Understanding the FCC Exposure Rules for Handheld Radios

By extrapolating from the SAR exposure limits of commercial radios, hams can adjust their operations to keep RF exposure in line with regulations.

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Much effort has gone into helping amateurs determine safe exposure distances for HF radios. Along with myriad tools and information, an easy-to-use calculator is available on the ARRL website (**www.arrl.org/rf-exposure-calculator**). However, determining RF exposure from handheld radios presents a different challenge that is less easily addressed.

Under FCC regulations, any exposure from a source between 100 kHz and 6 GHz that is less than 20 centimeters — about 8 inches — from any part of the body must comply with localized specific absorption rate (SAR) limits (see Figure 1). SAR is the truest measure of RF exposure, corresponding to the rate of energy absorption in human tissue. Other methods of determining exposure are estimates and are usually expressed as incident RF power density or, for lower frequencies, as incident electric and magnetic field strengths. Although determining human internal exposure from incident fields is less accurate, it is a more practical prediction method, as field strength is relatively easy to measure and more easily modeled. SAR, by contrast, is extremely difficult to measure or model.

Figure 1 — Most amateur radio operators hold their handheld transceivers about 2 – 4 inches in front of their mouths for best transmission clarity; however, per FCC regulations, any RF exposure from a source between 100 kHz and 6 GHz that is less than approximately 8 inches from any part of the body must comply with localized SAR limits.

How Is SAR Tested?

The most common method for measuring SAR involves a probe making measurements in every 1 gram of tissue (a cube that is approximately 1 centimeter on each side). Of course, inserting probes into human beings is not practical, so SAR measurements are typically made in "phantoms" made of materials that mimic the electromagnetic properties of tissue. Computer modeling of SAR is possible but highly complex, as the model must account for the electromagnetic properties and spatial distribution of all types of tissue found in the body. Manufacturers whose products require FCC certification spend a lot of money testing SAR, and given the expense and complexity, this testing is not feasible for the radio amateur.

In the US, cell phones and commercial handheld radios are tested for SAR, but amateur radio transmitters, with the exception of certain commercially manufactured external power amplifiers, are not included in these requirements. Testing is intended to confirm that the transmitter conforms with FCC regulations for power output, spurious emissions, and human exposure; however, amateur radio operators have the right to use modified equipment, which would annul any certification. For instance, when you buy an amateur handheld radio, you can easily change the antenna, which is likely to change the parameters of exposure. As a result, the FCC determined that transmitters intended for radio amateurs do not need certification, but they are still required to comply with all FCC regulations, including RF exposure to the licensed operators and the people around them.

So, if amateur handheld radios aren't being tested for SAR, how is an amateur supposed to conform with the exposure regulations? Ric Tell, K5UJU, had the idea to compare commercial handheld radios, for which SAR testing is required, with similar amateur radio handhelds. This is a reasonable approximation — manufacturers are unlikely to design entirely new radios for amateurs but rather make small modifications to their designs for use in the commercial space and in the amateur radio spectrum. In a study of the FCC certification database, Ric characterized commercial radios

for their SAR exposure levels at or near the amateur 2-meter (144 – 148 MHz), 1.25-meter (222 – 225 MHz), 70-centimeter (420 – 450 MHz), and 33-centimeter (902 – 928 MHz) bands. Tell outlined his findings in his July/August 2021 *QEX* article, "Amateur Portable Radios (Handheld Transceivers): Exposure Considerations Based on SAR."

Duty Cycle

Human RF exposure is assessed as a time-averaged value. The FCC limits for amateurs are based on the time average of the instantaneous exposures over a 6-minute period. Thus, if a radio's instantaneous exposure is double the FCC limit but transmission occurs for less than 3 minutes over any 6-minute period, the time-averaged exposure complies with the FCC limits.

SAR measurements of handheld radios for FCC certification are typically based on a 50% transmit cycle, with the expectation that a person using a handheld radio generally talks for half the time and listens for half the time. However, if the amount of time talking is decreased appropriately, virtually any transmitter can be used in compliance with FCC exposure regulations.

FCC exposure regulations give licensed radio amateurs a lot of control over their own exposure. Even if a given handheld radio exceeds the SAR limits extrapolated from commercial radios, the knowledgeable amateur operator can tailor the times that transmissions take place so that the 6-minute time-averaged SAR is less than the FCC limit.

Determining Handheld RF Exposure

You can make reasonable estimates of SAR exposure by extrapolating from tested commercial handheld radios to the exposure of untested amateur handheld radios. The test results for many commercial handhelds are summarized in Tell's *QEX* article. If you know the SAR exposure from a commercial handheld radio that is similar to your amateur handheld, then that value can be used. For instance, if the FCC database contains exposure results for a commercial radio made by a given corporation, there is a good chance that the results would be proportional for that corporation's amateur handheld operated at a nearby frequency.

If the results for a comparable commercial radio aren't known, the safest calculation is based on the worst case in the database. In Figure 2 of Tell, SAR results from several radios are plotted as normalized values, with units of W/kg/W (see Figure 2). SAR is measured in W/kg and the normalization is for 1 W of transmitted power at a 50% duty cycle. These values can then be extrapolated to the wattage produced by a particular

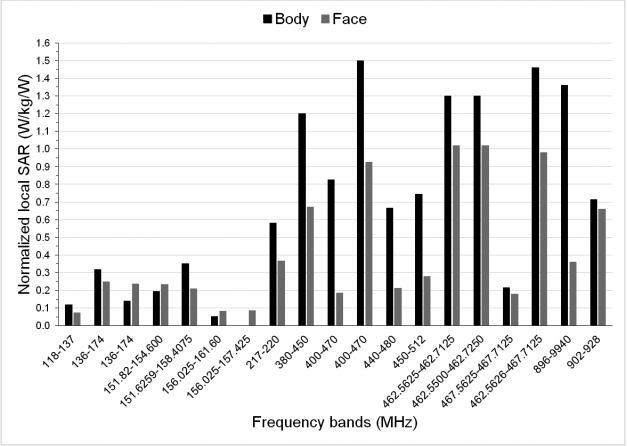

Figure 2 — This graph, from Figure 2 in Ric Tell's, K5UJU, July/August 2021 *QEX* article, "Amateur Portable Radios (Handheld Transceivers): Exposure Considerations Based on SAR," depicts the local 1-gram averaged SAR produced by commercial handheld radios in the FCC's equipment authorization database that operate near or within amateur radio bands. The SAR estimates assume a 50% duty cycle at 1 W.

radio. Table 1 summarizes the reference values that can be used for each band.

The most common value to use, which may be conservative but ensures that you do not exceed FCC limits, is the high SAR. If you have a radio from a manufacturer that does not have entries in the FCC database, you can use the normalized high SAR values of 0.35 W/kg/W on 2 meters; 0.59 W/kg/W on 1.25 meters; 1.50 W/kg/W on 70 centimeters, and 1.35 W/kg/W on 33 centimeters. If, for example, your radio transmits 10 W on these bands, your extrapolated SAR exposure would be 3.5 W/kg on 2 meters; 5.9 W/kg on 1.25 meters; 15.0 W/kg on 70 centimeters, and 13.5 W/kg on 33 centimeters. Because the FCC local SAR exposure limit for a licensed amateur radio operator is 8 W/kg, operating with a 50% duty cycle would conform to that limit on 2 meters and 1.25 meters, but it would exceed the exposure limit on 70 centimeters and 33 centimeters.

Controlling Your Exposure

There are three general actions that you can take to ensure that you're keeping exposure levels below the FCC limit:

1. **Lower your power**. Most handheld radios can be programmed to transmit different power levels. Some give a choice of two power levels (Hi and Lo) or three levels (Hi, Med, and Lo). The power outputs associated with those levels vary by manufacturer and radio model, but using the handheld radio at lower power levels is one way to operate within the exposure limits.

Table 1 — SAR Reference Values

Amateur Band	Number of Reference Radios	Low SAR (W/kg/W)	High SAR (W/kg/W)	Mean SAR (W/kg/W)	Median SAR (W/kg/W)
2 m	6	0.05	0.35	0.19	0.17
1.25 m	1	0.59	0.59	0.59	0.59
70 cm	9	0.21	1.50	1.02	1.20
33 cm	2	0.71	1.35	1.03	1.03

2. **Move away from the transmitter**. You can also use your handheld radio farther away from you. One way is to place the radio more than 20 centimeters, or 8 inches, from any part of your body, holding it farther away or placing it on a nearby table; you can operate it from even farther away with a remote speaker-mic. Another way of distancing yourself from the source of exposure is to replace the handheld's antenna with a transmission line to a standalone antenna more than 20 centimeters away. You can still hold the radio in your hand, but your exposure will be from the antenna, which is now farther away. In both cases, you can calculate exposures using incident fields, such as what is done by the ARRL Exposure Calculator.

3. **Limit your talking time**. You can limit your exposure by reducing the duty cycle of your transmission. The SAR values listed in the FCC database are based on a 50% duty cycle, or 3 minutes of talking over a 6-minute period. Your talking time does not have to be consecutive — it is the sum of all the time that you talk during any 6-minute period.

To calculate the maximum amount of time that you can talk over 6 minutes, start with the tested SAR limit that you are using — either from Table 1 or from the values reported to the FCC from a similar radio — multiplied by the power you will be transmitting and multiplied by 2 to account for the 50% duty cycle used to obtain that tested SAR value. Divide that value into the local SAR limit (8 W/kg) and multiply that fraction by 6 to give you the maximum number of minutes that you can transmit in a 6-minute period.

$$M = \frac{8}{S \times P \times 2} \times 6$$

where
M = Maximum transmit time (minutes)
S = Tested SAR (W/kg/W)
P = Power (W)

Table 2 — Maximum Talk Time per 6-Minute Period

Band	5 W	10 W	15 W	20 W
2 m	Unlimited	Unlimited	4.6 minutes	3.4 minutes
1.25 m	Unlimited	4.0 minutes	2.7 minutes	2.0 minutes
70 cm	3.2 minutes	1.6 minutes	1.1 minutes	0.8 minutes
33 cm	3.6 minutes	1.8 minutes	1.2 minutes	0.9 minutes

Using a 10 W radio as an example, you could talk on 2 meters for the entire 6 minutes without exceeding the exposure limit; on 1.25 meters, you could talk 68% of the time, or for 4 minutes out of every 6 minutes; on 70 centimeters, you could talk no more than 27% of the time, or 1.6 minutes out of every 6 minutes, and on 33 centimeters, you could talk no more than 30% of the time, or 1.8 minutes out of every 6 minutes. Time limits for 5, 10, 15, and 20 W for each of these bands are shown in Table 2.

With the recent availability of low-cost amateur handheld radios with increased power output levels, the question of excessive exposure has been raised. But by using the existing SAR test results for similar commercial radios, a reasonable estimate can be made about the resulting exposure from these radios. Even for radios that exceed FCC SAR limits, modifications to operating procedures can keep your exposure levels within acceptable limits.

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