

Over Exposure

Complying with the May 3rd 2023 FCC RF Exposure Regulations

Presented to Metrocrest Amateur Radio Society
8/10/2023 by Ron Reeves NN5R

What's the Big Deal?

- What's the problem with RF Exposure?
 - RF Exposure has the potential to cause heating of human tissue
 - If the heating exceeds the ability of the human body to disperse the heat, health can be compromised.
- The FCC updated the RF Exposure regulations
 - Established common regulations regardless of the radio service
 - Eliminated some categorical exemptions
- No Technical Changes
 - Physics hasn't changed
 - RF exposure limits have not changed
 - Your station operation must still comply with the FCC's RF Exposure limits
 - Past methods for performing evaluations are still valid and usable

How is the ham operator impacted?

- You must perform a station evaluation.

The Amateur Radio Service is no longer categorically excluded from certain aspects of the RF exposure rules. Licensees can no longer avoid performing an exposure assessment simply because they are transmitting below a given power level.

- You must repeat the evaluation if you modify your station in a way that affects RF exposure.
- The good news:
 - The average HF / VHF ham station is probably ok – but you must perform the evaluation.

What Documentation is Required?

- Sign Form 610 stating that you will comply with FCC regulations.
- No requirement to submit your evaluation – unless requested.
- Put it into Practice
 - Do the RF Exposure Evaluation for your station operation
 - File the evaluation somewhere convenient – logbook, filing cabinet, computer, etc.
 - If you change something affecting RF radiation, repeat the evaluation.

RF Exposure Safety – Part 1

- RF Exposure Safety is mostly about RF Exposure Density over Time
- RF Exposure Density is a function of
 - RF Power
 - More power = Higher RF Energy = Higher RF Density
 - Modulation Duty Cycle
 - 100% duty cycle modes (FT8, Digital, AM, FM) = More RF
 - Lower duty cycle modes (CW 40%, SSB 20%) = Less RF
 - How often we transmit – Transmit / Receive Ratio
 - More frequent transmission = More RF Exposure
 - Distance from the Antenna
 - RF energy is denser closer to the antenna
 - Antenna Gain and Radiation Pattern

RF Exposure Safety – Part 2

- RF Exposure Safety is also about Frequency
- The higher the frequency, the more biologically damaging the RF Energy

In the case of exposure of the whole body, a standing ungrounded human adult absorbs RF energy at a maximum rate when the frequency of the RF radiation is in the range of about 70 MHz. RF safety standards are generally most restrictive in the frequency range of about 30 to 300 MHz.

Key Terms and Definitions

- ERP
 - Effective Radiated Power – How much RF Power is effectively being radiated? ERP includes considerations for RF loss in the feedline and antenna gain.
- MPE
 - Maximum Permissible Exposure – How much RF in a particular frequency range can the human body take? Expressed in terms of Power Density, and Electric and Magnetic Field Strength. MPE presumes uniform whole-body exposure. MPE applies if the antenna is > 8 inches from the human body.
- SAR
 - Specific Absorption Rate – How fast does a specific element of the human body (tissue, eyes, organs) absorb RF Energy at the specific frequency? A complex topic. Difficult to model. SAR applies if the antenna is < 8 inches from the human body. SAR determination is beyond the skill of most hams.
- PAC
 - Positive Access Control – A fence, locked door, or other active measure to prevent access to overexposure areas. Use of PAC has signage requirements. See the FCC Rules.
- Minimum Compliance Distance
 - How close to the antenna can I be and still comply with the RF Exposure limits?
- Controlled vs Uncontrolled Space

Controlled Space

- You control access to the area – i.e., your fenced backyard.
- Who has access? Your family and the dog.
- You and your family are aware of the RF Exposure risks.
- You know the Minimum Compliance Distance for Controlled Space.
- You can limit your station operation to times when no one is in the Controlled Space.

The Minimum Compliance Distance for Controlled Space is computed over a 6-minute exposure period.

Uncontrolled Space

- You have no control over the area – i.e., your neighbor's side of the fence, public street / alley, your unfenced front yard, etc.
- Everyone has unrestricted access to the Uncontrolled Space.
- The general public is unaware of the RF Exposure risks.
- The general public may not be aware of the RF radiation.
- The general public is unaware of the Minimum Compliance Distance for Uncontrolled Space.

The Minimum Compliance Distance for Uncontrolled Space is computed over a 30-minute exposure period. This is more conservative than for Controlled Space resulting in a longer Minimum Compliance Distance.

Determining the Minimum Compliance Distance

- Use the ARRL Online RF Exposure Calculator – see <http://www.arrl.org/rf-exposure-calculator>
- Do a simple analysis making broad assumptions
 - Assume all your transmitter output power makes it to the antenna
 - Assume there's no power loss in your feedline
 - Use suggested ARRL numbers for mode duty cycle and antenna gain
 - Include the effects of Ground Reflections – it gives you a more conservative result
- The calculator will compute the Minimum Compliance Distance for both Controlled Space and for Uncontrolled Space.

ARRL Calculator Example Data Entry

<http://www.arrl.org/rf-exposure-calculator>

View detailed instructions for each parameter. (opens in new tab/window)

Parameters

- Power at Antenna: (Need help with this?) (watts)
- Mode duty cycle:
- Transmit duty cycle: (time transmitting)
You transmit for minutes then receive for minutes (and repeat).
- Antenna Gain (dBi): (Need help with this?)
- Operating Frequency (MHz):

Include Effects of Ground Reflections

I use max rig power

Higher T/R ratio gives a more conservative result

Click for help

Gives a more conservative result

ARRL Calculator Example Results

← Click here to calculate

Results for a controlled environment:

Maximum Allowed Power Density (mW/cm²):

Minimum Compliance Distance (feet):

Minimum Compliance Distance (meters):

For an uncontrolled environment:

Maximum Allowed Power Density (mW/cm²):

Minimum Compliance Distance (feet):

Minimum Compliance Distance (meters):

The base of the j-pole antenna is on my roof roughly 14' above the ground and 8' above the top of my head.

I can be 2.6' away from the antenna and still be compliant. My 6' tall family can stand directly under the antenna (8' away) and I'm compliant to both the controlled and uncontrolled distances.

The antenna is about 12' laterally inward from the side of the house. The minimum straight-line distance to a 6' tall person standing in my driveway leaning against my house is about 14.4'. I'm compliant.

Nirvana – No one can get close enough to my 2m antenna to be overexposed.

Run the Calculator - Examples

1. A 2m J-pole (gain 3) on the roof of the house driven by a 45w FM rig (100% modulation) with a 2-minute transmit / 10-minute receive ratio. (2.6' / 4.4') (Controlled Space / Uncontrolled Space)
2. A ground-mounted trap vertical operating on 40m (gain 1.5) driven by a 100w rig on CW (40% modulation) with a 2-minute transmit / 10-minute receive ratio (0.5' / 0.8')
3. A 20m dipole at 20' in the backyard driven by a 100w shack-in-a-box on SSB (20% modulation) with a 2-minute transmit / 10-minute receive ratio (0.74' / 1.3')
4. A 20m dipole at 20' in the backyard running FT8 (100% modulation) at 20 watts with a 1-minute transmit / 5-minute receive ratio. (0.52' / 1.2')
5. A 20m dipole at 20' in the backyard driven by a 1000w linear on SSB (20% modulation) with a 2-minute transmit / 10-minute receive ratio (2.3' / 4.0')
6. A 6m dipole at 20' in the backyard driven by a 1000w linear on SSB (20% modulation) with a 2-minute transmit / 10-minute receive ratio (4.9' / 8.5')
7. A 10m dipole at 20' in the backyard driven by a 1000w linear on SSB (20% modulation) with a 2-minute transmit / 10-minute receive ratio (4.6' / 7.9')
8. A 10m 3-element Yagi (gain 8.1) on top of a 50' tower driven by a 1000w linear on SSB (20% modulation) with a 2-minute transmit / 10-minute receive ratio (9.0' / 15.7')

Calculator Results

Minimum Compliance Distance

Case	Band	Antenna	Ant Gain	Height	Pwr	Mode	Duty Cycle	Xmit Time	Rcv Time	Controlled Space	Unc Space
1	2m	J-Pole	3	14' Roof	45	FM	100%	2	10	2.6'	4.4'
2	40m	Vertical	1.5	Ground	100	CW	40%	2	10	0.5'	0.8'
3	20m	Dipole	2.15	20'	100	SSB	20%	2	10	0.74'	1.3'
4	20m	Dipole	2.15	20'	20	FT8	100%	1	5	0.52'	1.2'
5	20m	Dipole	2.15	20'	1000	SSB	20%	2	10	2.3'	4.0'
6	6m	Dipole	2.15	20'	1000	SSB	20%	2	10	4.9'	8.5'
7	10m	Dipole	2.15	20'	1000	SSB	20%	2	10	4.6'	7.9'
8	10m	3-el Yagi	8.1	50'	1000	SSB	20%	2	10	9.0'	15.7'

Evaluate the Results

- Measure out the Minimum Compliance Distance for Uncontrolled Space from your antenna
- If your fence is further out than the Minimum Compliance Distance
 - You're done with the math.
 - Your neighbors and the general public are safe (for that mode / power / TR ratio / frequency / antenna).
 - Talk with your family about RF Exposure – Get your kids into ham radio
 - Protect your family and pets – Don't operate while they are in the backyard
- If the Minimum Compliance Distance is in your neighbor's yard
 - Step 1 – Don't panic
 - Step 2 – Do a more detailed evaluation – Do you really have an RF Safety issue?
 - Step 3 – If you still have an issue, there are solutions

Step 2 – Do a more detailed evaluation

- Usually only necessary when you have a potential RF safety issue.
- Check your data entry and units. Did you enter the right numbers into the calculator?
- Compute how much power is really getting to the antenna
 - Consider power loss in the tuner and in the feedline
- Did you use the most appropriate numbers for
 - Modulation Duty Cycle?
 - Transmit / Receive ratio? Do you really talk that long and that often?
- How much gain does your antenna really have?
 - Consider the antenna's gain at different lobes in its radiation pattern
- Consider the impact of Ground Reflections – it gives you a more conservative result.
- Repeat the evaluation.

Exemption from a more detailed evaluation

- FCC Rules allow for “exemptions” from performing more detailed exposure evaluations.
 - Distance from human to antenna must be $> \lambda / 2 \pi$
 - There’s a table – For 40m, this is 22.1’. For 20m, this is 11.1’.
- Read about this exemption in the RF Safety Chapter of the *ARRL Handbook*
- Understand the FCC Rules before using the exemptions.
- Understand your station’s RF radiation.

There is no exemption from complying with the FCC RF exposure regulations.

Step 3 – How do I limit RF Exposure?

- Suppose you have an RF Exposure Safety issue. What can you do?
- Reduce the RF Power – Can you make the contact with less?
- Reduce the modulation duty cycle – Use a lower duty cycle mode
- Reduce how often you transmit vs receive
- Change operating bands – Lower Frequency = Lower Distance
- Put more distance between the antenna and people / pets
 - Move the fence
 - Raise the antenna higher – Move the antenna out of the attic – Get a tower
 - Move the antenna further from your neighbor's yard
 - Change antennas (Reduce the Gain)
- Limit your operating hours to when you can operate safely (no kids, no pets, and no neighbors within the Minimum Compliance Distance)

It is your responsibility to make sure that no person is ever exposed above the MPE listed in the FCC Rules.

Park and Field Day Operations

- You must evaluate your Park and Field Day operations
- Run the numbers for your favorite modes / power / bands using the antennas you commonly take to the park
- Make a chart of the Minimum Compliance Distances for Uncontrolled Space
- Put the chart in your go-bag
- Setup the antenna so you can watch the Uncontrolled Space
- Use Yellow Caution Tape to keep people out of the Uncontrolled Space
- Raise the antenna so no one can get within the Minimum Compliance Distance
- Be sure someone runs the numbers for your Field Day setup

Gotcha's

- Radials for a vertical ground plane antenna are part of the antenna system. The Minimum Compliance Distance starts at the end of the radial – in addition to the vertical element.
- The counterpoise of an EFHW antenna also radiates RF. The Minimum Compliance Distance applies to the entire antenna.
- The Minimum Compliance Distance for a dipole generally inscribes a large 3d oval around both legs of the dipole including the ends of the dipole – unless you consider the dipole lobes.
- The 2m ground plane antenna on the roof radiates down into your house and may present an unexpected RF Exposure to your family.
- Your head is closer to your attic antenna than you think.

What about my HT?

- The HT is < 8 inches from your head – a localized SAR determination must be made.
 - SAR computations are beyond the skills of most hams
- FCC expects HT manufacturers will perform the test and provide the results / certification to the ham.
- Survey of commonly used commercial HT power levels did not cause overexposure
- A study of SAR measurements of commercial HTs operating just above the 2m ham band with similar output power and rubber duck antennas were below the FCC SAR limits.

Where to go for more information

- ARRL RF Safety page at <http://www.arrl.org/rf-exposure>
- RF Safety section of the *ARRL Handbook*
 - Written by Greg Lapin, N9GL, Chair of the ARRL RF Safety Committee
- May 2023 QST Article by Greg Lapin, N9GL
- FCC OET Bulletin 65 www.fcc.gov/general/oet-bulletins-line
 - Largely written by members of the ARRL RF Safety Committee
- RF Safety section of the ARRL Antenna Book
- ARRL textbook *RF Exposure and You*
 - Out-of-print but available for free download from ARRL
 - Beware – The text regarding the FCC rules is out-of-date