

Montgomery Amateur Radio Club

RF Safety

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RF Safety

- What comes to mind?
 - Exposure?
 - Heating?
 - High Current?
 - High Voltage?
 - Arcing? Flashover?
 - Interference/Coupling? (Q: Coax Cable # Conductors?)
 - Secondary Emission?

Terminology Used

- MPE – Maximum Permissible Exposure
- Controlled – You Maintain Control
- Uncontrolled – General Population
- RF Power – Watts at the Antenna
- Gains and Losses – Expressed in dBi
- Duty Factor – Modulation % of Envelope
- Duty Cycle – Time On/Off Ratio
- 6-Minute and 30-Minute Time Averaging

Key Fact:

- FCC's limits are *exposure* limits, not *emission* limits.

References

Publication: OET BULLETIN 65, dated August 1997
"Evaluating Compliance with FCC Guidelines for
Human Exposure to Radiofrequency Electromagnetic Fields"

https://transition.fcc.gov/Bureaus/Engineering_Technology/Documents/bulletins/oet65/oet65.pdf

FCC Publication: OET BULLETIN 65, Supplement B,
dated November 1997
"Additional Information for Amateur Radio Stations"

https://transition.fcc.gov/Bureaus/Engineering_Technology/Documents/bulletins/oet65/oet65b.pdf

FCC MPE Limits

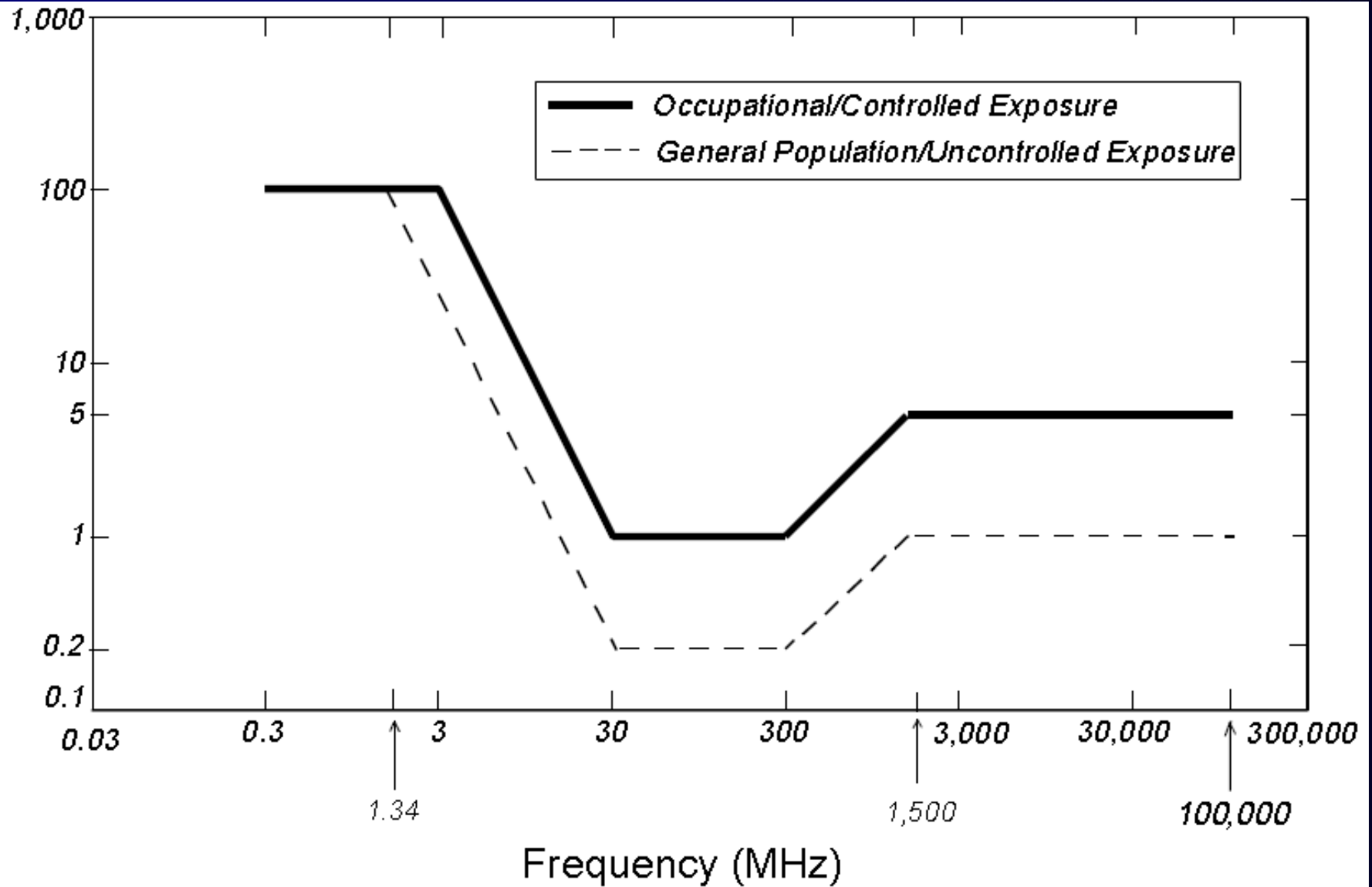


Table-1. Categorically Excluded

Wavelength Band	Evaluation Required if Power* (watts) Exceeds:
MF	
160 m	500
HF	
80 m	500
75 m	500
40 m	500
30 m	425
20 m	225
17 m	125
15 m	100
12 m	75
10 m	50
VHF (all bands)	50

Mobile Operation is Categorically Excluded – but beware!

Duty Factor Duty Cycle



20% Duty Factor for Non-Compressed Speech.

50% Duty Cycle

Result: $100 \text{ Watts} \times 20\% \times 50\% = 10 \text{ Watts}$

AT THE
TRANSMITTER

Duty Factor Table / Mode

Mode	Duty Factor	Notes
Conversational SSB	20%	Note 1
Conversational SSB	50%	Note 2
Voice FM	100%	
FSK or RTTY	100%	
AFSK SSB	100%	
Conversational CW	40%	
Carrier	100%	Note 3

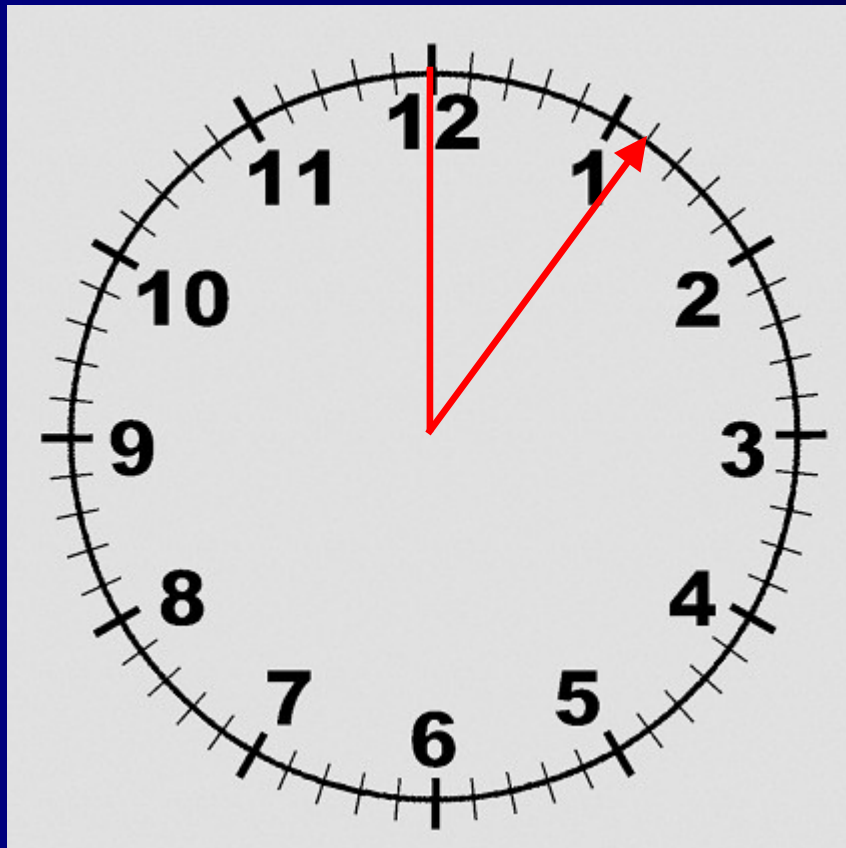
Note 1: Includes voice characteristics and syllabic duty factor. No speech processing.

Note 2: Includes voice characteristics and syllabic duty factor. Heavy speech processor employed.

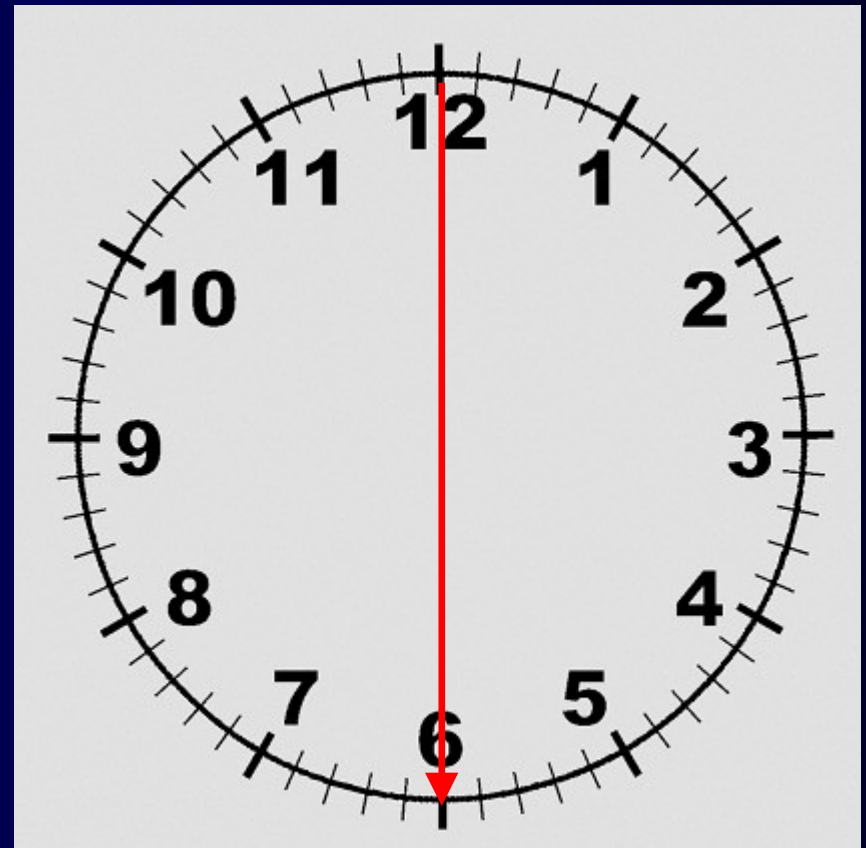
Note 3: A full carrier is commonly used for tune-up purposes

Time Averaging *(Exposure not Emission)*

6-Minute Controlled



30-Minute Uncontrolled



Losses

.5 db = 11% Loss
 1 db = 20% Loss
 2 dB = 37% Loss
 3 dB = 50% Loss
 6 dB = 75% Loss
 10dB = 90% Loss

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

Band	RG-58	RG-8X	RG-8A, RG-213	RG-8 Foam	"9913" & eqv	½" 50Ω "hardline"	"Ladder line"
160 m	0.5	0.4	0.3	0.2	0.2	0	0
80 m & 75 m	0.7	0.5	0.4	0.3	0.2	0.1	0
40 m	1.1	0.7	0.5	0.4	0.3	0.2	0
30 m	1.4	0.9	0.6	0.5	0.4	0.2	0
20 m	1.7	1.1	0.8	0.6	0.5	0.3	0
17 m	2.0	1.2	0.9	0.7	0.6	0.3	0.1
15 m	2.2	1.3	1.0	0.7	0.6	0.3	0.1
12 m	2.4	1.4	1.1	0.8	0.6	0.3	0.2
10 m	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
2 m	6.5	3.6	3.0	2.0	1.6	1.0	0.7
1¼ m	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		15	15	8.8	6.4	5.2	

Example: 1

- For example, if a 1,500-watt PEP amateur single-sideband station (with no speech processing) transmits two minutes on, two minutes off then two minutes on again in any six-minute period (the averaging time period for controlled exposure), then for **controlled exposure** situations the effective power would be:

$$1,500 \text{ W} \times 0.2 \text{ (20\% from Table 2)} \times (4 \text{ of 6 minutes}) = \mathbf{200 \text{ W}}$$

- For **uncontrolled exposures** the averaging time is 30 minutes and the total transmission time during any 30-minute period would be 20 minutes out of 30. The result would then also be:

$$1,500 \text{ W} \times 0.2 \times (20 \text{ of 30 minutes}) = \mathbf{200 \text{ W}}$$

Example: 2 (Table Solutions)

TABLE 5. Three-element "triband" Yagi assuming surface (ground) reflection

Distance (meters) from any part of the antenna for compliance with either occupational/controlled or general population/uncontrolled <u>exposure</u> limits						
	14 MHz, 6.5 dBi		21 MHz, 7 dBi		28 MHz, 8 dBi	
Power (watts)	con.	unc.	con.	unc.	con.	unc.
100	1.4	3.1	2.2	5	3.4	7.5
500	3.1	7	5	11.2	7.5	16.7
1,000	4.5	10	7.1	15.8	10.6	23.7
1,500	5.5	12.2	8.7	19.4	13	29

Example: 3 (Table Solutions)

TABLE 6. Omnidirectional HF quarter-wave vertical or ground plane antenna (estimated gain 1 dBi) assumes surface (ground) reflection

Distance (meters) from any part of the antenna for compliance with either occupational/controlled or general population/uncontrolled exposure limits										
	3.5 MHz		7 MHz		14 MHz		21 MHz		28 MHz	
Transmitter power (watts)	con.	unc.	con.	unc.	con.	unc.	con.	unc.	con.	unc.
100	0.2	0.4	0.4	0.8	0.8	1.7	1.1	2.5	1.5	3.3
500	0.4	0.9	0.8	1.9	1.7	3.7	2.5	5.6	3.3	7.5
1000	0.6	1.3	1.2	2.7	2.4	5.3	3.5	7.9	4.7	10.6
1500	0.7	1.6	1.4	3.2	2.9	6.5	4.3	9.7	5.8	12.9

Example: 4 (Table Solutions)

TABLE 7. Horizontal half-wave dipole wire antenna (estimated gain 2 dBi) assuming surface (ground) reflection

Distance (meters) from any part of the antenna for compliance with either occupational/controlled or general population/uncontrolled exposure limits										
	3.5 MHz		7 MHz		14 MHz		21 MHz		28 MHz	
Transmitter power (watts)	con.	unc.	con.	unc.	con.	unc.	con.	unc.	con.	unc.
100	0.2	0.5	0.4	0.9	0.9	1.9	1.3	2.8	1.7	3.7
500	0.5	1.0	0.9	2.1	1.9	4.2	2.8	6.3	3.8	8.4
1000	0.7	1.5	1.3	2.9	2.6	5.9	4	8.9	5.3	11.8
1500	0.8	1.8	1.6	3.6	3.3	7.2	4.9	10.9	6.5	14.5

Take-Aways

- Every Amateur Station Must Do This!
- Exposure vs Emission Limits
- Controlled vs Uncontrolled Environments
- 6-Minute and 30-Minute Averaging
- Duty Factor and Duty Cycle Adjusted
- Apply Gains and Losses
- Table Lookups / Online Calculators
- Compliance or Modifications/Mitigations

Questions?

