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VIA ECFS

May 7, 2021

Marlene H. Dortch, Secretary
Federal Communications Commission
45 L Street NE
Washington, DC 20554

Re: ET Docket No. 19-226 Human Exposure to Radiofrequency Electromagnetic Fields and Reassessment of FCC Radiofrequency Exposure Limits and Policies
Notice of *Ex Parte* Discussion

Dear Ms. Dortch:

On May 6, 2021, members of the RF Safety Committee (RFSC) of ARRL, The National Association for Amateur Radio, and the Radio Society of Great Britain (RSGB) met by teleconference with several members of the FCC's Office of Engineering and Technology (OET). The RFSC members included Chairperson Gregory Lapin, Richard Tell, Matthew Butcher and Kazimierz Siwiak plus RSGB member Peter Zollman. The OET staff that participated included Martin Doczkat, Kevin Graf, Chrysanthos Chrysanthou, Gulmira Mustapaeva, Robert Acacio, Damian Ariza and Sean Yun plus Alphonso Tarditi from the OET Laboratories.

The purpose of this meeting was to continue the discussion of exposure rule changes that took place on May 3, 2021 and to examine ways that radio amateurs could perform testing or modeling to confirm that they were in compliance with the new exposure rules.

<u>Equipment Authorization</u>

Prior to this rule change, radio equipment used by radio amateurs did not require authorization by the FCC. The ARRL representatives commented on how important that has been to the Amateur Radio Service, as much of the equipment in use is either designed and built by radio amateurs or is commercial equipment that they have modified. For much of the equipment the changes in exposure rules have no effect on their applicability for use. Radio amateurs are capable of either modeling or measuring the radiated fields from their equipment for the purpose of human exposure analysis using MPE thresholds. However, an exception that has arisen in the new rules is the requirement of SAR testing for any equipment used by radio amateurs that is operated within 20 cm of a person.

It was generally agreed that SAR testing is beyond the means and abilities of most radio amateurs. Thus, if an amateur radio operator develops or modifies radio equipment that is operated within 20 cm of the body, we sought to identify alternatives to SAR testing that would still confirm compliance with the exposure limits.

It was brought to our attention that the OET Laboratories had recently revised KDB 447498 D01 DR04, *RF Exposure Procedures and Equipment Authorization Policies for Mobile and Portable Devices*, which is currently under review. We agreed to obtain a copy of this draft document and submit applicable comments on the FCC Electronic Comment Filing System.

A distinction was made between the date on which the rules went into effect, May 3, 2021, and the date by which new equipment authorization testing must occur. On May 3, 2021 all existing transmitting stations were required to conform to the newly enacted rules, with a 2-year transition period for all stations that had been in use, conforming with the previous rules. Equipment that had been authorized under the old rules still retains its authorization without additional testing under the new rules. One class of equipment that is not described by this condition is that used in the Amateur Radio Service, which did not require FCC authorization. We were informed that any radio that was acceptable for use prior to the rule change would remain acceptable under the new rules, even if the same design continues to be manufactured after the effective date of the new rules. This is expected to change when the new guidance for testing goes into effect (i.e., the revision of KDB 447498 to version V07). The expected date for this change is December 31, 2021.

Discussion was held about substituting antennas on a handheld transmitter that had been previously certified to conform to the FCC exposure limits. Replacement of the antenna on an approved device voids the manufacturer's SAR certification unless the exact replacement antenna was also tested, which is not likely. It was mentioned that, theoretically, the larger the antenna the lower the SAR in nearby tissue would be, because the energy is emitted from a larger surface. Thus, if the manufacturer's SAR testing is performed with a small antenna that is found to meet FCC thresholds, then replacement of any antenna that is physically larger should also meet those thresholds. We suggested that this concept could be included in manufacturer testing protocols and then a retesting exemption could be specified for any replacement antenna that meets this condition. No conclusion was reached on this suggestion.

A manuscript, written by Richard Tell, was discussed (a copy of that document is attached to this disclosure). Mr. Tell reviewed the SAR measurements for a selection of existing handheld radios the have antennas external to the radio housing (in contrast to the case of most cellular technology) in the FCC Equipment Authorization database. He concentrated on radios that operated on frequencies near bands assigned to the Amateur Radio Service. His hypothesis was that the radios used in commercial services and in the nearby amateur radio service are virtually identical and that SAR results for one service could be applied to the other service without additional testing. In every case the results indicated that exposure from handheld radios was below the FCC occupational thresholds, to which radio amateurs are held. Even if there are slight variations of exposure levels at amateur radio frequencies, the SAR exposure would be expected to continue to be below the thresholds.

Other Forms of Exposure

Another question was raised about the effect that induced currents in the body would have on the SAR at HF frequencies and below. Induced currents are not quantified in the existing FCC RF exposure rules, but are being considered in an open NPRM, FCC 19-126, which is part of docket EC 19-226. It was confirmed that under the current rules, SAR evaluation is not required for any type of exposure other than those in which a human is less than 20 cm from the antenna.

OET Bulletin 65

There was not sufficient time to discuss changes in the exposure rules that would require modifications to OET Bulletin 65 and its Supplement B. We agreed to schedule a subsequent meeting at which this topic would be addressed.

Conclusion

We thank the Commission and OET staff for setting aside the time to meet with us to help make sure that radio amateurs are able to comply with the exposure rules that have been codified. We look forward to future collaborations in which we can further improve the processes of modeling and testing for compliance of exposure regulations.

This notice is being filed electronically pursuant to Section 1.1206 of the Commission's rules. Please contact me if you have any questions.

Respectfully submitted,

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Amateur Portable Radios (HTs): Exposure Considerations Based on SAR

Richard (Ric) A. Tell, K5UJU

Introduction

In what might have been unnoticed by most hams, the FCC has instituted new rules related to human exposure that went into effect on May 3, 2021 that may now potentially require compliance with limits on specific absorption rate (SAR) (1). This new rule, among others, is a part of what is called the FCC's ET Docket No. 19-226 that changes the way that parties determine and achieve compliance with the Commission's limits on human exposure (2). Of special interest to amateur radio licensees, the new rules no longer necessarily exempt hand-held radio transmitters or handi-talkies (HTs) used by hams from certification that their use will comply with an SAR limit, something that historically has always been a requirement for commercial HTs (those used outside the amateur radio service).

Potentially good news with respect to compliance for hams, however, is the announcement that the FCC will allow a two-year review period for existing operations to come into compliance with the new rules. Namely, licensees of existing facilities and operations will have until May 3, 2023 to achieve compliance. Conversely, all new facilities and operations will be subject to the new rules immediately as of May 3, 2021 with, apparently, no grace period relating to compliance. According to the FCC announcement, it appears that the commission intends to grandfather any equipment that was presumed to be compliant prior to the May 3 date. Since amateur radio equipment has never been required to be certified as to performance, except for certain power amplifiers, it seems reasonable to assume that all existing HTs, the focus of this article, would remain designated as compliant devices. New HTs purchased after the effective date, however, would presumably need to become certified, but any SAR testing, if mandatory by the FCC, might conceptually only become required after some to-be-determined transition period. In summary, amateurs are no longer relieved from compliance with FCC RF exposure rules by exception. Rather the amateur service will now be treated similar to all of the other services regulated by the FCC.

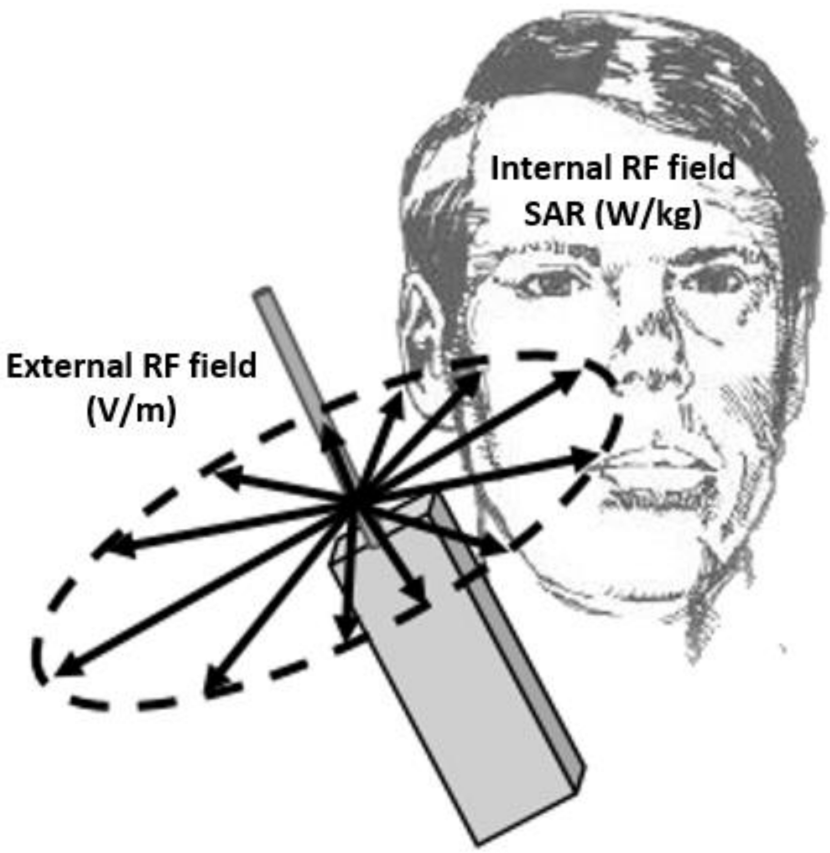
Aside from the question of exactly when operation of a particular HT is expected to comply with the new rules, the whole matter of SAR and how it relates to exposure of the user and others nearby is a complex subject and generally not familiar to most hams. Indeed, the assessment of SAR itself is beyond the capability of the vast majority of licensees. This article helps provide a basic understanding of what SAR is all about and how it relates to the safety of operating equipment, whether hand-held of not, that produces radio frequency (RF) fields. The following presents a simplified explanation of SAR to help in appreciating the complexity of the new FCC requirements as they may relate to controlling SAR.

Background

Fundamentally, RF fields interact with objects in an environment, often inducing RF currents to flow in those objects. If the exposed object is composed of a lossy (absorptive) material, such as human tissue, the induced currents largely lead to heating. If the heating effect is sufficiently robust, associated with very intense RF field strengths, there may be an increase in the temperature of the exposed tissues. Hence, tissue heating is directly related to the strength of the electric field strength within the tissue. The preferred way to quantify this internal heating effect is a quantity called the specific absorption rate (SAR) expressed by the unit watt per kilogram (of tissue) (W/kg). SAR expresses the rate at which an electromagnetic field delivers energy to the subject tissue. SAR is an expression of energy absorption rate because power is the time derivative of energy (1 W is equivalent to 1 joule/second). Thus, an SAR of 1 W/kg is equivalent to an energy absorption rate of 1 joule/kg-sec.

Side bar 1

RF electric and magnetic fields external to the body result in internal electric fields that can produce tissue heating based on the specific absorption rate (SAR)



SAR limits for safe exposure

The FCC RF exposure limits are based on limiting the SAR averaged over the whole body and as averaged over any one gram of tissue. These limits are designed to protect against increases in core temperature of the body and of localized regions of tissue that might result in an adverse health effect. For amateur radio licensees, members of the licensee's household and persons who are occupationally exposed to RF fields, the whole body SAR limit is set at 0.4 W/kg (averaged over the entire body mass) and a local (spatial maximum) SAR limit of 8 W/kg (averaged over any single gram of tissue in the body). For members of the general population (all persons who are not amateur licensees or occupationally exposed), the corresponding SAR values are 0.08 W/kg whole body and a local value of 1.6 W/kg. The FCC RF exposure limits specify maximum permissible exposure (MPE) values of RF fields that exist outside the body that are expressed as values of electric (E) field strength (V/m) and magnetic (H) field strength (A/m) as well as power density (W/m^2 or mW/cm^2). Compliance with the MPEs is intended to ensure that the whole body SAR and local SAR limits within the body are always respected and, clearly, electric and magnetic field strengths in air are much easier to measure (and calculate) than those values inside the body. Because cell phones are used by the general population with no particular expectation they may be exposed to RF fields, the applicable limit is the more stringent SAR value of 1.6 W/kg. HTs used in commercial activities must comply with the less restrictive limit of 8 W/kg.

It should be noted that the FCC in the US references the limit for local SAR to an average over a one gram cube of tissue. The recommended local SAR limit developed by the Institute of Electrical and Electronics Engineers (IEEE) in their IEEE Std™ C95.1-2019 specifies a larger averaging tissue mass of 10 g in the shape of a cube (3). This greater averaging mass has been found to better correlate local tissue temperature increase with local SAR. This same larger averaging mass is also specified in the International Commission on Non-ionizing Radiation Protection (ICNIRP) guidelines widely applied in Europe (4). More about this later.

For RF sources that are sufficiently far from the body, MPE values accurately correlate with SAR. A complicating factor, however, is that a measurement of the E or H fields (or power density) outside the body does not necessarily accurately correlate with the local SAR in tissue *when the RF source is extremely close to the body surface*. This is why the FCC requires all commercially used HTs including cell phones to be evaluated on the basis of local SAR, not MPE, before they are allowed to be sold in the US. As might be suspected, for cell phones as well as HTs, the greatest SAR in the body is usually at the point where the transmitter is positioned. This might be the ear in the case of a cell phone or the front of the face in the case of an HT. During SAR measurements, the transmitter is positioned either in direct contact with the head or other part of the body such as when cell phones or HTs are mounted at the waist. When test laboratories evaluate SAR for common HT use, the HT is positioned at typically 2.5 cm in front of the face, similar to when the HT is held in front of the mouth. A specially shaped phantom is often used for laboratory measurements of SAR, the phantom being similar to a manikin filled with a material that simulates the RF absorption characteristics of human tissue. Cell phone and commercial HT manufacturers must commit to these detailed laboratory measurements for every model of their RF emitting product, revealing the maximum local SAR that can result when the device is operating normally at its maximum rated power. This has led to a gigantic database of equipment certifications resident in the FCC's equipment authorization database[1]. In each testing case, the product is placed in appropriate positions relative to the phantom while miniature probes are robotically moved throughout the interior of the phantom to measure the E field strength. Based on the measured E field in the phantom and the conductivity of the tissue equivalent material filling the phantom, the SAR is determined.

SIDE BAR 2

SAR can also be determined through theoretical analysis but, in practice, cell phones and commercial HTs are always evaluated for SAR using the described laboratory procedures. The analysis approach makes use of the so-called finite difference time domain (FDTD) method, a complex computer based computation wherein the human body is modeled by breaking it into a very large number of small voxels (typically measuring one or two mm on a side), each with an assigned set of electrical properties to mimic the electrical characteristics of human tissues. The computations can take hours to run on super-fast machines with the output data ultimately processed to display local SAR values in a three dimensional fashion.

A challenge for amateur radio licensees

Fortunately, this SAR evaluation process has never before been required for equipment used in the amateur radio service, which can lead to increased costs of equipment. It remains to be seen how these new FCC rules will impact the certification of amateur radio HTs for conformance with the local SAR limit. Just as important, though, is the matter of how amateur radio operators would be able to conclude that their use of a ham HT complies with the relevant SAR limits for the equipment that they currently operate.

Confronted with this challenge, an alternative but practical approach to assessing compliance of amateur radio HTs against the fundamental exposure criterion of SAR is required. This paper suggests that, at this point in time and supported by the extensive database of equipment certifications available from the FCC, most amateur radio HTs already can be expected to comply with local SAR values that underlie the FCC RF exposure rules. For example, the FCC's equipment authorization database represents more than two decades worth of detailed, time consuming and expensive SAR test results for cell phones and commercially used HTs as well as for all kinds of other RF emitting devices that may be used close to the body. It is proposed that this extensive set of SAR certification data can be used to amateur radio's advantage. Of particular interest are the many reports filed in the database on commercial HTs that operate in frequency bands that are extremely close to (or, in some cases, actually within) those authorized for the amateur service. Fortunately, there are several bands allocated for commercial communications that are essentially similar to those used by hams in the VHF and UHF spectrum. For example, the US amateur bands at 2 m (144-148 MHz), 1.25 m (219-225 MHz), 70 cm (420-450 MHz) and 33 cm

[1] https://apps.fcc.gov/oetcf/eas/reports/GenericSearch.cfm

(902-928 MHz) are frequency allocations very close to those used for commercial communications activities and for which SAR evaluations have been conducted.

By examining SAR measurement results for commercial HTs operated in these close-by frequency bands, significant insight can be gleaned on the likelihood of compliance of similar amateur radio HTs despite the fact that the amateur versions of these radios have not necessarily been directly measured for SAR. For instance, say that 2 W commercial HTs that operate just below and just above the two-meter band are found to comply with the SAR limit. It would seemingly be reasonable to conclude that an amateur 2 W HT that operates in the two-meter band would also be found to be similarly compliant.

A practical example

To help illustrate this concept, an example search of the FCC equipment authorization database was conducted of a limited number of SAR certifications; the sheer size of the database begs the question of how much effort would be required to query every certification to determine its relevance to VHF/UHF HT compliance. Ideally, some sort of automated process would be very helpful in sorting through the thousands of reports but that remains to be determined, if feasible, by the FCC. The manual approach to searching the database and extracting relevant SAR data, while extremely time consuming, can, nonetheless, result in helpful insights.

Of great utility, virtually all of the SAR certifications of commercial HTs contained in the FCC database include the results of SAR measurements averaged over both the FCC's 1 g averaging mass as well as a 10 g averaging mass applicable to most markets outside the US. Figure 2 illustrates the results of an initial and limited inspection of the FCC's database for SAR certifications of commercially used HTs across the VHF/UHF spectrum for compliance with the FCC limits. The indicated local SAR values retrieved from SAR reports have been normalized to 1 W and are relative to a duty cycle of 50% based on the push-to-talk (PTT) operation of the HT.[2]

[2] For compliance determination purposes, the FCC applies a presumed duty cycle of 50% for PTT operation of the HT.

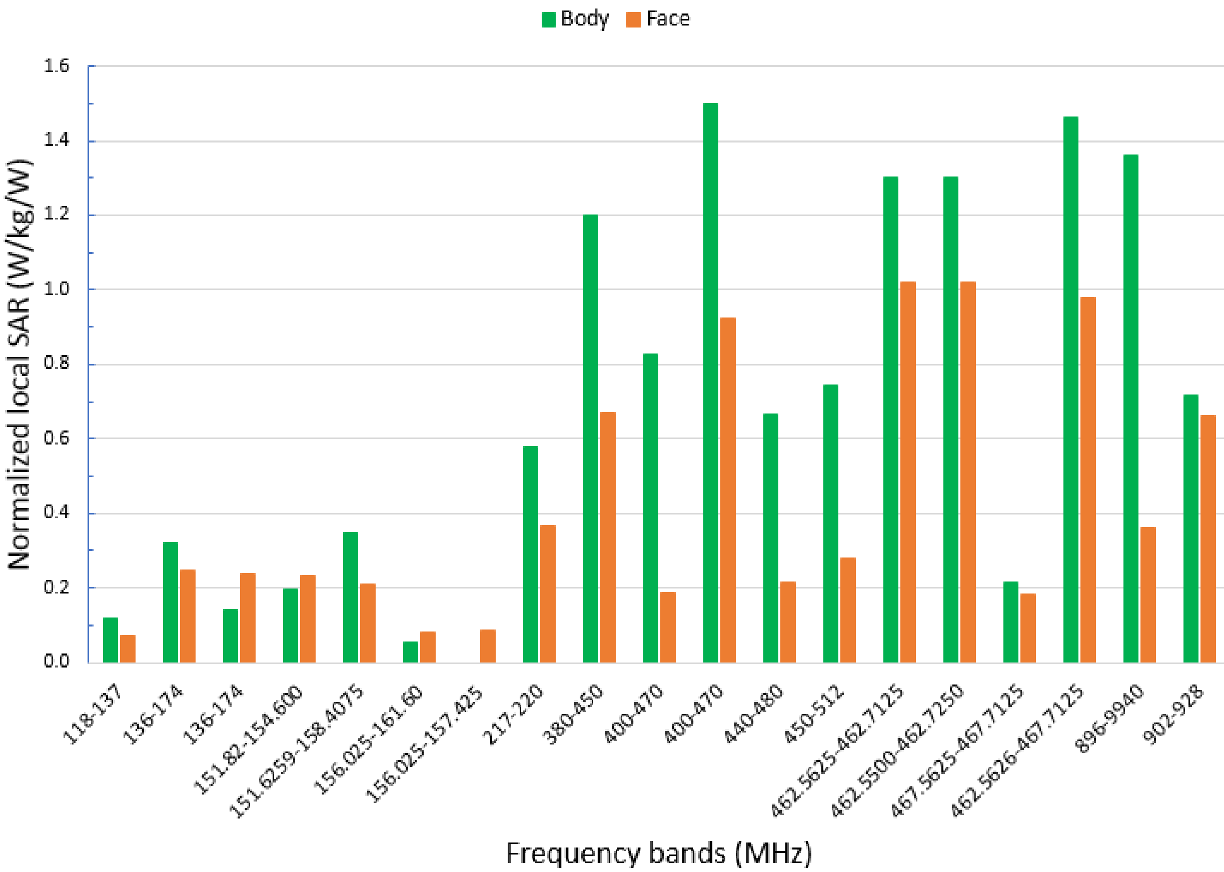


Figure 2. Local one-gram averaged SAR produced by commercial HTs that operate near or within amateur radio bands (based on 50% PTT duty cycle and 1 watt). These data are potentially applicable to US amateurs regulated by the FCC should the FCC require compliance with SAR limits.

Of particular note is the lower normalized local SARs associated with VHF HTs as opposed to those used in the UHF range; the higher frequencies result in a shorter depth of penetration resulting in higher surface region SARs. Also apparent from the data in Figure 2 is the relatively wide margin by which the VHF local SARs comply with the more stringent local SAR required for devices used by the general population, i.e., 1.6 W/kg. The FCC applies the occupational MPEs (and by association, a higher local SAR limit, i.e., 8 W/kg) to amateur radio operators and members of their households. In the US, the application of occupational limits to hams is based on the presumption by the FCC that licensed radio operators have a basic awareness of their potential exposure and are knowledgeable of how to prevent excessive, unsafe exposures.

A practical application of Figure 2 is the extrapolation of the normalized local SARs to a local SAR of 8 W/kg (the FCC limit for amateurs) to determine the power level that would result in 8 W/kg. For example, in the 2 m band, it might be presumed that an HT operating with a power of up to 22.9 W (not realistic for an HT) could be used before exceeding the amateur radio operator SAR limit (8 W/kg divided by 0.35 W/kg/W). For a 70 cm HT, a power of 5.3 W could be used that would just comply with the local SAR limit (8 W/kg divided by 1.5 W/kg/W).

A similar display of normalized local SAR based on an averaging mass of 10 g, rather than just 1 g, is provided in Figure 3. The same attribute of relatively lower local SAR for VHF HTs is apparent, but the actual normalized values are less than those that would result from the smaller averaging mass of 1 g. This characteristic results from the greater volume of tissue over which highly localized points of SAR within tissue may be averaged. The practical upside of this is, obviously, that 10 g averaging allows for higher HT operating powers.

It is also noteworthy that there is a variation in the normalized SAR values, sometimes among different HTs that operate in an identical frequency band. This is likely to reflect differences in the antennas or other accessories that may be used with the specific radios.

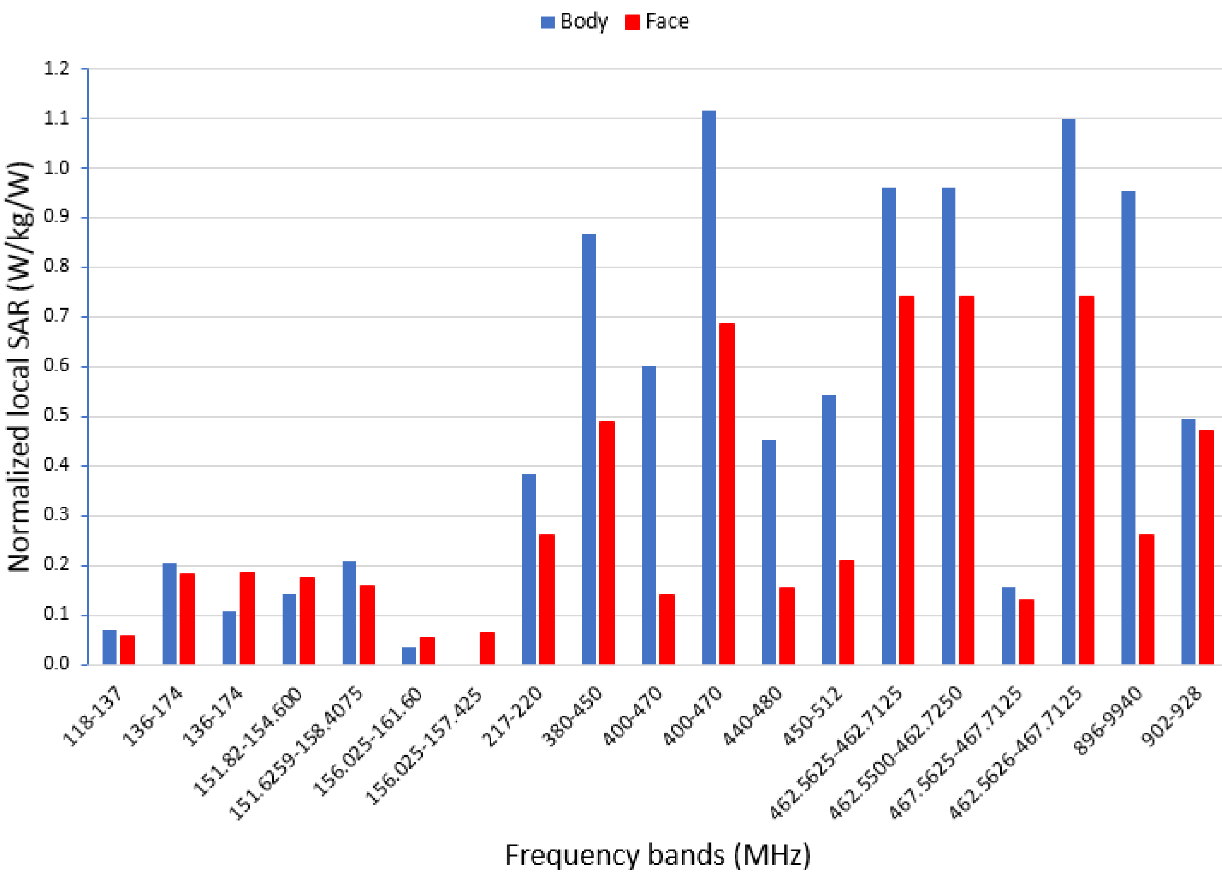


Figure 3. Local ten-gram averaged SAR produced by commercial HTs that operate near or within amateur radio bands (based on 50% PTT duty cycle and 1 watt). These data are potentially applicable to amateurs subject to regulations based on SAR limits as specified by ICNIRP[3].

For hams outside the US who must comply with ICNIRP guidelines, assessing compliance would be based on applying the 10 g averaging mass and on somewhat greater SAR values. For instance, the ICNIRP local SAR limit for occupational exposure is 10 W/kg as opposed to the FCC's 8 W/kg

[3] Whether regulatory agencies in other countries than the US presume a PTT duty cycle of 50% is not certain.

while the local limit for the general public is 2 W/kg as opposed to the FCC's 1.6 W/kg. Hence, the normalized SARs shown in Figure 3 should be extrapolated to a value of 10 W/kg for estimating the maximum HT power that would comply with the ICNIRP occupational SAR limits. This results in greater permissible HT powers than could be permitted with the smaller averaging mass specified by the FCC. Two competing factors are potentially relevant to the HT compliance issue where exposure limits are based on ICNIRP. First is whether hams are considered as members of the general public or whether they are treated as occupationally exposed workers, the public exposure limits being a factor of five more stringent. Second, the greater local SAR averaging mass would help mitigate against noncompliance.

Irregular ham HT configurations and SAR

When reviewing the SAR certification reports in the FCC database, it is evident that the SAR testing procedures can become rather onerous. This is reflected in the multiple configurations of an HT with different antennas, battery packs and other accessories such as microphones and headsets that are each individually evaluated for many commercial HTs. From a ham's perspective, however, this extensive testing process for commercial HTs would seem to help support an argument that common amateur use of third-party accessories such as higher gain antennas, etc., will not materially change the rather clear conclusion that ham HTs would continue to comply with exposure rules requiring assessment of SAR. Of particular relevance, for the HTs identified in this limited exercise, a variety of antenna lengths were found to have often been included in the tests. The results plotted in Figures 1 and 2 encompass the absolute maximum reported local SARs for each HT, regardless of a particular accessory, in the interest of conservatism.

Conclusions

A careful but limited examination of SAR test results available in the FCC's equipment authorization database suggests that HTs commonly used in the amateur radio service would not exceed exposure regulations based on the magnitude of local SARs. This tentative conclusion could be used to support an amateur radio operator's contention that their past use of existing HTs as well as acquisition and use of new HTs complies and will be expected to comply with possible SAR based exposure regulations. Extension of this initial data analysis is recommended to further clarify this conclusion. Operation of relatively higher power HTs could result in exceeding local SAR limits for members of the general population and care should be exercised in permitting unlicensed persons to use such HTs even under the supervision of a licensed control operator.

SIDE BAR 3

In the US, the American Radio Relay League (ARRL) is working diligently toward development of guidance to amateurs to help in their compliance efforts in view of the new FCC RF rules. In this context, the ARRL RF Safety Committee, chaired by Dr. Gregory Lapin, N9GL, (email: n9gl@arrl.org) is monitoring the new regulatory requirements that are applicable to the amateur radio service and working to develop appropriate methods to help hams in their compliance efforts.

Simultaneously, a small group of UK amateurs in the Radio Society of Great Britain (RSGB) and the ARRL in the US has been convening since mid-2020 to collaboratively attack the same issue, i.e., how amateurs can best assert and/or demonstrate compliance with the proposed new RF rules to be administered by Ofcom in the UK and the new changes in how the FCC rules are being applied to hams in the US. For more information on this activity, see articles in RadCom from the RSGB or contact John Rogers, M0JAV (email: m0jav@rsgb.org.uk).

Outside the jurisdiction of the FCC, Ofcom in the UK has announced that it will impose new license requirements for UK hams that are based on the ICNIRP guidelines. The RSGB has developed useful information on this upcoming requirement (5). At this time, however, it remains to be seen exactly how such new regulations might impact UK hams. Interestingly, Ofcom is only concerned with radio operations that cause exposure of the general public, not with the potential exposure of hams themselves. However, Public Health England and/or the UK Health and Safety Executive, separate government entities in the UK, could recommend RF exposure limits that might include exposure limits for hams. Whether any of the possible regulatory provisions in the UK would apply the more permissive exposure limits for occupational exposure to amateur radio operators, similar to the FCC, or the more restrictive limits applicable to the general public, is unknown.

Ric Tell, K5UJU, received his Novice ticket in 1959, first operating with a home brew 7.5 W transmitter during the greatest solar cycle of his life. Eventually achieving an Extra Class license in 1970, his predominant activities have included his professional pursuits in the areas of RF safety, RF instrumentation, antenna analysis, hazard assessments and compliance evaluations. After spending 20 years with the Environmental Protection Agency, he has operated his own scientific consulting business since 1987. His ham radio interests are primarily QRP CW operation and experimenting with antennas. He holds a BS degree in physics and an MS degree in radiation sciences and is a member of the ARRL RF Safety Committee and is a Life Fellow of the IEEE. Ric chairs the IEEE Committee on Man and Radiation (COMAR) and Subcommittee 2 on RF safety programs in the IEEE International Committee on Electromagnetic Safety, Technical Committee 95. He can be reached at rtell@radhaz.com.

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