Technician License Course
Chapter 9.2
Lesson Module 21
Radio Frequency Exposure

http://www.arrl.org/chpt-9-safety

RF Exposure

- Exposure to high levels of RF can cause problems.
- RF radiation is non-ionizing [T0C01] and therefore cannot cause genetic damage. [T0C12]
- If precautions are taken, RF exposure is minimal and not dangerous.
- Problem is RF energy can heat body tissues.
  - Heating depends on the RF intensity and frequency.
- RF exposer may be limited by:
  - Preventing access to locations with RF strong fields
  - Making sure strong fields are not ceratitid in or directed to areas where people might be present.
- RF burns can be eliminated by proper grounding or preventing access to an antenna. [T0C07]

RF Exposure and Frequency

- When body parts act like antennas, those parts absorb RF energy at certain frequencies (wavelengths) more efficiently and increase risk.
- RF exposure risk varies with frequency.
  - The body absorbs more energy at some frequencies than others. [T0C05]

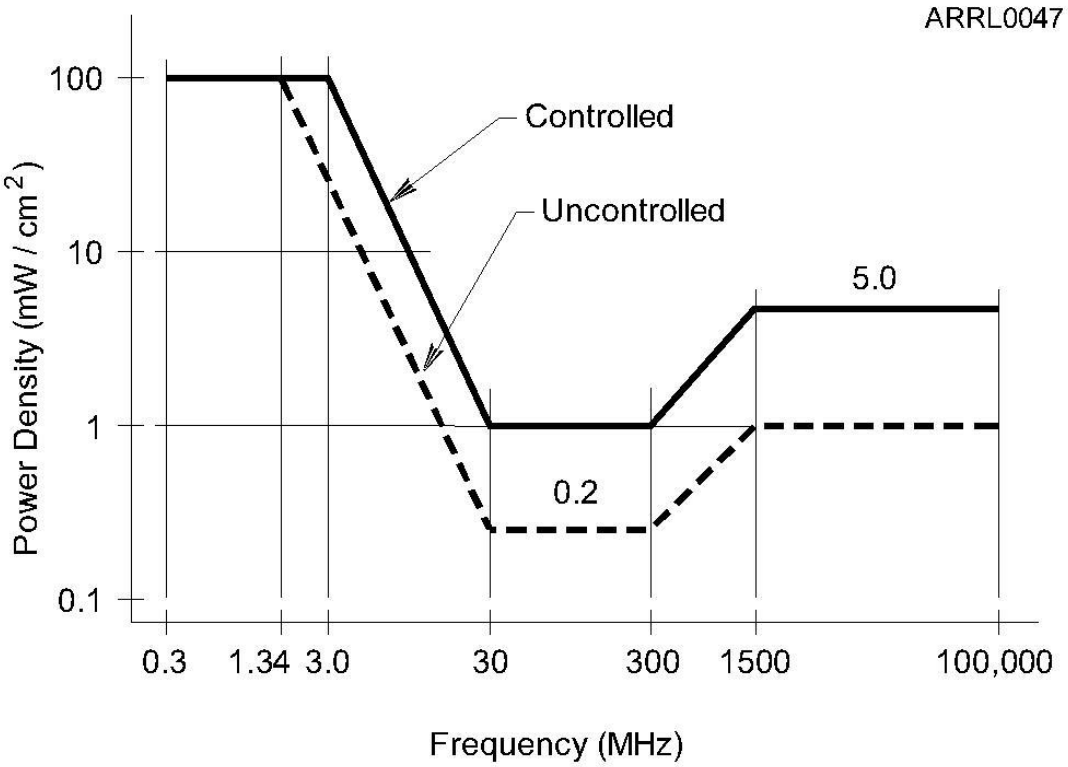
RF Intensity

- Body heating varies with frequency and intensity and is defined as the "specific absorption rate" or SAR
- Power Density (mW/cm^2)
  - Actual transmitter power.
    - Higher power, higher risk.
  - Antenna gain and proximity.
    - Beam antennas focus available energy.
    - Being physically close or standing in the beam direction increases risk.
  - Mode duty cycle.
    - The more time the power output is at high level, the higher the risk.

Exposure Limits

- The safe level of exposer is established by the FCC defined as the Maximum Permissible Exposure (MPE)
- MPE varies with frequency as shown in Figure 9.2
- Body resonance (high absorption) for an adult
  - Grounded, 35 MHz
  - Un-grounded, 70 MHz
  - Adult head, 400 MHz
- MPE is lowest at 50 MHz and highest at 3.5 MHz. [T0C02]

RF Exposure and Frequency



Antenna Proximity

- Controlled Environment.
  - You know where people are standing in relation to your antenna and you can do something about it.
  - More power is allowed because you can make adjustments if needed.
- Uncontrolled Environment.
  - You have no idea, or have no control of people near your antenna.
  - Less power is allowed because you have to assume the worse case scenario.

Maximum Permissible Exposure (MPE) Limits

Table 9.3
Maximum Permissible Exposure (MPE) Limits

Controlled Exposure (6-Minute Average)

Frequency Range (MHz)	*Power Density (mW/cm^2)*
0.3-3.0	(100)*
3.0-30	($900/f^2$)*
30-300	1.0
300-1500	f/300
1500-100,000	5

Uncontrolled Exposure (30-Minute Average)

Frequency Range (MHz)	*Magnetic Field Power Density (mW/cm^2)*
0.3-1.34	(100)*
1.34-30	($180/f^2$)*
30-300	0.2
300-1500	f/1500
1500-100,000	1.0

f = frequency in MHz
* = Plane-wave equivalent power density

Mode Duty Cycle

- The more time the transmitted power is at high levels, the greater the duty cycle, and the greater the exposure risk.
- Duty cycle must be considered when evaluating exposure [T0C10]
- A 50% duty cycle signal may have 2 times the power to remain in safe limits [T0C13]

Table 9.4

Operating Duty Cycle of Modes Commonly Used by Amateurs

Mode	*Duty Cycle*	*Notes*
Conversational SSB	20%	1
Conversational SSB	40%	2
SSB AFSK	100%	
SSB SSTV	100%	
Voice AM, 50% modulation	50%	3
Voice AM, 100% modulation	25%	
Voice AM, no modulation	100%	
Voice FM	100%	
Digital FM	100%	
ATV, video portion, image	60%	
ATV, video portion, black screen	80%	
Conversational CW	40%	
Carrier	100%	4
Digital (PSK31, RTTY)	100%	

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

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

Note 3: Full-carrier, double-sideband modulation, referenced to PEP. Typical for voice speech. Can range from 25% to 100%, depending on modulation.

Note 4: A full carrier is commonly used for tune-up purposes.

RF Exposure Evaluation

- All fixed stations must perform an exposure evaluation based on there TX power levels (See table 9.5). Several methods are available to do this.
  - The most common method of evaluation is the FCC's OET Bulletin 65. [T0C06]
  - Changes in your station that can required a new evaluation are: Increased TX power, higher antenna gain, or adding a new frequency band. [T0C09]
- At lower power levels, no evaluation is required. Varies with frequency – example: below 50 W at VHF.
- Relocating antennas is one way to reduce RF exposure
- Also, regardless of the exposure evaluation results, make sure that people cannot come into contact with your antennas – RF burns are painful
- ARRL Web site resources for RF Exposure Evaluation; www.arrl.org/rf-exposure

Thresholds for Exposure Evaluation

- If the TX power to your antenna is less than the levels shown in Table 9.5, on the frequencies that you operate, then no evaluation is required. [T0C03]
- RF Exposure Calculator, http://hintlink.com/power_density.htm

Table 9.5
Power Thresholds for RF Exposure Evaluation

Band	Power (W)
160 meters	500
80	500
40	500
30	425
20	225
17	125
15	100
12	75
10	50
6	50
2	50
1.25	50
70 cm	70
33	150
23	200
13	250
SHF (all bands)	250
EHF (all bands)	250

What type of radiation are VHF and UHF signals? (T0C01)

* A. Gamma radiation
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* C. Alpha radiation
* D. Non-ionizing radiation

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* C. 440 MHz
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* B. 1 watt forward power
* C. 50 watts PEP at the antenna
* D. 50 watts PEP reflected power

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What factors affect the RF exposure of people near an amateur radio antenna? (T0C04)

* A. Frequency and power level of the RF field
* B. Distance from the antenna to the person
* C. Radiation pattern of the antenna
* D. All of these choices are correct

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Why do exposure limits vary with frequency? (T0C05)

- A. Lower frequency RF fields have more energy than higher frequency fields
- B. Lower frequency RF fields do not penetrate the human body
- C. Higher frequency RF fields are transient in nature
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Which of the following is an acceptable method to determine that your station complies with FCC RF exposure regulations? (T0C06)

- A. By calculation based on FCC OET Bulletin 65
- B. By calculation based on computer modeling
- C. By measurement of field strength using calibrated equipment
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What could happen if a person accidently touched your antenna while you were transmitting? (T0C07)

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Which of the following actions might amateur operators take to prevent exposure to RF radiation in excess of FCC-supplied limits? (T0C08)

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* C. Increase the duty cycle
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How can you make sure your station stays in compliance with RF safety regulations? (T0C09)

- A. By informing the FCC of any changes made in your station
- B. By re-evaluating the station whenever an item of equipment is changed
- C. By making sure your antennas have low SWR
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Why is duty cycle one of the factors used to determine safe RF radiation exposure levels? (T0C10)

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- A. The difference between lowest usable output and maximum rated output power of a transmitter
- B. The difference between PEP and average power of an SSB signal
- C. The ratio of on-air time to total operating time of a transmitted signal
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