RF Exposure Rules 2021

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With a lot of help from
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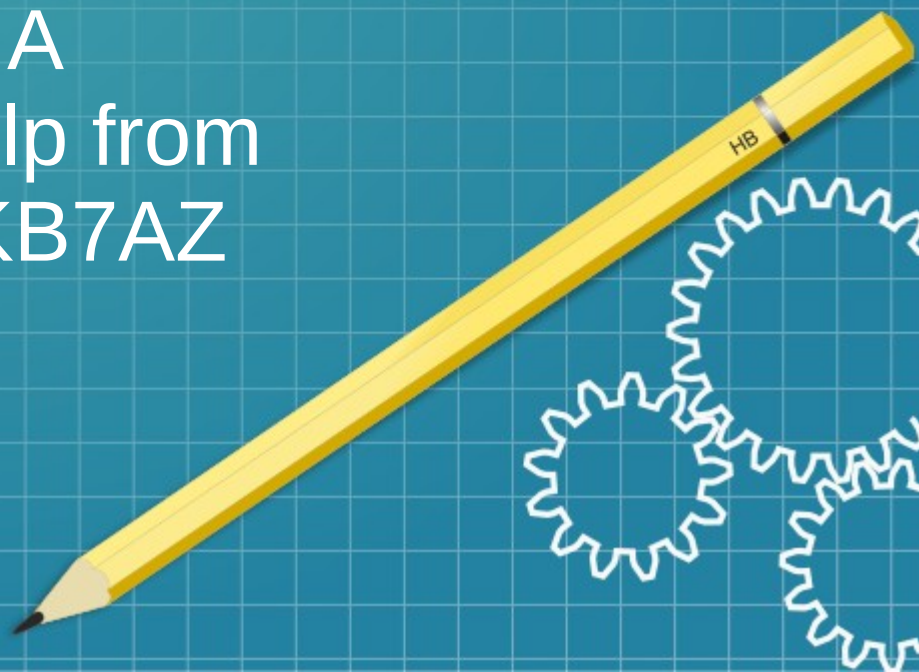


FCC Human Exposure Rules

- Originally released in 1996
- Radio amateurs were introduced to human exposure limits for the first time
- Most amateurs were exempt based on power
- Minor rule changes were made in 2013
- New rule changes were published in the April 1, 2020 Federal Register
- New rules were supposed to take effect June 1, 2020
- Delayed for review
- After review last fall, May 3 was set as effective date

Changes

- Amateurs are no longer categorically excluded from evaluation
- 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 Specific Absorption Rate (SAR) criteria
- SAR modeling is accepted in addition to SAR testing

Definitions

- Maximum Permissible Exposure (MPE) limits are based on IEEE STD C95.1-2019
- SAR limits are the same as the 1979 ruling:
  - 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 considered to be in the Controlled Exposure category
- All hams should perform their own exposure analyses and have it available if asked.
- You do not have to submit results to the FCC unless asked
- Keep your analysis updated and current

Definitions

- **S**pecific **A**bsorption **R**ate
- The time derivative of the incremental energy (dW) absorbed by (dissipated in) an incremental mass (dm) contained in a volume element (dV) of given density (ρ).
- SAR is expressed by the unit of watt per kilogram (W/kg).
- In other words, it is a measure of how quickly the body can dissipate heat that is absorbed from incident RF power.
- **M**aximum **P**ermissible **E**xposure
- Derived from SAR
- Expressed in mW/cm^2

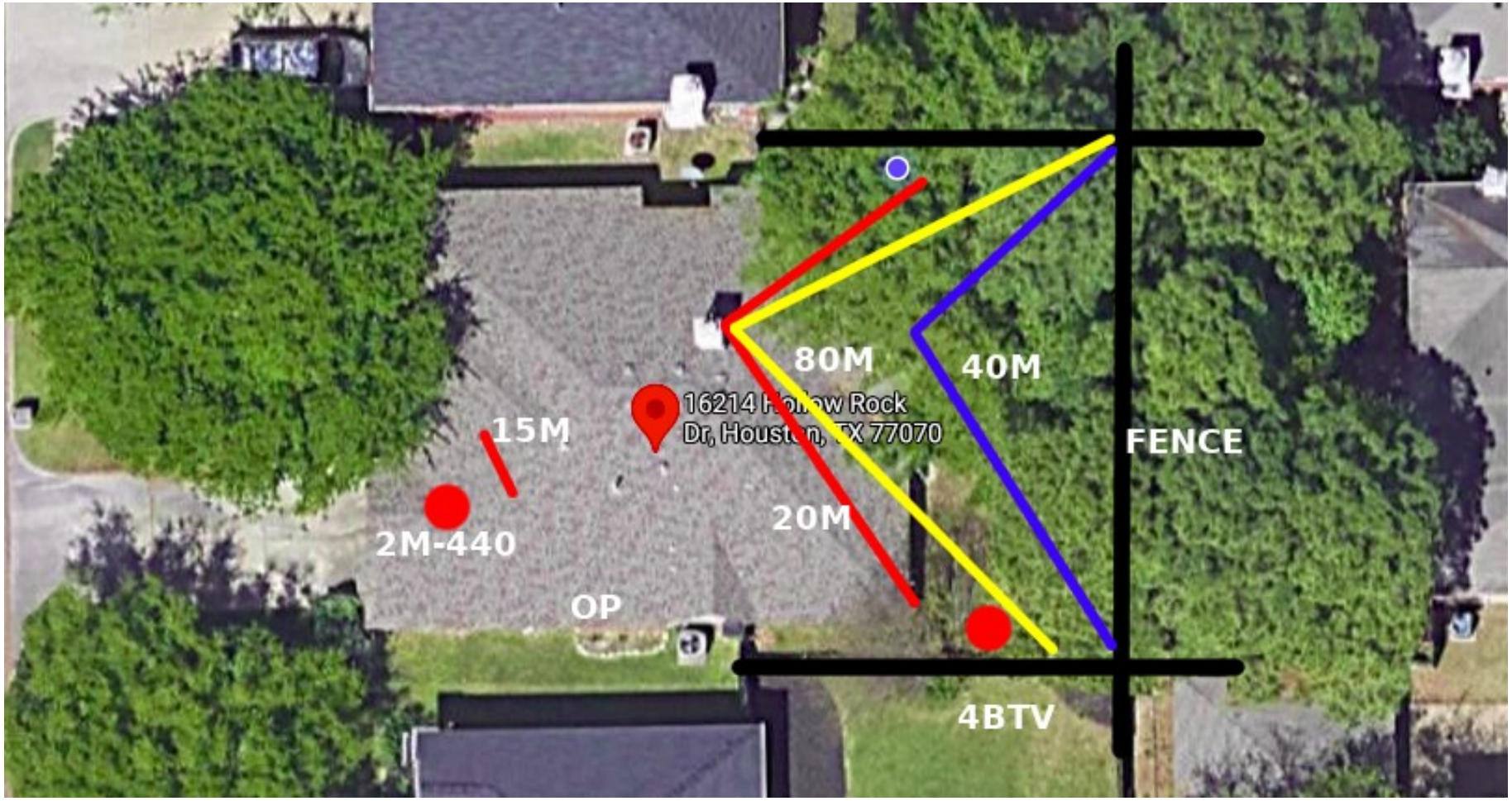
Definitions

- The MPE limits are primarily aimed at laboratory, military, and commercial RF-based installations such as communicationcenters and broadcast stations.
- Controlled environment:
  An area where the occupancy and activity of those within is subject tocontrol for the purpose of protection from RF exposure hazards.
- Uncontrolled environment:
  The preferred term is “general public exposure.” Any area other than a controlled environment.
- The uncontrolled environment includes locations where persons are not made fully aware of the potential for exposure by the owner, operator, or party responsible for the source or cannot exercise control over their exposure.
- **E**ffective Bsotropic **R**adiated **P**ower - the power radiated in a single direction

First Steps

- Document station
  - Transmitter power
  - Feedline length – determines loss factor
  - Connectors
  - Antenna type (gain) and direction
  - Tuner and/or balun losses
- Sketch is helpful

My QTH



Antenna Table

Antenna	Controlled	Uncontrolled
80M Bazooka	15 ft	14.6 ft
40M Bazooka	16 ft	29.1 ft
20M Bazooka	15 ft	30.4 ft
4BTV-80	18 ft	28.2 ft
4BTV-40	18 ft	19.9 ft
4BTV-20	18 ft	19.1 ft
4BTV-10	18 ft	19.3 ft
15M Dipole	11.5 ft	15 .8ft
2M-Ringo	17.8 ft	9.5 ft
440-Ringo	17.8 ft	9.5 ft

Calculate Time Average EIRP

- Start with rated or measured transmitter or amplifier output
- Account for all transmitter-to-antenna losses in dB
  - Feedline
  - Connectors
  - Baluns / chokes / tuners
  - Loss factor = $10^{-(dB/10)}$
- Antenna gain =$10^{(dB/10)}$
- Adjust for duty factor
  - Modulation type
  - Operating habits

Calculate Peak EIRP

- Peak EIRP is a function of the following:
  - Transmitter or amplifier output
  - Decrease for transmission line loss – (loss per 100 ft * length) / 100
  - Decrease for connector losses
  - Decrease for baluns, isolation transformers, tuners. Use manufacturer data or measure.
- Consider Antenna gain (dBi)
  - For RF exposure calculations, use the gain from the antenna radiation center toward where humans could be exposed
  - Start with peak gain, and then apply a decrease as appropriate

Final Exposure Value

- The final exposure value is the incident RF power density averaged over 30 minutes
- Three parameters determine how much to reduce the peak power to derive the average power
  - Modulation type (next slide)
  - Transmit duty factor based on usage (next slide)
  - How much time out of 30 minutes someone would spend in the area while being subjected to the RF field if that time is less than 30 minutes.

Transmit Duty Factor

- The following table shows common transmit duty factor values
- Apply the 30-minute average duty factors to the ERP calculations
- Duty factors are often different for each band
- Adjust for your operating habits

Mode	Instantaneous	Average (30 min)	Your average
SSB	20%	Casual – 10%	
Processed SSB	50%	DX – 5% Contest – 25-50%	
CW	40%	<20%	
RTTY	100%	Contest – 25% Casual – 10%	
AM, FM	100%	Conversation – 10%	
Digital	100%	FT8 – 40%	

Calculate Power Density

- Power density is a function of the following
  - Time averaged RF power at the antenna feed point
  - Antenna gain in the direction of where people could be
    - Peak gain reduced by the off-peak angle
  - Distance from the antenna to where people could be
  - Use the worst case combination of power and duty factor
- S = Power density in watts/m2
  - P = Power at the antenna feed point (time averaged) in watts
  - G = Antenna gain relative to isotropic in the direction of people
    - In linear terms, not dB [linear = 10 (gain in dBi/10)]
  - R = Distance from the antenna radiation center to the location of people in meters

$$S=P \times G/4 \pi R^2$$

Sample Calculation

- Allowable Exposure = 7500 W/m 2 and 3357 W/m 2
  - Time Average EIRP = Feed Power * Peak Gain * Duty Factor
  - Ave EIRP = 913 * 1.64 * 0.2 = 300 watts (Digital Modes 20%)
- Controlled (House) is 60 feet (19.7 meters), 0 dB decreased gain
  - Power Density = 300 / 4 π (19.7) 2 = 61.5 x10 -3 W/m 2
  - Margin = 10 Log (7500 / 61.5x10 -3) = 50.9 dB
- Uncontrolled (Yard) is 36 feet (11.8 meters), 0 dB decreased gain
  - Power Density = 300 / 4 π (11.8) 2 = 171.5 x10 -3 W/m 2
  - Margin = 10 Log 3357 / 171.5 x10 -3 = 42.9 dB

Summarize

- Determine if the power density where people will be is greater than the allowable threshold
- If the threshold is exceeded, then decide on and execute mitigation plan for that case:
  - Limit RF power
  - Move antennas
  - Block access to the antenna area

Exemption

- Exemption means that a particular frequency/power/antenna combination does not require further evaluation
- The new exemptions will be based on three things:
  - Frequency
  - Maximum ERP (taking into account antenna gain) for a particular antenna
  - Distance between a person and any radiating part of the antenna
- Exemptions do not apply to distances less than $\lambda/2\pi$
- If both criteria in the following slides are met, then you do not need to make additional calculations on that particular frequency/power/antenna combination.

Exemption Criteria 1

RF Environmental Evaluation must be performed if any person at any time 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	$3450\ R^2 / f2$
30-300	$3.83\ R^2$
300-1500	$0.0128\ R^2\ f$
1500-100000	$19.2\ R^2$
R is in meters and must be greater than $\lambda/2\pi$	

Exemption Criteria 2

Exemptions can only be taken if the distance between the antenna and a human is greater than these distances (λ/2π):

160 m	82.8 feet
80 m	41.3 feet
75 m	38.8 feet
60 m	29.6 feet
40 m	20.7 feet
30 m	15.5 feet
20 m	10.3 feet
17 m	8.8 feet
15 m	7.8 feet

12 m	6.2 feet
10 m	5.2 feet
6 m	3.1 feet
2 m	1.0 foot
1.25 m	7,8 inches
For higher frequencies, λ/2π is less than 20 cm (7.8 inches) SAR exemption or testing is required	
70 cm	4.3 inches
33 cm	2.0 inches

Exemption Table

Band	Exempt distance	Actual Distance	Threshold ERP	Actual ERP
160 m	82.8 ft		15705 W	
80 m	38,8 ft		3926 W	
60 m	29,6 ft		2146 W	
40 m	20.7 ft		1179 W	
30 m	15.5 ft		700 W	
20 m	10.3 ft`		948 W	
17 m	8.8 ft		190 W	
15 m	7.8 ft		435 W	
12 m	6.2 ft		101 W	
10 m	5.2 ft		36.3 W	
6 m	3.1 ft		35.6 W	
2 m	1 ft		43.1W	
70 cm	4.3 in		64.7 W	

Note that the distances are to the closest radiating part of the antenna, not the center of radiation

Measuring Field Strength

- You can also satisfy the requirements by measuring the E and H field strength
- Refer to MPE Table for controlled and uncontrolled spaces
- Simple E and H field probes - http://kn4s.com/rf.html
- Simple probes and common DVM
- Plans

FCC MPE Table

(A) Limits for Occupational/Controlled Exposure

Frequency Range (MHz)	Electric Field Strength (E) (V/m)	Magnetic Field Strength (H) (A/m)	Power Density (S) (mW/cm^2)	Averaging Time $\|E\|^2$, $\|H\|^2$ or S (minutes)
0.3-3.0	614	1.63	(100)*	6
3.0-30	1842/f	4.89/f	($900/f^2$)*	6
30-300	61.4	0.163	1.0	6
300-1500	--	--	f/300	6
1500-100,000	--	--	5	6

(B) Limits for General Population/Uncontrolled Exposure

Frequency Range (MHz)	Electric Field Strength (E) (V/m)	Magnetic Field Strength (H) (A/m)	Power Density (S) (mW/cm^2)	Averaging Time $\|E\|^2$, $\|H\|^2$ or S (minutes)
0.3-1.34	614	1.63	(100)*	30
1.34-30	824/f	2.19/f	($180/f^2$)*	30
30-300	27.5	0.073	0.2	30
300-1500	--	--	f/1500	30
1500-100,000	--	--	1.0	30

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

Mobile and Portable

Online Calculator

- Simpler than running the calculations for each case
- Available anywhere internet is available
- Some of the basic info is programmed into the calculator
- Author – Vernon Maury, N7OH

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