Changes to FCC RF Exposure Rules 2021

How Radio Amateurs Must Evaluate Human Exposure from their Stations Differently Beginning May 3, 2021

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Speaker

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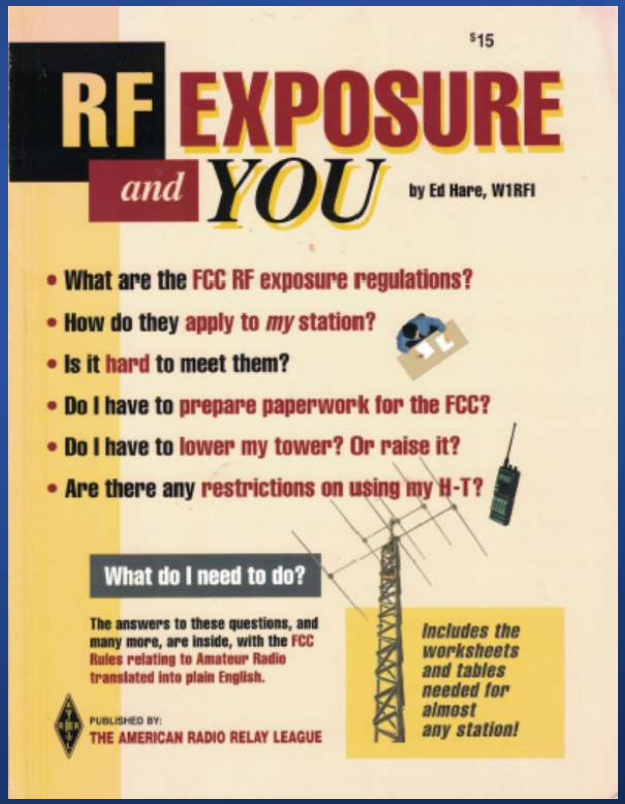
FCC Human Exposure Rules

- Became effective for hams in 1998
  - Radio amateurs were introduced to human exposure limits for the first time.
  - ARRL published ***RF Exposure and You***
  - No longer in print but PDF is available:

    www.arrl.org/files/file/Technology/RFsafetyCommittee/RF Exposure and You.pdf
- Minor rule changes were made in 2013
  - No changes for Radio Amateurs.



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FCC Human Exposure Rules Updates

- New rule changes were published in the April 1, 2020 Federal Register
  - New rules were to take effect June 1, 2020.
  - Changes were delayed to May 3, 2021.
  - Existing stations have until May 3, 2023 to comply.
  - New or changed stations after May 3, 2021 must comply immediately.
- Rule changes to 47 CFR Parts 1, 2, 15, 18, 22, 24, 25, 27, 73, 90, 95, 97 and 101.
  - Amateur Radio Service is affected by Parts 1, 2, and 97.

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What Has Changed

- Amateurs No Longer Have **Categorical Exclusions** to Evaluation
  - Stations with power at the antenna input below certain limits did not have to perform routine evaluations.
  - No mobile transmitters had to perform routine evaluations.
- New **Exemptions** to Routine Evaluation are based on frequency, power and distance.
- All transmitters that are within 20 cm of the body must be evaluated with SAR.
- SAR modeling is accepted in addition to SAR testing.

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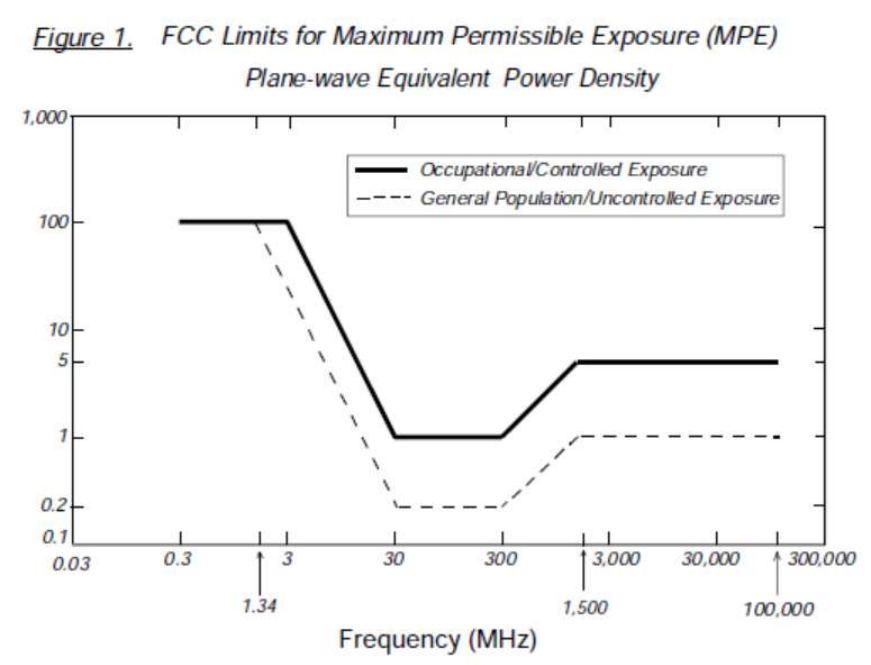
What Has Not Changed

- MPE limits are the same – see graph
- SAR limits are the same:
  - 0.4 W/Kg averaged over the whole body.
  - 8 W/Kg averaged over any 1 gram of tissue.
  - 20 W/Kg averaged over 10 grams of tissue in the hands, wrists, feet and ankles.
- Hams and their families are still considered to be in the Occupational / Controlled Exposure category (including 6 min averaging rather than 30 min).
- Hams are expected to perform their own exposure analyses and **do not have to submit results to the FCC unless asked** (but count on being asked if anyone complains about your station to the FCC).



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Previous Categorical Exclusions in § 97.13(c)

The licensee must perform the routine RF environmental evaluation prescribed by § 1.1307(b) of this chapter, if the power of the licensee's station (in watts at the input to the antenna) exceeds the limits given in the following table:

160 m 500
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
70 cm 70
33 cm 150
23 cm 200
13 cm 250
SHF (all bands) 250
EHF (all bands) 250

Repeater stations (all bands):

non-building mounted antennas: height above ground level to lowest point of antenna <10 m *and* power >500 W ERP

building mounted antennas: power >500 W ERP

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Previous Categorical Exclusions in § 1.1307(b)

- In addition to the exclusions based on frequency band and power:
  - All other mobile, portable, and unlicensed transmitting devices were categorically excluded from routine environmental evaluation for RF exposure.
  - This means that most likely no one measured the SAR of your HT or mobile rig.

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FCC Caveat to Categorical Exclusions

- Categorical Exclusions were meant to simplify the lives of ham radio operators by identifying situations where overexposure is unlikely.
- It should be obvious that it is still possible to have an overexposure situation on a categorially excluded system.
- The FCC has an overriding requirement:

No station is exempt from *compliance* with the FCC's rules and with the MPE limits.

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What the Change Means for Hams

- If you performed an environmental assessment on your station in the past, it still applies and you're done.
- If a **Categorical Exclusion** applied to you and you didn't perform an environmental assessment, you may now need to do so.
  - Categorical Exclusion was based on power entering the antenna for each band.
- **Categorical Exclusions** for hams have been replaced by **Exemptions** for every service.

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What the Change Means for Hams

- All mobile radios were previously Categorically Excluded for hams.
  - That includes handheld radio that are held next to the head.
- The new Exemptions are based on distance from the antenna to the body.
  - Anything less than 20 cm must be measured or modeled with SAR.
  - SAR is very complicated to either measure or model.
  - The SAR Exemptions are only valid for frequencies above 300 MHz.

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New Exemptions

- The new **Exemptions** are based on three things:
  - Frequency
  - Maximum ERP (taking into account feedline loss and antenna gain)
  - Distance between a person and any part of the antenna
  - **Exemptions** do not apply to distances less than $\lambda/2\pi$ (reactive near-field)
- **Exemptions** require less calculation than a full exposure analysis.
- If you don't qualify for an exemption, you can still perform the full analysis, which takes into account T/R duty cycle.

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New Exemptions

RF Environmental Evaluation must be performed if any person will be closer than R meters to any radiating part of the antenna and the **ERP** exceeds the values calculated from the following table:

Frequency (MHz)	Threshold ERP (watts)
0.3-1.34	$1920\ R^2$
1.34-30	$3450\ R^2 / f^2$
30-300	$3.83\ R^2$
300-1500	$0.0128\ R^2\ f$
1500-100000	$19.2\ R^2$

f is in MHz, R is in meters and must be > λ/2π

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For antennas closer than 40 cm to a person, and your frequency is greater than 300 MHz, exceeding the levels in the following formulas determines if SAR Evaluation must be performed:

$P_{th}(mW) = ERP_{20\ cm}(d/20\ cm)^x$ for $d \le 20$ cm

Where $x = -\log_{10}(60 / ERP_{20\ cm}\sqrt{f})$

f is in GHz

d is the separation distance in cm

$P_{th}(mW) = ERP_{20\ cm}$ for 20 cm < d ≤ 40 cm

$ERP_{20\ cm}(mW) = 2040\ f$ for 0.3 GHz ≤ f < 1.5 GHz

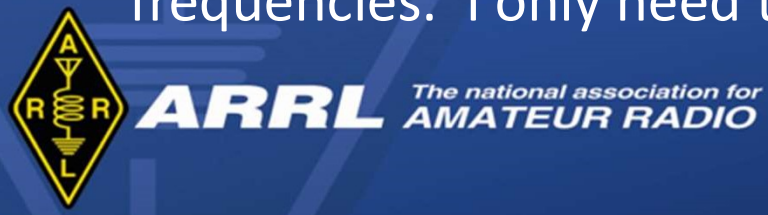
$= 3060$ for 1.5 GHz ≤ f ≤ 6 GHz

An Example Calculation

- I have a multiband (20, 17, 15, 12 & 10M) vertical in my yard.
- There is a sidewalk 15’ (5 meters) away from my antenna.
- I have a 100W transmitter that uses 50’ of RG-58 to feed the antenna.
- To check if I qualify for an Exception, I use the table from the last slide. The same equation applies to all bands on my vertical:

  Maximum ERP = $3450\ R^2 / f^2$

- To simplify, I notice that the allowed ERP decreases most for higher frequencies. I only need to calculate for the top of the 10M band:



An Example Calculation

- First determine my maximum ERP allowed at the top of 10M:

  $3450 \times (5 \text{ meters})^2 / (29.7 \text{ MHz})^2 = 97.8$ watts ERP

- Next determine my ERP:

  ERP = (Transmitter Power - Feedline Loss) x Antenna Gain

  - 50’ of RG-58 at 29.7 MHz has 1 db of loss so 22% of the power is lost.
  - A ground-plane vertical has 0 dBd of gain so the gain factor is 1.0

  ERP = (100W - 22W) x 1.0 = 78W

- The allowed radiated power is 97.8W and my ERP is 78W.
- This antenna qualifies for the Exception!

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An Example Calculation

- If I change anything (antenna position closer to the sidewalk, increased transmitter power, install better coax) I have to recalculate.
- So now, let's try to determine how close I can put the antenna to the sidewalk and still retain my Exception:
- Rearrange my equation:

$$R = \sqrt{(ERP * f^2 / 3450)} = \sqrt{(78 * (29.7)^2 / 3450)} = 4.5 \text{ meter}$$

- So, I could move the antenna half a meter closer to the sidewalk and still be able to claim the Exception.

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An Example Calculation

- What if I can't claim the Exception?
- There are several possibilities:
  - I never use 10M above 28.6 MHz, so recalculate at that frequency.
  - Move the antenna farther away from the sidewalk.
- Or, perform a full evaluation...
  - The Exceptions are very conservative.
  - If I calculate the actual exposure of people on the sidewalk I will find that it is less than the Exception allows for.
  - One large difference is averaging time. If I talk the same amount of time that I listen, then exposure is halved.

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Exemption Minimum Distances (λ/2π)

Exemptions cannot be taken if the distance between the antenna and a human is less than these distances:

160 m (1.8-2.0 MHz) ..... 82.8 feet
80 m (3.5-3.75 MHz) ..... 41.3 feet
75 m (3.75-4.0 MHz) ..... 38.8 feet
40 m (7.0-7.3 MHz) ..... 20.7 feet
30 m (10.1-10.15 MHz) ..... 15.5 feet
20 m (14.0-14.35 MHz) ..... 10.3 feet
17 m (18.068-18.168 MHz) ..... 8.8 feet
15 m (21.0-21.45 MHz) ..... 7.8 feet

12 m (24.89-24.99 MHz) ..... 6.2 feet
10 m (28.0-29.7 MHz) ..... 5.2 feet
6 m (50-54 MHz) ..... 3.1 feet
2 m (140-144 MHz) ..... 1.0 feet
1.25 m (222-225 MHz) ..... 7.8 inches
For higher frequencies, λ/2π is less than 20 cm
SAR Exemption or Testing is required.
70 cm (420-450 MHz) ..... 4.3 inches
33 cm (902-928 MHz) ..... 2.0 inches

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What About the 2M HT?

- The 2M HT is not covered under the new Exemptions:
  - Its antenna is within 20 cm of the head
  - Its frequency is < 300 MHz
- No known SAR tests have been performed with Amateur HTs
  - SAR testing is too complex for most hams to perform.
  - SAR modeling is also too complex for most hams to perform.
- Newly produced amateur HTs will have to be characterized by their manufacturers for SAR.
- Amateur HTs manufactured before the rule change on May 3, 2021 are grandfathered-in.

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How Will Hams Follow the Rules Going Forward?

- The new rules have been released with a 2-year transition period for existing stations.
- The FCC's aids for following human exposure rules: *OET Bulletin 65* and *OET Bulletin 65 Supplement B for Radio Amateurs* are being revised.
- The ARRL RF Safety Committee is working with the FCC personnel to revise these documents.
- ARRL is working on finding or developing tools that all hams can use to perform exposure assessments.

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Modeling

- Three main types of modeling used to predict human exposure.
  - Method of Moments (NEC)
  - Finite Difference Time Domain (FDTD)
  - Finite Element Analysis (FEM)
- Modeling must take into account patterns in:
  - Near Field
  - Far Field
- SAR Modeling must account for energy absorption in tissue.
  - The model must include realistic absorption in the body.

Evaluating Exposure

- The key indicator of exposure is Specific Absorption Rate (SAR)
  - Defined as the rate at which energy is absorbed by tissue.
  - Amount of tissue can be 1 gram, 10 grams, or whole body depending on the type of exposure.
  - Typically measured in W/Kg.
  - Complicated (and expensive) to measure or model.
- Maximum Permissible Exposure (MPE) can estimate SAR
  - Assumption of plane wave exposure.
  - E-field typically measured in V/m.
  - H-field typically measured in A/m.
  - EM power density typically measured in mW/cm^2

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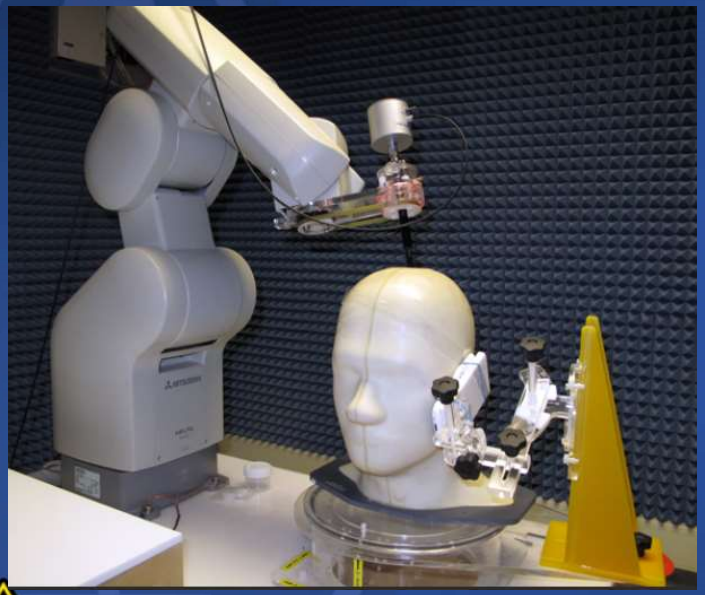
SAR Testing for Mobile Devices



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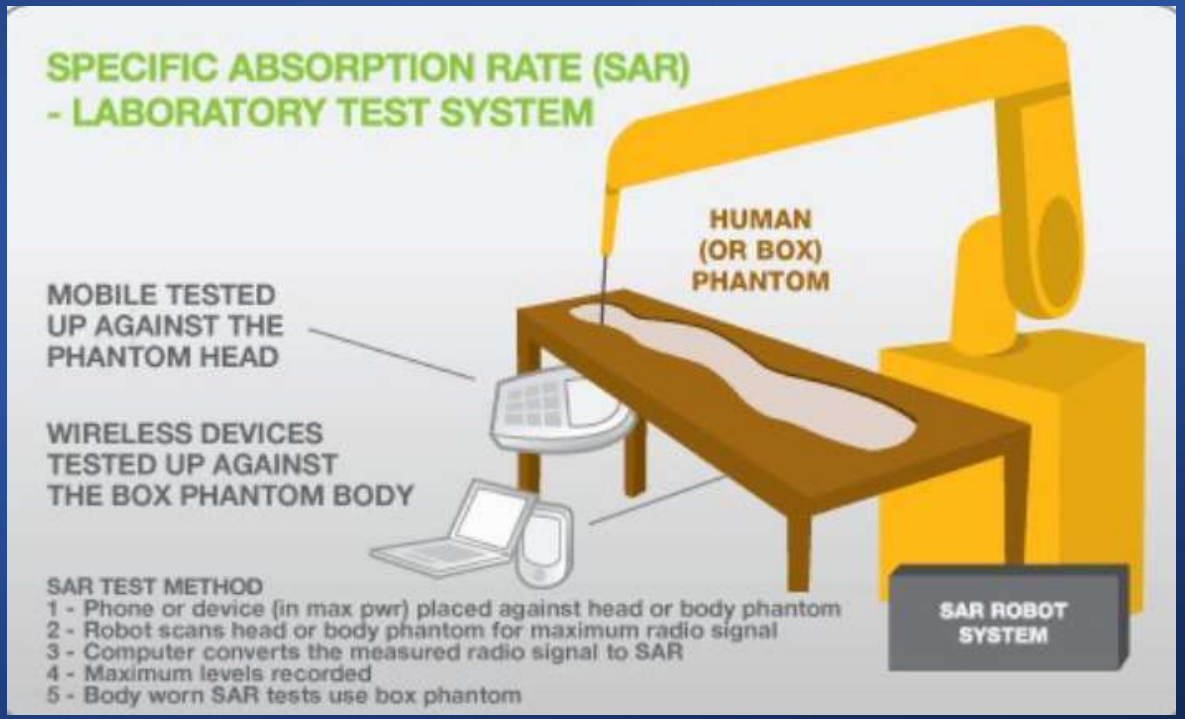
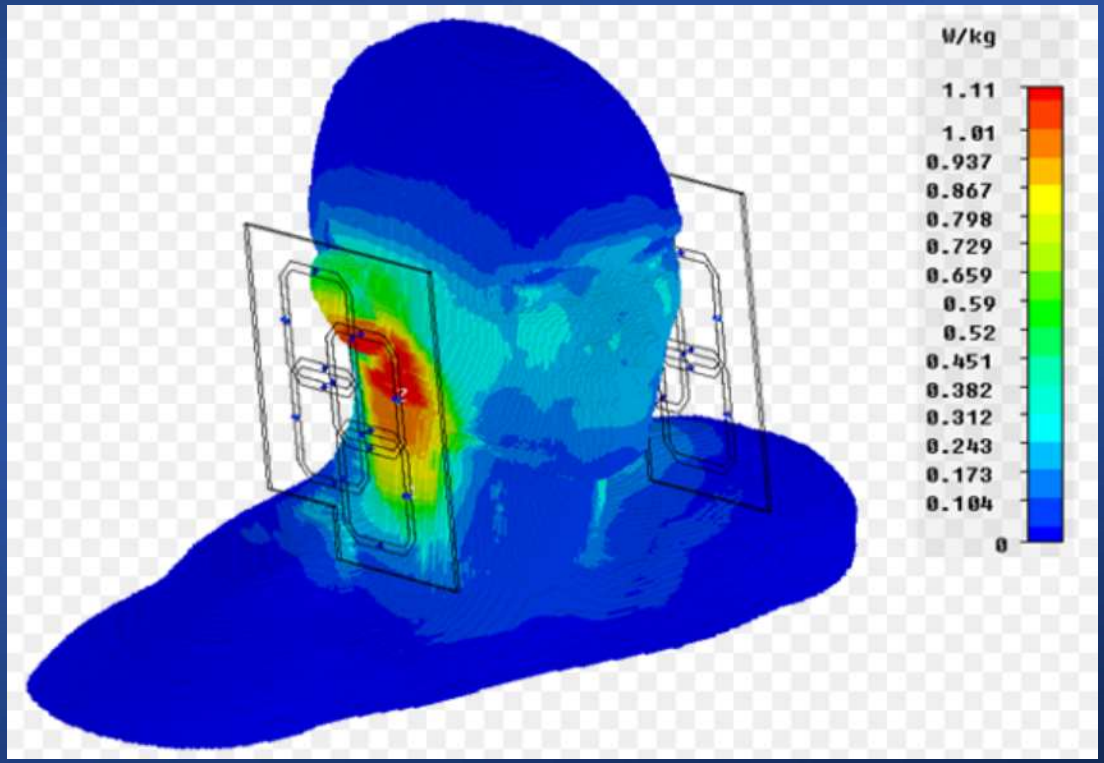


SAR Modeling for Mobile Devices

- FDTD or FEM modeling
- Requires exact antenna configurations.
- Must be repeated for all orientations.



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Some issues with SAR

- If a manufacturer goes to the added expense of testing its HTs for SAR, will they pass that cost on to the consumer?
- SAR tests are specific for a particular antenna.
  - A manufacturer can perform SAR testing with different antennas.
  - If a ham changes the HT antenna to one that was not tested, the SAR results may no longer be valid.
- The RFSC is studying whether existing SAR testing on commercial HTs can be extended to cover HTs in the nearby ham bands.

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Possible Future Changes

- The FCC issued an NPRM last year that is examining other possible changes to the exposure regulations:
  - Addition of Electrostimulation effects at frequencies below 10 MHz as instantaneous values rather than averages over time.
  - Extension of the high exposure limits from 100 GHz to 3 THz.
  - New localized MPE limits above 6 GHz.
- Electrostimulation limits would have the greatest effect on ham radio operations.

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Misconceptions

- From what I've been seeing online, there are a several of misconceptions about the FCC Exposure Rules making the rounds
- The FCC is not trying to stop you from operating.
  - The Amateur Radio Service is a valued FCC Service and they go out of their way to make it possible for us operate.
  - They have classified us as being part of the occupational group, which gives us higher thresholds.
  - They have provided the Exceptions table to allow us to avoid the more detailed assessments for many stations.

Misconceptions

- Equipment (except HTs) does not have to certified.
  - Every ham is responsible for confirming that his or her operating does not cause people to be exposed to RF over the FCC thresholds.
  - There are many options for controlling this. To name a few:
    - mounting your antennas higher,
    - keeping people away from your antenna with ropes or signs,
    - talking for shorter periods of time,
    - lowering your power,
    - pausing your operating when people are known to be near your antennas.

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Misconceptions

- You don’t need any special test equipment to meet the exposure requirements.
  - The only thing that is difficult to measure or model is the antenna that is less than 20 cm from a human.
  - We are working with the FCC to make sure hams do not have to perform SAR tests.
  - If the simple calculations say there is too much exposure, you can perform a full analysis using an available modeling tool, such as EZNEC, to get a more exact solution. Often you will find that no one is exposed above the FCC thresholds when you calculate more exactly.

Summary

- Be prepared to perform environmental analyses on your station.
- Nothing about the evaluation has changed, so if you did it before you already comply under the new regulations.
- You don’t need to worry about the SAR limits for handhelds, the manufacturers will perform the testing when required.
- As always, whether you are required to perform an environmental analysis or not, you must comply with the FCC’s exposure limits.
- Operate safely. Common sense should tell you what to do.

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