under the authority derived from a reciprocal arrangement. When completed, this worksheet may be retained in the station records so that if and when the setup is changed, it may more easily be re-evaluated. **Do not send the completed worksheets to the FCC.**

If the amateur station is to be operated on more than one wavelength band, or with several different antennas or combinations of apparatus, each is considered to be a separate setup. It might be helpful, therefore, to complete a separate worksheet for each setup. For an amateur radio station where two or more transmitters are used with the same antenna on the same wavelength band, it is only necessary to consider the setup that uses the highest power to the antenna input.

Top of each page. At the top of each page are blanks to fill in the amateur station call sign **(item 1),** the wavelength band under consideration **(item 2),** and a number or identifier that will identify the each setup **(item 3).** The purpose for **repeating** these items on each page is so that the various pages of a particular completed worksheet could be reassembled if they were to become separated. Additionally, at the top of Page 1 of the worksheet, there are blanks for the location of the station **(item 4),** the name of the person completing the worksheet **(item 5),** and the date (item 6).

Section I

Items 7 and 8. Fill in the manufacturer and model of the transmitter or transceiver and any RF power amplifier, or a brief description of these if they are home built.

Item 9. Fill in the Peak Envelope Power (PEP) output of the transmitter (use the PEP of the external amplifier, if one is to be used), in Watts (A). Many commercially manufactured transmitters and RF power amplifiers have a built-in power meter that can provide a measurement of PEP with reasonable accuracy for this purpose. Also, commercially manufactured external PEP reading power meters are available for stations that use common coaxial cables as feed lines. If there isn't any capability to measure the PEP output, the maximum PEP capability specified by the manufacturer may be used, or a reasonable estimate, based on factors such as measured power input, the maximum capability of the final amplifier devices or the power supply, may be used.

Check the PEP output against Table 1. Because the PEP input to the antenna (H) can't be more than the PEP output (A), it's worthwhile at this point to take a quick look at Table 1 on page 3 of Supplement B to *OET Bulletin 65.* If the PEP output (A) does not exceed the value listed for the wavelength band under consideration, neither will the PEP input to the antenna (H). If that is the case, a routine RF evaluation is not required for this setup, and it isn't necessary to complete the rest of the worksheet. Otherwise, continue as follows.

Item 10. Fill in the PEP output used in item 9, converted to dBW. The power unit dBW expresses the ratio of the power in question to 1 Watt, in deciBels. The following chart can be used to convert common PEP levels in Watts to dBW. For power levels that fall in between the levels given, use the next higher power.

Watts	dBW	Watts	dBW	Watts	dBW
1	0	20	13	100	20
2	3	25	14	150	22
3	5	30	15	200	23
5	7	40	16	500	27
10	10	50	17	1000	30
15	12	80	19	1200	31
		1500	32		

Alternatively, the following mathematical formula can be used to do the conversion:

$$\text{Power}_{dBW} = 10 \times \log(\text{power}_{Watts})$$

Items 11 and 12. Fill in the feed line type and loss (attenuation) specification (C). The attenuation or loss of a feed line is higher for higher frequencies. Therefore, the wavelength band of operation must be taken into account when determining what the feed line loss specification is. Manufacturers of coaxial cables develop tables showing the attenuation of various types of cables at various frequencies. There are also graphs and charts showing feed line attenuation versus frequency in readily available amateur radio handbooks and publications. The conservative approximate loss specifications for commonly used feed line type, given in the table on the next page, can also be used. In terms of feed line loss, a "conservative" estimate means that the feed line is very unlikely to have a lower loss than the estimate, although it may easily have a higher loss than estimated.

Item 13. Fill in the length of the feed line in feet (D). **Item 14**. Fill in the calculated feed line loss (E) in dB. Calculate the feed line loss (E) by multiplying the feed line loss specification (C) by the feed line length (D). Inherent feed line loss often increases as the feed line ages. Also, feed line loss is considerably larger if the antenna impedance is not matched to the feed line impedance (causing a high SWR). However, for the purposes of this work sheet, do not consider or rely upon any additional feed line loss attributable to feed line aging or mismatch.

Feed Line Loss Specifications for Commonly Used Feed Lines - (dB/100 feet)

Band	RG-58	RG8X	RG-8A RG213	RG-8 Foam	"9913" & Equiv.	½" 50Ω Hardline	Ladder Line
160m	0.5	0.4	0.3	0.2	0.2	0	0
80/75m	0.7	0.5	0.4	0.3	0.2	0.1	0
40m	1.1	0.7	0.5	0.4	0.3	0.2	0
30m	1.4	0.9	0.6	0.5	0.4	0.2	0
20m	1.7	1.1	0.8	0.6	0.5	0.3	0
17m	2.0	1.2	0.9	0.7	0.6	0.3	0.1
15m	2.2	1.3	1.0	0.7	0.6	0.3	0.1
12m	2.4	1.4	1.1	0.8	0.6	0.3	0.1
10m	2.5	1.5	1.3	0.9	0.7	0.4	0.2
6 m	3.5	2.1	1.7	1.2	0.9	0.5	0.3
2m	6.5	3.6	3.0	2.0	1.6	1.0	0.7
1¼m	8.4	4.6	4.0	2.6	2.0	1.3	
70 cm	12	6.5	5.8	3.6	2.8	1.9	
33 cm	19	9.6	9.0	5.4	4.0	3.0	
23 cm	23	12	11	6.4	4.6	3.7	
13 cm		1.5	1.5	8.8	6.4	5.2	

Items 15 and 16. There may be other loss causing components in the feed line between the transmitter or external amplifier output and the antenna input. For example, there may be antenna switches or relays, directional couplers, duplexers, cavities or other filters. Usually the losses introduced by these components are so small as to be negligible. However, for setups operating in the VHF and higher frequency bands, the losses introduced by feed line components can be substantial. If this is the case, fill in a brief description of what these components are in item 15, and a conservative estimate of the total loss in dB in item 16, feed line components loss (F). Otherwise, write 0 (zero) in item 16. In terms of feed line component loss, a "conservative" estimate means that the feed line components are very unlikely to have a lower loss than the estimate, although they may easily have a higher loss than estimated. If the feed line component loss is not known, write 0 (zero) in item 16.

Item 17. Fill in the PEP input to the antenna, in dBW (G). Calculate this by subtracting the calculated feed line loss (E) and the feed line components loss (F) from the PEP output in dBW (B). Expressed as a mathematical equation, this is:

$$G = B - E - F$$

If G is less than 17 dBW, a routine RF evaluation is not required for this setup, and it isn't necessary to complete the rest of the worksheet. Otherwise, continue as follows.

Item 18. Fill in the PEP input to the antenna used in item 17, converted to Watts. The following table can be used to convert PEP levels in dBW to Watts. The entries in this table correspond to the power levels in Table 1 in OET Bulletin 65, Supplement B. For power levels that fall in between the levels given, use the next higher power.

dBW	Watts	dBW	Watts	dBW	Watts
17.0	50	21.0	125	24.0	250
18.5	70	21.8	150	26.3	425
18.8	75	23.0	200	27.0	500
20.0	100	23.5	225		

Alternatively, the following mathematical formula can be used to do the conversion:

$$Power_{Watts} = 10^{\frac{power_{dBW}}{10}}$$

Item 19. If the setup under consideration is an amateur radio repeater station, skip over this item and go directly to item 20. Otherwise, proceed as follows: Compare the PEP input to the antenna in Watts (H) to the power level listed in Table 1 in *OET Bulletin 65, Supplement B,* for the wavelength band to be used.

If the PEP input to the antenna in Watts (H) is less than or equal to the power level listed in Table 1 of *OET Bulletin 65, Supplement B,* for the wavelength band to be used, put a check mark in the first box. This means that the FCC rules do not require that a routine RF evaluation of the amateur radio setup be performed before it can be operated. It is not necessary to complete the rest of the worksheet.

On the other hand, if the PEP input to the antenna in Watts (H) exceeds the power level listed in Table 1 in *OET Bulletin 65, Supplement B,* for the wavelength band to be used, put a check mark in the second box. This means that a routine RF evaluation of this setup must be performed before it may be used to transmit. This requirement may be satisfied by completing the second section of the worksheet, by using methods outlined in OET Bulletin 65 or by employing any other technically valid method.

Note: Items 20 through 26 are only for amateur radio repeater setups.

Item 20. Fill in the manufacturer and model of the transmitting antenna for the amateur repeater setup, or a brief description of the antenna type (e.g. vertical collinear array).

Item 21. Check the appropriate box to indicate whether or not the repeater antenna is mounted on a building.

Item 22. Fill in the height above ground level of the lowest radiating part of the repeater antenna, in meters (I). One meter equals 3.28 feet.

Item 23. Fill in the maximum gain of the repeater antenna, in dBd (J). The term maximum gain means the highest antenna gain the antenna exhibits in any direction, not just in the direction of nearby places where people could be exposed to RF electromagnetic fields. The unit "dBd" means that the gain is expressed as a ratio between the power flux density ("pfd") that the antenna in question produces and the pfd that a lossless half-wave dipole antenna would produce in free space (when both antennas have the same input power. Antenna gain of commercially manufactured antennas mounted in various typical arrangements is generally measured by the manufacturer on an antenna test range. The manufacturer may specify maximum antenna gain in dBd or dBi or both. If the gain is specified in dBi, for the purpose of this item simply subtract 2.15 dB from the dBi specification to obtain the dBd. Take into account, if possible, any increase in the gain resulting from the mounting arrangement (e.g. if the antenna is side-mounted on a tower). If the it is a home built antenna, estimate the maximum gain likely to be realized for an antenna of that type. Although antenna gain includes antenna efficiency, assume the efficiency is 100% for the purpose of this item.

Item 24. Fill in the maximum effective radiated power (ERP), in dBW (K). Calculate this by adding the PEP input to the antenna in dBW (G) and the estimated maximum repeater antenna gain (J). Expressed as a mathematical equation, this is:

$$K = G + J$$

Item 25. Fill in the maximum ERP used in item 24, converted to Watts (L), using the same methods as in the instruction for item 18.

Item 26. If L is less than or equal to 500 Watts (or K is less than 27 dBW), a routine RF evaluation is not required for this amateur radio repeater setup. Furthermore, even if L exceeds 500 Watts (i.e. K equals or exceeds 27 dBW), provided that the antenna is not located on a building and is installed such that the lowest point of the antenna is at least 10 meters (33 feet) above the ground level, a routine RF evaluation of this amateur radio repeater setup is not required. In either case, put a check mark in the first box. This indicates that a routine RF evaluation of the amateur radio repeater setup is not required before it can be operated.

In all other cases, put a check mark in the second box. This means that a routine RF evaluation of this amateur radio repeater setup must be performed before it can be operated. This requirement may be satisfied by completing the second section of the worksheet, by using methods outlined in *OET Bulletin 65* or by employing any other technically valid method.

Section II

Item 27. Fill in a brief description of the antenna. If it is a commercially made antenna, indicate the manufacturer and type.

Item 28. Fill in the height above ground level of the lowest radiating part of the antenna, in meters (M). One meter equals 3.28 feet.

Item 29. Fill in the antenna gain in dBi (N). The term "antenna gain" generally refers to the field intensity at a given distance radiated by the antenna with a given power input, relative to an ideal lossless reference antenna type such as a half-wave dipole (dBd) or an isotropic radiator (dBi), fed with the same power and measured at the same distance. Antenna gain is a result of the directivity (i.e. that more energy is radiated in some directions than in others) and the efficiency (that some portion of the energy is not radiated as electromagnetic fields, but is instead converted to heat as a result of electrical resistance in the antenna materials and its surroundings). For this item, consider only the directivity of the antenna. The efficiency factor is considered in items 35-36.

Check Table 4. At this point, refer to Table 4 in Supplement B to OET Bulletin 65 (the W5YI table). For the wavelength band indicated in item 2, and using the PEP input to the antenna (H) and the antenna gain (N) from the worksheet, find the minimum necessary separation distances in meters from the antenna for uncontrolled and controlled environments. Pencil these distances in item 38 as (T) and (U) respectively. For power levels and antenna gains between those provided in the table, use the next higher values. This table is for a worst case analysis. Proceed now to the instruction for item 39, understanding that, if the worst case distances derived using Table 4 are not met in reality, they can be erased from item 38 and the evaluation can then proceed into further detail with the next instruction.

Item 30. Fill in the emission type used (e.g. SSB, CW, FM, FSK, AFSK, etc.).

Item 31. Fill in an emission type factor (O). The following table may be used.

CW Morse telegraphy	0.4
SSB voice	0.2
SSB voice, heavy speech processing	0.5
SSB AFSK	1.0
SSB SSTV	1.0
FM voice or data	1.0
FSK	1.0
AM voice, 50% modulation	0.5
AM voice, 100% modulation	0.3
ATV, video portion, image	0.6
ATV, video portion, black screen	0.8

This emission type factor accounts for the fact that, for some modulated emission types that have a non-constant envelope, the PEP can be considerably larger than the average power. See also Table 2 in *Supplement B* of *OET Bulletin 65* which provides examples of duty factors for modes commonly used by amateur radio operators.

Items 32 and 33. Fill in the transmit duty cycle and duty cycle factor. The duty cycle is the percentage of time in a given time interval (6 or 30 minutes) that the amateur radio station is in a transmitting condition, including instants where a transmission is in progress, but there is momentarily no power input to the antenna (e.g. the spaces between the "dits" and "dahs" of Morse telegraphy, the pauses between words of SSB telephony). The duty cycle factor is simply this percentage expressed in decimal form. For example, 20% becomes 0.2.

This transmit duty cycle is one of the parameters that is most easily controlled by the amateur radio station operator. As an example, with directed net or list operation, consideration should be given to whether the station is a net control station (relatively more transmit time) or a check-in (lots of listening time, relatively less transmission). When transmissions are carried through a repeater, the repeater timer may serve as a reminder to limit the length of continuous transmissions. With casual two way conversations, the transmit duty cycle could be approximated as 50%. A more detailed discussion, with examples, is contained in *Supplement B* to *OET Bulletin 65* under the heading of "Time and Spacial Averaging".

Item 34. Fill in the average power input to the antenna (Q), in Watts. This is calculated by multiplying the PEP input to the antenna, in Watts (H), by the emission type factor (O) and the duty cycle factor (P). Expressed as a mathematical equation, this is:

$$Q = H \times O \times P$$

__Check Tables 5-17 and/or 18-31__. At this point, refer to Tables 5 through 17 (the Overbeck/Siwiak/FCC tables) and/or Tables 18 through 31 in *Supplement B* to *OET Bulletin 65* (the ARRL tables). For the wavelength band indicated in item 2, and using the average power input to the antenna (Q) and selecting the appropriate table for the type of antenna, find the minimum necessary separation distances in meters from the antenna for uncontrolled and controlled environments. Note the limitations on appropriate use of these tables set forth in the bulletin. Write the distances found in item 38 as (T) and (U) respectively. For power levels and antenna gains between those provided in the table, use the next higher values.

__Items 35 and 36__. This item can be used for calculating the power flux density in accordance with the methods outlined in *OET Bulletin 65,* where antenna efficiency is a significant factor. Fill in the antenna efficiency and antenna efficiency factor (R). The antenna efficiency is the percentage of the input power that is radiated as electromagnetic energy. The antenna efficiency factor is simply this percentage expressed in decimal form. For example, 20% becomes 0.2. For most antennas, the efficiency is high enough to be negligible. For some antennas, however, particularly shortened vertical ground plane antennas, mobile whips, resistor broadbanded antennas, and small loops, the radiation resistance of the antenna may be so low that a significant portion of the energy is lost as heat in the antenna and it's ground system. Consult available amateur radio publications literature for more details. Otherwise, assume that the antenna efficiency is 100% and the antenna efficiency factor (R) is 1.0.

__Item 37__. Fill in the average power radiated (S). This is calculated by multiplying the average power input to the antenna (Q) by the antenna efficiency factor (R). Expressed as a mathematical equation, this is:

$$S = Q \times R$$

__Item 38__. This item is for filling in the distances, in meters, obtained from the various tables in **Supplement B** to **OET Bulletin 65.** It is also a good idea to jot the table number down next to this item so that the source of the distances indicated is known.

__Item 39__. Fill in the actual estimated, calculated or measured shortest physical distances, in meters, between the radiating part of the station antenna and the nearest place where the public or a person unaware of RF fields could be present, and the nearest place where a person who is aware of the RF fields could be present, (V) and (U) respectively.

__Item 40__. This item is a table where the evaluator may fill in calculated or measured power flux densities at locations where persons may be present. Power flux density may be calculated by methods outlined in Section 3 of *Supplement B* to *OET Bulletin 65.* If valid measurements are made at a reduced power level (that would comply with exposure guidelines), it can be assumed that these measurements may be adjusted proportionally to predict field levels at a higher power.

Conclusions Section

At the end of the work sheet is a page where the evaluator can indicate his or her finding that the evaluated amateur radio setup is in compliance with FCC rules. A setup that does not comply must not be used for transmission until it is brought into compliance.

The evaluator should check the boxes [ ] next to any and all statements that apply to the evaluated amateur radio setup. The blank lines can also be used to elaborate on circumstances that support the conclusion.

The first four check boxes are for the situation where, for any of various reasons, it is very unlikely or simply not possible for any person to be in a location where he or she would be exposed to radiofrequency electromagnetic fields that are strong enough to exceed the levels prescribed in the FCC Guidelines for Human Exposure. The second four boxes are for the situation where a person could be in a location where he or she could be briefly exposed to radiofrequency electromagnetic fields that are strong enough to exceed the levels prescribed, but that other considerations ensure that a person will not remain in that location long enough to receive exposure in excess of that allowed by the FCC Guidelines for Human Exposure.

Optional Worksheet and Record of Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields for Amateur Radio Stations

1. Call sign: ____________ 2. Wavelength band: ______
3. Setup #: _____ 4. Station location: ______________
5. Evaluated by: ________________ 6. Date: __________

I Initial Determination as to whether a Routine Evaluation is required by FCC Rule Section 97.13 for this amateur radio station setup.

7. Transmitter description: ____________________
8. External amplifier description:____________________
9. Peak Envelope Power (PEP) output, in Watts: (A)_______Watts
10. PEP output, converted to dBW: (B)_______ dBW
11. Feed line type: ____________
12. Feed line loss specification: (C)_______ dB/100 ft.
13. Feed line length: (D)_______ feet
14. Calculated feed line loss: (E)_______ dB
15. Other feed line components, if any: ______________
16. Feed line components loss: (F)_______ dB
17. PEP input to antenna, in dBW: (G)_______ dBW
18. PEP input to antenna, converted to Watts: (H)_______ Watts

19. INITIAL DETERMINATION FOR STATIONS OTHER THAN REPEATERS: (for repeater stations go to the next page)

[ ] Based on the peak envelope power input to the antenna (H) calculated above, **a routine evaluation is NOT required** by FCC rules for operation as described of this setup in the stated wavelength band. It is not necessary to complete the rest of this worksheet.

[ ] Based on the peak envelope power input to the antenna (H) calculated above, **a routine evaluation is required** by FCC rules for operation as described of this setup in the stated wavelength band. The licensee may satisfy the requirement for a routine evaluation by completing the rest of this worksheet.

20. Repeater antenna description: ____________________

21. Repeater antenna location: [ ] mounted on a building
    [ ] not on a building
22. Minimum repeater antenna height above ground level: (I) _______ meters
23. Estimated maximum repeater antenna gain: (J)_______ dBd
24. Maximum Effective Radiated Power (ERP), in dBW: (K)_______ dBW
25. Maximum ERP, converted to Watts: (L)_______ Watts

INITIAL DETERMINATION FOR AMATEUR REPEATER STATIONS:

[ ] Based on the effective radiated power (L) calculated above and the antenna height (I) and location of the antenna, **a routine evaluation is NOT required** by FCC rules for operation as described of this amateur radio repeater station in the stated wavelength band. It is not necessary to complete the rest of this worksheet.

[ ] Based on the effective radiated power (L) calculated above and the antenna height (I) and location of the antenna, **a routine evaluation is required** by FCC rules for operation as described of this amateur radio repeater station in the stated wavelength band. The licensee may satisfy the requirement for a routine evaluation by completing the rest of this worksheet.

Reminders:

- A routine evaluation is not required for vehicular mobile or hand-held amateur radio setups. However, amateur radio operators should be aware of the potential for exposure to radiofrequency electromagnetic fields from these setups, and take measures (such as reducing transmitting power to the minimum necessary, positioning the radiating antenna as far from humans as practical, and limiting continuous transmitting time) accordingly to protect themselves and the occupants of their vehicles.
- The operation of each amateur radio setup must not exceed the FCC's guidelines for human exposure to radiofrequency electromagnetic fields, regardless of whether or not a routine evaluation is required.
- Although a particular amateur radio setup may by itself be in compliance with the FCC's guidelines for human exposure to radiofrequency electromagnetic fields, the cumulative effect of all simultaneously operating amateur radio setups (and any other operating transmitters in other services) at the same location or in the immediate vicinity must also be considered.

II. Routine Evaluation of amateur radio station setup.

27. Antenna description: ________________
28. Antenna height above ground level: (M)_______ meters
29. Lossless antenna gain (directivity only): (N)________ dBi
30. Emission type: ________
31. Emission type factor: (O)_______
32. Transmit duty cycle: _____%
33. Duty cycle factor: (P)_______
34. Average power input to the antenna: (Q)_______ Watts
35. Antenna efficiency: _____%
36. Antenna efficiency factor: (R)_______
37. Average power radiated: (S) _______ Watts
38. Minimum necessary distance from radiating part of antenna to place where:
    - public may be present (uncontrolled) (T)_______ meters
    - amateur radio operator may be present (controlled): (U)_______ meters
39. Actual distance from radiating part of antenna to nearest place where:
    - public may be present (uncontrolled): (V)_______ meters
    - amateur radio operator may be present (controlled): (W)_______ meters
40. Calculated power flux density:

Location	Power Flux Density

CONCLUSIONS

Based on this routine evaluation, operation of this amateur radio station setup in accordance with the technical parameters entered above complies with the FCC's guidelines for human exposure to radiofrequency (RF) electromagnetic fields. The following statements provide the basis for this conclusion.

[ ] It is physically impossible or extremely unlikely under normal circumstances for any person to be in any location where their exposure to RF electromagnetic fields would exceed the FCC guidelines, because:

[ ] the antenna is installed high enough on a tower or tree or other antenna support structure, such that it is not possible under normal circumstances for persons to get close enough to the antenna to be where the strength of the RF electromagnetic fields exceed the levels in the applicable FCC guidelines.

[ ] fences, locked gates and/or doors prevent persons who are unaware of the possibility of RF exposure from normally gaining access to locations where the strength of the RF electromagnetic fields exceed the levels in the applicable FCC guidelines.

[ ] ____
____
____

[ ] Although persons could normally be in location(s) where the RF fields from the evaluated setup exceed the guideline levels, the following factors ensure that FCC human exposure guidelines will not be exceeded:

[ ] Signs have been installed that alert persons to the presence of RF electromagnetic fields and warn them not to remain for an extended period.

[ ] The locations where RF electromagnetic fields may exceed the guideline levels are roadways or other areas where human presence is transient.

[ ] ____
____
____

W5YI REPORT
America's Oldest Ham Radio Newsletter

The W5YI Tables - (Developed by Fred Maia, W5YI Group, working in cooperation with the ARRL.)

Estimated distances in meters 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") using typical antenna gains for the amateur service and assuming 100% duty cycle and maximum surface reflection. Chart represents worst case scenario.

An example of how to read the chart: If you are radiating 500 watts from your 10 meter dipole (about a 3 dB gain), there must be at least 4.5 meters (about 15 feet) between you (and your family) and the antenna - and a distance of 10 meters (about 33 feet) between the antenna and your neighbors. The FCC has determined that radio operators and their families are in the "controlled" environment and your neighbors in the "uncontrolled" environment.

(for the MF/HF Amateur Bands) - All distances are in meters

Freq. (MF/HF) (MHz/Band)	Antenna Gain (dBi)	Peak Envelope Power (watts) 100 watts		500 watts		1000 watts		1500 watts	
		Con.	Unc.	Con.	Unc	Con.	Unc.	Con.	Unc.
2.0 (160m)	0	0.1	0.2	0.3	0.5	0.5	0.7	0.6	0.8
2.0 (160m)	3	0.2	0.3	0.5	0.7	0.6	1.06	0.8	1.2
4.0 (75/80m)	0	0.2	0.4	0.4	1.0	0.6	1.3	0.7	1.6
4.0 (75/80m)	3	0.3	0.6	0.6	1.3	0.9	1.9	1.0	2.3
7.3 (40m)	0	0.3	0.8	0.8	1.7	1.1	2.5	1.3	3.0
7.3 (40m)	3	0.5	1.1	1.1	2.5	1.6	3.5	1.9	4.2
7.3 (40m)	6	0.7	1.5	1.5	3.5	2.2	4.9	2.7	6.0
10.15 (30m)	0	0.5	1.1	1.1	2.4	1.5	3.4	1.9	4.2
10.15 (30m)	3	0.7	1.5	1.5	3.4	2.2	4.8	2.6	5.9
10.15 (30m)	6	1.0	2.2	2.2	4.8	3.0	6.8	3.7	8.3
14.35 (20m)	0	0.7	1.5	1.5	3.4	2.2	4.8	2.6	5.9
14.35 (20m)	3	1.0	2.2	2.2	4.8	3.0	6.8	3.7	8.4
14.35 (20m)	6	1.4	3.0	3.0	6.8	4.3	9.6	5.3	11.8
14.35 (20m)	9	1.9	4.3	4.3	9.6	6.1	13.6	7.5	16.7
18.168 (17m)	0	0.9	1.9	1.9	4.3	2.7	6.1	3.3	7.5
18.168 (17m)	3	1.2	2.7	2.7	6.1	3.9	8.6	4.7	10.6
18.168 (17m)	6	1.7	3.9	3.9	8.6	5.5	12.2	6.7	14.9
18.168 (17m)	9	2.4	5.4	5.4	12.2	7.7	17.2	9.4	21.1
21.145 (15m)	0	1.0	2.3	2.3	5.1	3.2	7.2	4.0	8.8
21.145 (15m)	3	1.4	3.2	3.2	7.2	4.6	10.2	5.6	12.5
21.145 (15m)	6	2.0	4.6	4.6	10.2	6.4	14.4	7.9	17.6
21.145 (15m)	9	2.9	6.4	6.4	14.4	9.1	20.3	11.1	24.9
24.99 (12m)	0	1.2	2.7	2.7	5.9	3.8	8.4	4.6	10.3
24.99 (12m)	3	1.7	3.8	3.8	8.4	5.3	11.9	6.5	14.5
24.99 (12m)	6	2.4	5.3	5.3	11.9	7.5	16.8	9.2	20.5
24.99 (12m)	9	3.4	7.5	7.5	16.8	10.6	23.7	13.0	29.0
29.7 (10m)	0	1.4	3.2	3.2	7.1	4.5	10.0	5.5	12.2
29.7 (10m)	3	2.0	4.5	4.5	10.0	6.3	14.1	7.7	17.3
29.7 (10m)	6	2.8	6.3	6.3	14.1	8.9	19.9	10.9	24.4
29.7 (10m)	9	4.0	8.9	8.9	19.9	12.6	28.2	15.4	34.5

(for the VHF/UHF Amateur Bands) - All Distances are in meters

Freq. (VHF/UHF) (MHz/Band)	Antenna Gain (dBi)	Peak Envelope Power (watts) 50 watts		100 watts		500 watts		1000 watts	
		Con.	Unc.	Con.	Unc	Con.	Unc.	Con.	Unc.
50 (6m)	0	1.0	2.3	1.4	3.2	3.2	7.1	4.5	10.1
50 (6m)	3	1.4	3.2	2.0	4.5	4.5	10.1	6.4	14.3

Freq. (VHF/UHF) (MHz/Band)	Antenna Gain (dBi)	Peak Envelope Power (watts) 50 watts Con.	50 watts Unc.	100 watts Con.	100 watts Unc	500 watts Con.	500 watts Unc.	1000 watts Con.	1000 watts Unc.
50 (6m)	6	2.0	4.5	2.8	6.4	6.4	14.2	9.0	20.1
50 (6m)	9	2.8	6.4	4.0	9.0	9.0	20.1	12.7	28.4
50 (6m)	12	4.0	9.0	5.7	12.7	12.7	28.4	18.0	40.2
50 (6m)	15	5.7	12.7	8.0	18.0	18.0	40.2	25.4	56.8
144 (2m)	0	1.0	2.3	1.4	3.2	3.2	7.1	4.5	10.1
144 (2m)	3	1.4	3.2	2.0	4.5	4.5	10.1	6.4	14.3
144 (2m)	6	2.0	4.5	2.8	6.4	6.4	14.2	9.0	20.1
144 (2m)	9	2.8	6.4	4.0	9.0	9.0	20.1	12.7	28.4
144 (2m)	12	4.0	9.0	5.7	12.7	12.7	28.4	18.0	40.2
144 (2m)	15	5.7	12.7	8.0	18.0	18.0	40.2	25.4	56.8
144 (2m)	20	10.1	22.6	14.3	32.0	32.0	71.4	45.1	101.0
222 (1.25m)	0	1.0	2.3	1.4	3.2	3.2	7.1	4.5	10.1
222 (1.25m)	3	1.4	3.2	2.0	4.5	4.5	10.1	6.4	14.3
222 (1.25m)	6	2.0	4.5	2.8	6.4	6.4	14.2	9.0	20.1
222 (1.25m)	9	2.8	6.4	4.0	9.0	9.0	20.1	12.7	28.4
222 (1.25m)	12	4.0	9.0	5.7	12.7	12.7	28.4	18.0	40.2
222 (1.25m)	15	5.7	12.7	8.0	18.0	18.0	40.2	25.4	56.8
450 (70cm)	0	0.8	1.8	1.2	2.6	2.6	5.8	3.7	8.2
450 (70cm)	3	1.2	2.6	1.6	3.7	3.7	8.2	5.2	11.6
450 (70cm)	6	1.6	3.7	2.3	5.2	5.2	11.6	7.4	16.4
450 (70cm)	9	2.3	5.2	3.3	7.3	7.3	16.4	10.4	23.2
450 (70cm)	12	3.3	7.3	4.6	10.4	10.4	23.2	14.7	32.8
902 (33cm)	0	0.6	1.3	0.8	1.8	1.8	4.1	2.6	5.8
902 (33cm)	3	0.8	1.8	1.2	2.6	2.6	5.8	3.7	8.2
902 (33cm)	6	1.2	2.6	1.6	3.7	3.7	8.2	5.2	11.6
902 (33cm)	9	1.6	3.7	2.3	5.2	5.2	11.6	7.3	16.4
902 (33cm)	12	2.3	5.2	3.3	7.3	7.3	16.4	10.4	23.2
1240 (23cm)	0	0.5	1.1	0.7	1.6	1.6	3.5	2.2	5.0
1240 (23cm)	3	0.7	1.6	1.0	2.2	2.2	5.0	3.1	7.0
1240 (23cm)	6	1.0	2.2	1.4	3.1	3.1	7.0	4.4	9.9
1240 (23cm)	9	1.4	3.1	2.0	4.4	4.4	9.9	6.3	14.0
1240 (23cm)	12	2.0	4.4	2.8	6.2	6.2	14.0	8.8	19.8

All distances are in meters. To convert from meters to feet multiply meters by 3.28. Distance indicated is shortest line-of-sight distance to point where MPE limit for appropriate exposure tier is predicted to occur.

Amateur radio operators should be aware that the new FCC radiofrequency safety regulations address exposure to people - and not the strength of the signal. Amateurs may exceed the *Maximum Permissible Exposure* (MPE) limits as long as no one is exposed to the radiation.

The updated MPE limits are indicated in electric (V/m) and magnetic (A/m) field strengths and power density between 300 kHz and 300 MHz. MPE limits above 300 MHz are specified in power density (mW/cm^2) only.

There are two ways to determine whether your station's radio frequency radiation is within the MPE guidelines established for "controlled" and "uncontrolled" environments. One way is direct "**measurement**" of the RF fields. The second way is through "**prediction**" using various equations and calculational methods described in *OET Bulletin 65* and *Supplement B.* The above tables were developed using the equations supplied by the FCC.

In general, most amateurs will not have access to the appropriate calibrated equipment to make accurate field strength/power density measurements. The field-strength meters in common use by amateur operators and inexpensive hand-held field strength meters do not provide the accuracy necessary for reliable measurements, especially when different frequencies may be encountered at a given measurement location.

It is more feasible for amateurs to determine their PEP output power at the antenna using the *RF Compliance Worksheet* and then look up the required distances to the controlled/uncontrolled environments using the *W5YI Tables.*