REPEATERS AND RF SAFETY

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Remember the RF safety rules?

At our home stations, estimating RF exposure is easy and heavy-duty math is usually avoided. We don't have to go out and buy a calibrated field strength meter! In spite of early fears of the regulations, our HF or VHF-UHF stations will easily slide under the environmental impact bar, even while running a full gallon to a Yagi. Not so, for repeaters. Because the rules are somewhat different, a real site survey may be necessary

Background

Our regulations are based on work done by a number of committees: the Institute of Electrical and Electronic Engineers/ American National Standards Institute SCC-28, the ARRL Biological Effects of Non-Ionizing Radiation Committee, the Committee on Man and Radiation and the National Council for Radiation Protection and Measurements. (The latter 2 were originally created to deal with ionizing radiation.).

With time the committees agreed on a standard based on *exposure*, as opposed to other effects. The standard takes account of human body electrical resonance, and is, therefore, *frequency specific*. Finally, it is *occupationally specific*; that is, it requires a different maximum permissible exposure (MPE) for the general public, as opposed to those working with radio frequency emitters. This is called the "two-tiered" standard. The MPE is derived from tissue heating, itself the result of radiofrequency energy absorption.

During its deliberations on ET Docket 93-62 [1] the FCC refused a categorical exemption of radio amateurs from the proposed regulations. Over the objections of some colleagues they elected to group us with the radio professionals, thus requiring a less stringent exposure standard for our home stations. The price of this hard-fought exception was the inclusion of examination elements within the licensing process and the necessity of performing some kind of evaluation for RF safety on every proposed station, prior to placing it on the air. The regulations resulting from this Docket appear in Part 97. They are subtitled, " 97.13 Restrictions on station location" [2]. Further details are best found in the FCC OET Bulletin 65 [3].

The FCC guides and the articles in *QST* are quite helpful for the average ham. If the licensee meets the criteria outlined, nothing further needs to be done, except to log the findings. (Do not send the homework to the FCC!)

FCC OET 65 Supplement B [4], page 48, contains an "optional" work sheet. This sheet walks the amateur licensee through a station evaluation. In general, there is almost no math required to complete the job. There are many tables of safe separation distances for various kinds of antennas, both at HF and UHF. as well as tables of feedline losses. The

League and several hams contributed this entire section - very nicely done. In addition, The University of Texas Radio Club web page has an easy-to-use calculator.[5]

FCC treats repeaters differently.

Perhaps, with the focus on home stations, repeaters receive relatively little attention. But it is with repeaters that the regulations can be tough, indeed.

Unlike the home station in which peak envelope power at the antenna feed point, duty cycle and emission type are relevant factors, FCC assumes a 100% duty cycle for all repeaters and requires estimation of effective *radiated* power.

From the Worksheet, page 2, you are to fill in:

- Repeater antenna description ___________________________________
- Repeater antenna location [ ] mounted on a building [ ] not on a building
- Minimum repeater antenna height above ground level (I)_______ meters
- Estimated maximum repeater antenna gain: (J)_______ dBd
- Maximum Effective Radiated Power (ERP) in dBW (K)______ dBW
- Maximum ERP, converted to Watts (L)_______ watts

The FCC then says: "If L is less than or equal to 500 watts (or K < 27dBW) a routine RF evaluation is not required for this amateur radio repeater setup. 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 portion of the antenna is at least 10 meters (33 ft) above the ground level, a routine evaluation of the amateur radio repeater setup is not required before it can be operated…"

Those of us whose repeaters are on building tops must take a much closer look. If the amateur is the sole occupant of a roof with controlled access and is running less than 500 watts ERP, all's well: simply enter this finding in the repeater station log. However, with good antennas readily available at swap meets, a 350-watt (25.4 dBW) 2- meter repeater coupled to a 6 dBd collinear with a short feed line is likely to exceed 500 watts ERP (27dBW).

If his antenna shares the rooftop with other emitters, to be exempted from further evaluation, the amateur licensee's contribution must not exceed **5%** of *his* allowable ERP for the frequency band in use, from a specific eyeball-to-mid-antenna distance. That eyeball can belong to a casual visitor (uncontrolled environment) or a person trained in RF awareness (controlled environment) - such as the amateur licensee.

In OET Bulletin 65, starting on page 32, there is a section titled, "Multiple transmitter sites and complex environments." They point out that the rules apply to all emitters present and the safety responsibility is a shared one. In the unlikely case that the proposed amateur station causes the radiation at some observation point to exceed 100% of the MPE at that point, the amateur must adjust his system to maintain compliance, or cajole the others present to change. This will be a Hobson's choice for most of us. We occupy these first rate sites by the generosity of the owner or site manager. If we tilt the balance to a requirement for environmental assessment, our stay may be brief, indeed! Hare's[5] Figure 5.17 indicates that the actual area of non-compliance may be a small fraction of the potential RF exposure area. Software[6] is available to produce this type of calculation. However, I suggest a more restricted view, based on actual potential vantage points on a given surface, such as a hatch opening on to the roof area. This should satisfy the FCC requirements, as set forth in their Bulletin.

Five per cent -or else!

We must know the" 5%" vantage point for our station. If the >5% area is inaccessible, the evaluation is over. Because the "5% rule", among other things baffled me, I am going to torture you with the math needed to do that evaluation.

Remember that this safety rule is based on time-averaged RF exposure. The amount of RF present at a distance, *r*, from a point source (isotropic) radiator derives from the illumination of the inside of a sphere by a candle centered therein. The intensity of the illumination by definition, is everywhere the same. We divide the power available by the area of the sphere, which is why π appears in the equation.

$$S = \frac{pg}{4\pi r^2} \qquad \text{Equation (1)}$$

S= Power density in units of power per unit area
p = Power available at antenna terminals. (transmitter power minus transmission losses)
g = Numerical power gain of antenna over an isotropic radiator
r = Distance from center of antenna to observer's eye.

Please note that all units must be consistent. If power is in watts, the distance to the observer must be in meters. Since the limits for power density are usually expressed in mW/cm^2, power goes in as milliwatts and the radial distance, *r*, is in centimeters.

The factor *pg* is the same as effective isotropic radiated power (EIRP). To get this number, the gain factor must be manipulated up from the manufacturer's usual gain rating over a dipole to gain over an isotropic source. The multiplication factor is 1.64.

To obtain the correct number for EIRP:

- Convert decibel gain into power gain.
  - Divide the decibel gain over a dipole by 10. (use the manufacturer's specification)
  - Take the anti-log of this number. (this is the 10^x key on my calculator)
- Determine power available at the antenna terminal. This will be transmitter power output minus all RF losses en route to the antenna.
  - Convert transmitter antenna terminal watts, P_o, to dBW

- Subtract dB loss in the feedline, connectors, duplexer, circulator, and in-line filters, and then converting the dB back to watts. (OR just carry a wattmeter to the antenna terminal, key the repeater transmitter, and measure the watts.)
- Multiply the available power at the antenna by the numerical gain of the antenna. This is effective radiated power (ERP) in watts.
- Multiply ERP by 1.64. This is EIRP - effective isotropic radiated power, the numerator of Equation (1) above.

Example: A 444 MHz repeater transmitter feeds 75 watts to a Decibel Products DB-420 collinear multiple dipole antenna, set up with an Omni pattern, 9.2 dBd gain. (Information from Decibel Products Div., Allen Telecom Group, Dallas, TX)

- Convert dBd to numerical gain:
  - Divide 9.2 by 10 and take the anti-log => numeric gain over dipole: $G_d = 8.32$
  - Convert to numeric gain over isotropic source
    - Multiply 8.32 by 1.64, the conversion factor, $G = 13.65$
- Convert 75 watts to dB
    - 10 Log 75 = 18.75 dBW
- Reduce this 18.75 dBW by the losses incurred in getting the RF to the antenna terminals. This is best done in terms of dB, so that we can perform the simpler calculation of subtraction of the dB's loss from the dB's generated. When finished, we convert back to watts, in order to maintain consistent units to plug into Equation (1)

- Tally up the Losses (Data from Andrew Corp. Orland Park, IL, Remec-Wacom, Ltd., Waco, TX, EMR Corp., Phoenix, AZ.
  - Feedline, 100 ft of 7/8" Andrew 5-50 with 2 type N connectors: -0.96 dB
  - Duplexer, Wacom WP-678 -1.2 dB
  - Bandpass filter, Wacom_WP-470-1 (moderate loss loops) -2.0 dB
  - Circulator/Isolator EMR 8550/34 -0.45 dB
  - 2nd Harmonic filter EMR FM 6550/S -0.10 dB
  - Four 2' long Andrew FSJ1-50A jumpers with 2 N-connectors; insertion loss per cable, 0.12 dB. -0.48 dB
  - TOTAL LOSS -5.19 dB

- Subtract Total Loss from Transmitter Po (5.19 from 18.75).

  - NET POWER 13.56 dBW

- Convert dB back to watts:
  - Divide NET POWER in dBW by 10.
  - Take anti-log. This is the Power available at the transmitting antenna
  - P = 22.70 Watts
- Multiply P *by* G_d to get Effective Radiated Power
  - ERP = 188.86 Watts

This is well below the 500 watts ERP allowed. If the amateur repeater antenna is mounted on a tower that is at least 10 m (33 ft) tall, the job is over!

- To finish the calculations, we convert ERP to effective isotropic radiated power:
  - Multiply *P by G:* EIRP = 309.85 watts

The formula for power density as a function of *r* becomes:

$$S = \frac{EIRP}{4\pi r^2} = \frac{1.64\,ERP}{4\pi r^2} \quad \text{(Adapted from Eq. 5, Suppl. B)}$$

Equation (2)

In our example above, let us assume that *r* is10 meters. We will get 0.2465 watts/m^2, which is equivalent to 0.02465 mw/cm^2, or 24.65 μw/ cm^2.

This problem can be worked in logarithms right up to the end with identical results. Simply add the dBd antenna gain to the net dBW. Divide the sum by 10 and take the anti-log of the result. This will be ERP in watts. There is really no need for bouncing back and forth from watts to dB. To get EIRP, simply add 2.15, before converting to watts. 2.15 is 1.64 expressed in decibels. [I think the FCC wants the reader to avoid the pitfall of entering dBd for *G* in the formula, whilst entering *P* in watts].

In the Appendix, I have extended the FCC's worksheet to add a Section III for evaluation of an Amateur radio repeater setup - with the focus on multi-antenna site analysis.

<u>Roof-mounted antennas</u>

When antennas are mounted near a smooth surface, re-radiation can account for an increase in field strength nearby. The worst case is 100% rooftop reflection, which doubles field strength → quadrupling the power density. For the example above, *pg* must be multiplied by 4, giving in our example, a much higher exposure: 98.60 μw/ cm^2.

Fortunately, the EPA will allow a factor of 1.6 times field strength, (instead of 2.0) which [when squared to get power] yields 2.56 times the free space power density. If we use 2.56 as our reflection factor, our example yields 63.10 μw/ cm^2, a significant reduction.

All these factors can be combined to get a single equation:

$$S = 33.4\,\frac{ERP}{r^2} \quad \text{(Eq. 9, Suppl. B)}$$

Equation (3)

S = Power density in μw/ cm^2.
ERP = Effective radiated power in <u>watts</u>.
r = distance in meters from center of antenna to observer’s eye.
(The factors of 1.64 and 1.6 are built into the constant 33.4).

The result is then compared with the maximum power density allowed in controlled and uncontrolled environments. If we run our hypothetical 440 repeater through this equation, we get 63.09 μw/ cm^2. This is well below the MPE of 1480 μw/ cm^2 at 440 MHz. (See below).

Doing it for real: at a real site.

The remaining calculations must be done on the site under test. The results and conclusions will be site specific and cannot be generalized to every other site.

All that is left to do is to calculate *r.* Unless the center of the antenna is at eye level of the observer, we will need to solve a right triangle.

Measure the distance from the observer to the base of the antenna, *d.* Measure (or estimate) the height *h,* to the middle of the antenna above the eyes of the observer (FCC uses 1.8 meters for the height of the human observer). Square both numbers, sum the squares and take the square root. Assuming your measuring tape is non-metric, divide the result by 3.28. This is *r* in meters. In familiar terms:

$$r = \sqrt{d^2 + h^2} \qquad \text{Equation (4)}$$

I suggest that you obtain some ruled paper ("graph pad") and sketch out your building top profile. Carry a 100-ft tape measure and work with a partner. Draw in the antenna and the proposed observer. Show the sight line, *r*, to the antenna. Calculate its length.

Figure 5, OET Bulletin 65, page 38 illustrates the simple geometry involved.

How we use the 5% rule:

If there are other emitters on the roof with the amateur, FCC says that the responsibility is shared. There is an exception - an important one: If the amateur station contributes 5% or less of *his* allowable power density at a given observation point, the amateur is exempted from further work! To find out if the proposed station slips under the bar, the actual proposed antenna location must be known

For a *controlled* environment, the maximum permissible exposure (MPE) power densities at VHF-UHF are: (Adapted from Bulletin 65, Appendix A, p. 47)

Band	Allowable	MPE
29 MHz	1.0 mW/cm^2.	29.7 MHz - 1000 μw/ cm^2
50- 1296 MHz:	f/300*	52 MHz - 173 μw/ cm^2
		222 MHz - 740 μw/ cm^2
		444 MHz -1480 μw/ cm^2.
>1500 MHz:	5.0 mW/ cm^2.	5000 μw/ cm^2

* f = frequency in MHz.

- All exposures are to be time averaged over **6** minutes.

Table (1)

If the rooftop is inaccessible to the public, these numbers will apply. However, aside from emergency egress, for the casual non-ham, non-RF-aware employee, the *uncontrolled* environment is considerably stricter. This is the other 'tier' of the two-tiered standard. For this scenario, MPE at VHF-UHF are:

Band	Allowable	MPE
29 MHz	$180/f^2$ mW/cm^2.	29.7 MHz - 204 μw/ cm^2.
50-1296MHz	f/1500 mW/cm^2	52. MHz - 35 μw/ cm^2
		146 MHz - 96 μw/ cm^2
		222 MHz - 148 μw/ cm^2
		444 MHz - 296 μw/ cm^2.
>1500 MHz	1.0 mW/ cm^2.	1000 μw/ cm^2.

- All exposures are to be time averaged over **30** minutes

Table (2).

Note the extraordinarily low value for 6 meters - a quarter wave is just under 5 feet ~ the height of a lot of young people.

In a controlled environment, the power density at the eye of an observer viewing the antenna of an amateur repeater operating at 444 MHz must not exceed 1.48 mW/cm^2. Taking 5% of this yields 74 μw/cm^2, the threshold for additional study of a repeater site, if it is shared with other emitters. The 63.10 μw/cm^2 that results from Equation 3 is safely below this number. Providing the observation point is inaccessible to the general public, the assessment in this example, is complete.

It can be a little difficult to figure out the observation point. For the casual walk-on, I'd suggest using the doorway or hatch that opens on to the roof as the observation point, providing the antenna is visible from this point. Each visible radiator on the rooftop contributes to the total power density at the observer's eye. If the amateur has more than one repeater - as in a linked system, for instance, the contribution of each radiator to the power density at the observer's eye must be summed. Any other co-located radiator will have its own *r, p and g* to examine and the resulting power density *S,* added to the amateur's contribution. Taken all together, these estimates can significantly inrease the safe separation distance for the proposed observer.

Safe Separation Distance

For the communications worker at the site, not only would it be good to know the power density at the entrance, but also to have some idea of this safe separation distance. Fortunately, Fred Maia, W5YI, has done our work for us. Please refer to Table 4b, page 24 in Supplement B. A 450 MHz repeater running 500 watts ERP will require 2.6 feet safe separation for the amateur licensee and other professionals; 5.8 feet for uncontrolled exposure. Fred assumed 100% duty cycle - required for all repeater calculations - and maximum surface reflection (not required, see above).

Maia's calculations apply to a single rooftop emitter. If there are other radiators, we must make our own on-site observations and calculations. In the example above, we can solve Equation (3) for *r,* given *pg*: and calculate 5% of *S*, from Tables 1 and 2 above.

$$r = \sqrt{\frac{33.4\,ERP}{S}}$$

Equation (5)

For 444 MHz, the $MPE_{5\%}$ = 74 μW/cm^2 for controlled access; 14.8 μW/cm^2 for uncontrolled access. In the example, this will define a radius of 9.23 m controlled; 20.7 m uncontrolled. (30.3 ft and 67.9 ft). The message here: if the amateur licensee has a choice, locate the antenna as far away as possible from any site access point, or mount it so that a roof or other structure shades it from the observation point.

<u>How can I just add up RF from all different kinds of RF radiation?</u>

When I first looked at the regulations. I had difficulty understanding how results from calculations made in several different frequency bands can be added at the observer's eyeball. I know, it's obvious now, but the "*r*" for each roof emitter is unique to that emitter, as are the antenna gain and transmitter power, decrements by filters, duplexers, circulators and feedline. Each calculation ends up in units of power per unit area at the eyeball. Hence, we can add up the very dissimilar RF sources. Each emitter will have its own MPE, not to be exceeded.

We must determine the emitter's per cent of its unique MPE. These per cents can be summed. They should not exceed 100% at the observation point under study.

<u>The second factor: time of exposure.</u>

Don't forget the exposure *time limits*: For our 440 repeater. the licensee can remain 3.7 feet away for 6 minutes max; the casual visitor gets 30 minutes at 8.2 feet line of sight separation.

Time and spatial averaging can be a bit complex. As the guide suggests. a repeater maintenance person can take twice the indicated exposure for 3 minutes, providing there is no exposure at all for the preceding *or following* 3 minutes. (Italics mine). In general, the product of time of exposure and the power density level at that observation point must not exceed the product of the specific (frequency dependent) MPE limit and the prescribed time limit. This allows the worker intermittent access. In the case of commercial broadcasting, going QRP clearly allows more time near the antenna. <u>The amateur should simply shut down his repeater while he or others work on or near the antenna.</u>

What to do if the MPE's are exceeded:

If the calculations indicate an unacceptable environment, there will need to be a site evaluation for better security, warning signs and so on. FCC lists 8 steps to take:

- Restricting access to high RF-field areas
- Operating at reduced power when people are present in high RF-field areas
- Transmitting at times when people are not present in high RF-field areas
- Considering duty factor of transmissions (N/A for repeaters, which are deemed to be 100% duty factor at all times)
- Time-averaging exposure
- Relocating antennas or raising antenna height
- Incorporating shielding techniques
- Using monitoring or protective devices
- Erecting warning/notification signage

Summary

The FCC has given amateurs much credit for being environmentally sensitive citizens. This is quite evident in the extensive document they have prepared just for us.

As we now know, RF safety regulations apply to all amateurs. For the home-based 100 watt PEP SSB station operating 80 meters, a simple log entry that station emissions fall well within the MPE limits will be easily possible - and all that is necessary. If doubt remains, download and follow the University of Texas page.

For the low power (<500 watts ERP) repeater operator whose station has a tower mounted antenna (base of antenna at least 10 meters above ground level), the same reassurance is usually possible. This will be true, even with the statutory use of ERP and a 100% duty cycle.

Stations located on rooftops, especially those that share space with other services, will need to take a much closer look, especially if the ERP exceeds 500 watts. The licensee should download the FCC OEP 65 and its Supplement B for Amateur Radio, as well as the ARRL articles. Do not report the station evaluation to the FCC. Log it at the repeater site.

Conclusion

I have shared my understanding of our special commitments as repeater licensees herein. Doing a site survey can be fun. The mental pushups required are gentle. It is worth doing well!

Appendix: FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields: Repeater Compliance Worksheet

This worksheet is designed to complement Appendix B, FCC OET Bulletin 65, Supplement B, beginning with Question 26 of the *Optional Worksheet and Record of Compliance.* This section assumes that the licensee has determined that a routine evaluation **is** required.

Because the proposed station is a Repeater, duty cycle is assumed to be 100%. ERP replaces PEP of a typical (SSB or CW) home station. It is further assumed that the base of the antenna of the proposed repeater is to be located < 10m above ground, or the ERP is expected to exceed 500 watts, or the station antenna is roof-mounted and the ERP exceeds 500 watts, or, regardless of ERP, the roof-mounted antenna shares the space with other RF emitters.

<u>Summary of spread sheet for multi antenna site</u>.

1. From examination of the site, determine if the observation point in question is within a controlled, or uncontrolled environment
2. Calculate S for the repeater antenna.
3. Calculate MPE's for each frequency in use, using appropriate table for controlled or uncontrolled environment.
4. Calculate 0.05 MPE for the frequency in use.
5. If this .05MPE > S for the ham, and the ham's ERP <500 watts, the exercise is over.
6. If this .05MPE < S for the ham repeater, proceed:

7. Calculate S for <u>each</u> transmitter antenna within the sight line of the observer.
8. Calculate the MPE for each of these radiators.
9. Calculate per cent of each MPE for each S
10. Add the per cents.
11. If this number exceeds 100%, an assessment for changes to bring the total to 100% o less will be required.
12. If this is not possible, fencing, signs and so on will be required in order avoid an environmental assessment.

- In order to simplify the math, we will do the calculations entirely with logarithmic (decibel) values, in so far as possible. We will follow the FCC outline in other respects, and will create a new Section III for this purpose.[1]
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III. Routine Evaluation of amateur radio repeater setup.

41. Antenna gain over a dipole in decibels[2]: (G_{dB})______dBd

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[1] The numbers pick up where the FCC OET document leaves off:

[2] Use the manufacturer's specification. With a directional antenna, as a worst case, use the gain of the maximum lobe. Assume 100% radiation efficiency.

42. Transmitter power available at antenna terminal _______ watts

Obtain the logarithm of this number.

Multiply this logarithm by 10. (X)______dBW

43. Calculate RF losses en route to antenna

Circulator/isolator _______ dB

2nd Harmonic filter _______ dB

Band-pass filter _______ dB

Duplexer _______ dB

Cable insertion loss[3] _______ dB

Antenna feedline insertion loss _______ dB

TOTAL LOSSES (Y) _______ dB

44. Determine Effective Radiated Power

Subtract (Y) from (X) = (P_{dB}) _______ dBW available at antenna terminal.

Add (G_{dB}) to (P_{dB}) = ERP_{dB} _______ dBW ERP in decibels over 1 watt.

Convert ERP_{dB} to watts.

Divide ERP_{dB} by 10.

Extract the anti-log of this number ERP _______ watts

45.From roof or tower measurements determine the sight line length, *r,* in meters to the proposed observer. Assume the observer's eyeball is 1.8 meters above his feet.[4] A sketch of the installation will help. This step will be repeated, if there are other observation points available to a site visitor. Make a sketch with distances noted thereon.

Description of emitters under study: ____

Observation point (point of radiation exposure) # ________ (reference the drawing).
Is the observation point in a controlled or uncontrolled environment? _____________

Transmitter # 1 (Amateur Repeater) ____________________________
Antenna #1 r_1______m
Transmitter # 2 (Amateur Aux Link 1)_____________________________________
Antenna #2 r_2 _____ m
Transmitter # 3 (Amateur Aux Link 2)_________________ ___________________
Antenna #3 r_3 _____ m

46. Calculate power densities. For towers, use equation 2; for rooftops, use equation 3. From Tables (1) or (2), enter the allowable power density (MPE) for the frequency. (Be sure that the units are consistent). Divide S by MPE, express as per cent MPE:

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[3] Each jumper cable and connectors thereon will introduce loss. Don't forget to include loss from the flexible jumper from cabinet to larger diameter hard line. Use published specifications for interconnects and main feedline. Multiply loss/ft in dB by feet, and add connector losses. Many commercial sites require a circulator/isolator and a band-pass cavity in the transmitter leg of the duplexer input. Hence, these are included as reminders in the work sheet.

[4] This will usually require solution of a right triangle whose base is 1.8 meters above the roof deck. This process is repeated for each antenna in view of the observer.

Transmitter	S		MPE		Per cent MPE
#1________	S_1_______	/m^2	_______	/m^2	_______
#2_________	S_2_______	/m^2	_______	/m^2	_______
#3_________	S_3 _______	/m^2	_______	/m^2	_______

AMATEUR STATION TOTAL PER CENT [should be < 100%] (A) _______

The first 2 columns will show if at the proposed observation point, any one transmitter will exceed the MPE. The 3rd column answers to the "5% rule" in which any one transmitter exceeds 5% of its allowable MPE, or, in the case of, say a repeater and two auxiliary link transmitters, the sum of the licensees' radiators do not exceed 100% of allowable MPE at that observation point. Either condition will trigger further study.

47. If each individual radiator's MPE is less than 5% of the allowed MPE, the study is over *unless* the proposed station exceeds 100% allowed MPE, *or* the MPE is exceeded by *the addition of the proposed station to an existing site with radiators visible at the observation point.* If there are additional sources of RF radiation visible to the proposed observer, the amateur licensee should construct an additional table, using the best information available to him, and add his total per cent to the co-sited emitters' per cent. Again, the total should not exceed 100%.

48. Calculations for co-sited (non-Amateur) emitters. Use this section, only if there are non-amateur emitters present.

From roof or tower measurements, determine the sight line length, *r,* in meters to the proposed observer. Assume the observer's eyeball is 1.8 meters above his feet. A sketch of the installation will help. This step will be repeated, if there are other observation points available to a site visitor. Make a sketch with distances noted thereon.

49. List of commercial emitters that are visible to the observer described above.

Transmitter # 4 (Commercial -pager, other service) ____________________________
Antenna #4 r_1______m
Transmitter #5____
Antenna #5 r_2 _____ m
Transmitter #6 ____ __________________
Antenna #6 r_3_____ m

46. Calculate commercial station power densities, S_4 -S_6. Use same equation chosen for amateur station study. Make additional study sheets, if necessary

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From Tables (1) or (2), enter the allowable power density (MPE) for the frequency. Use the same environmental constraints as used for the amateur stations.

Divide S by MPE, express as per cent MPE: (Be sure that the units are consistent).

Transmitter	S		MPE		Per cent MPE
#4________	S_4________	$/m^2$	________	$/m^2$	________
#5__________	S_5________	$/m^2$	________	$/m^2$	________
#6__________	S_6 ________	$/m^2$	________	$/m^2$	________

COMMERCIAL STATION TOTAL PER CENT (B) _______

The first 2 columns will show if at the proposed observation point, any one transmitter will exceed the MPE. The 3rd column answers to the "5% rule" in which any one transmitter exceeds 5% of its allowable MPE.

{A) + (B) must be < 100%. The newest arrival gets whatever per cent MPE is left over after the first arrivals are summed.

Please return to the main text for information regarding time averaging and steps to take in the event of excess RF exposure.

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[1] Guidelines for evaluating the environmental effects of radiofrequency radiation. ET Docket 93-62. Washington DC. Federal Communications Commission. (August) 1996: paragraphs 43, 83, 86. 160-163. http://www.fcc.gov/bureaus/engineering-technology/orders/1996/fcc96326.pdf

[2] Part 97 Amateur Radio Service. Federal Communications Commission. (November) 1999. http://www.arrl.org/field/regulations/news/part97/toc.html.

[3] RF Cleveland DM Sylvar JL Ulcek. Evaluating compliance with FCC guidelines for human exposure to radiofrequency electromagnetic fields. Federal Communications Commission Office of Engineering and Technology. Bull. 65 Ed. 97-01.(August) 1997. http://ftp.fcc.gov/Bureaus/Engineering_Technolgy/Documents/bulletin/oet65/oet65b.pdf.

[4] J.L. Ulcek and R.F. Cleveland, Jr. Evaluating compliance with FCC guidelines for human exposure to radiofrequency electromagnetic fields. Additional information for amateur radio stations. Federal Communications Commission Office of Engineering and Technology. Supplement B, Bull. 65 Ed. 97-01 (November) 1997.. http://ftp.fcc.gov/Bureaus/Engineering_Technolgy/Documents/bulletin/oet65/oet65b.pdf

[5]

[5] E Hare, W1RFI, RF Exposure and You. Newington, Ct, ARRL 1998 p. 5.23.

[6] Richard Tell Associates, Inc. http://www.radhaz.com.