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Microwave Emissions From Cell Phones Exceed Safety Limits in Europe and the US When Touching the Body

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ABSTRACT In our publications, we have shown both from measurements and computer modeling that the specific absorption rate (SAR) reduces by 10%–15% for every millimeter separation of the cell phone on account of rapidly diminishing EM fields in the near-field region of the cell phone antenna. This rapid reduction of SAR depending on the antenna and its location on the handset has been shown, both computationally and experimentally, regardless of the phantom model such as a flat phantom suggested for SAR compliance testing of devices in contact with the body, for a sphere phantom, and for head-shaped models used for SAR compliance testing of cell phones. Unfortunately, our observations in the past were based on SARs of only three cell phones. Expecting that the SARs for cell phones may exceed the safety limits for body contact, cell phone manufacturers have started to recommend that the devices can be used at 5–25 mm from the body even though it is difficult to see how to maintain this distance correctly under mobile conditions. The National Agency ANFR of France recently released the cell phone SAR test data for 450 cell phones that measure 10-g SARs reducing by 10%–30% for each millimeter distal placement from the planar body phantom. Their data corroborate our findings that most cell phones will exceed the safety guidelines when held against the body by factors of 1.6–3.7 times for the European/ICNIRP standard or by factors as high as 11 if 1-g SAR values were to be measured as required by the U.S. FCC.

INDEX TERMS XXXXX.

I. INTRODUCTION

Safety guidelines for radiofrequency (RF) microwave radiation have been proposed by the expert committees in the United States (Institute of Electrical and Electronics Engineers, IEEE) and by the International Committee for non-ionizing radiation protection (ICNIRP) of World Health Organization (WHO) [1], [2] as well as expert committees in Canada, Japan, Australia, etc. While the guidelines suggested by IEEE are followed by the U.S. Federal Communications Commission [FCC] in Washington, DC, the ICNIRP Standard is followed in Europe and many other countries in the world.

The IEEE safety guidelines followed by the FCC prescribe that the microwave emissions of a personal wireless device be limited to ensure that the mass-normalized power absorbed in any part of the body except limbs (specific absorption rate or SAR) does not exceed 1.6 W/kg for any 1 g of tissue in the shape of a cube [3]. The ICNIRP guideline is more lax and prescribes that the microwave radiation for such wireless devices not create an SAR in any part of the body of more than 2.0 W/kg for any 10 g of tissue. In published literature it has been reported that because of a larger volume for 10 g of tissue the ICNIRP standard will permit radiated powers of cell phones to be 2.5 to 3 times higher than those allowed by the IEEE/FCC standard [4]. The regulatory agency FCC requires that the personal wireless devices marketed in the U.S. meet the IEEE C95.1-1992 standard, thereby requiring lower radiated powers so as not to exceed SAR of 1.6 W/kg in any 1 g of tissue in the shape of a cube for all parts of the body except the limbs (''extremities'' such as hands, pinna, or the legs).

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II. RECENTLY SUGGESTED CHANGES BY INDUSTRY

Whereas the cell phones are often used held against the ear canal or against the body in shirt or pant pockets and are therefore very close to the body, the cell phone manufacturers

TABLE 1. SARs in W/kg measured for some representative telephones held against the flat phantom model of the body at manufacturer-suggested distances D and at distances of 5 and 0 mm as for actual use by consumers (taken from ANFR Test Report [10]).

Make	MODEL	SAR at Mfr. Suggested Distance D	SAR (5mm)	SAR (0mm)	Percent increase in SAR for	
					From D to 0mm	From 5 to 0mm
POLAROID	PRO 881A	1.05 (15 mm)	3.63	7.42	13.90%	15.40%
HTC	ONE SV	0.366 (15 mm)	2.256	7.183	22.00%	26.10%
BLACKBERRY	Z 10	0.934 (15 mm)	3.18	6.8	14.20%	16.40%
MOTOROLA	MOTOLUXE	0.254 (25 mm)	2.96	5.86	13.40%	14.60%
ORANGE	NEVA 80 (ZTE BLADE V770)	1.39 (15 mm)	3.62	5.79	10.00%	9.90%
HUAWEI	P9 (EVA-L09)	1.32 (15 mm)	3.18	5.6	10.10%	12.00%
MOTOROLA	RAZR I	0.507 (25mm)	2.27	5.51	10.00%	19.30%
SONY	XPERIA S CITIZY LT26i	0.748 (15 mm)	2.253	5.45	14.20%	19.30%
APPLE	iPHONE 5	0.825 (10 mm)	1.453	5.321	20.50%	29.60%
SAMSUNG	GALAXY S 5 SM-G900 F	0.545 (15 mm)	1.55	3.55	13.30%	18.00%
ECHO	NOTE	1.35 (5 mm)	1.35	4.15	25.20%	25.20%
APPLE	iPHONE 5C	1.11 (5 mm)	1.11	3.11	22.90%	22.95%
SAMSUNG	GALAXY J7 (SM-J710FN)	1.29 (5 mm)	1.29	3.56	22.50%	22.50%

in the last 5-10 years have started to recommend that they be held 5, 10, or 15 up to 25 millimeters from the body. We assume this additional spacing between the cell phone and the body was recommended because of our past publications that these wireless devices will not pass the safety standards when held against the body on account of the very rapidly diminishing EM fields close to radiating antennas [4]–[7], [10]. In spite of the manufacturer recommendations, we find it hard to believe that one can carry out a conversation when the telephone is held up to 25 millimeters away from the ear canal particularly in crowded noisy environments or that these recommended distances can be maintained consistently under mobile conditions without use of a spacer to maintain the suggested distances of 5 to 25 millimeters.

III. RECENT ANFR (FRANCE) CELL PHONE TEST MEASUREMENTS

On June 1, 2017, the National Agency (ANFR) of France released the cell phone SAR test results on hundreds of cell phones that they had been testing at accredited laboratories since January 2012 [9] using a two-sided version of the IEEE-recommended SAM model or a flat body-simulant model. The ANFR tests differed from regulatory tests in that they measured SARs with separation distances D recommended by individual manufacturers as well as placements that were closer at 5 and 0 millimeter to mimic actual use conditions by consumers holding the wireless device against the body, e.g. in their pockets where SARs higher than the safety limits have also been previously reported by us in peer reviewed published literature [10].

The ANFR test program measured the 10 g SAR called for in the European/ICNIRP standard at three positions of use: the manufacturer-suggested distance D (5, 10, 15, or 25mm) and 5 and 0 mm as for most likely use close to the body (5 mm presumably because of thickness of clothing). A strength of the ANFR results is they have tested 450 cell phones as against our very limited data based on 3 telephones [6], [10]. As the ANFR had tested a large number of cell phones resulting in a very large report [9], we decided to select a limited number of 13 telephones for this paper to illustrate the results. The SARs measured for these 13 selected cell phones are given in Table 1. Shown in this Table is that the telephones give SARs that are within ICNIRP guideline of 2.0 W/kg for manufacturer-suggested distances D (5, 10, 15, or 25 mm), but give SARs that are considerably higher than those of ICNIRP guidelines (by factors of 1.6 to 3.7 times) when the telephones are held against the body to mimic likely actual use conditions. In this context it should be mentioned that the SARs would be even higher by an additional multiplier of 2.5 to 3 or a factor of up to 11 times higher if 1 g values required by the IEEE/FCC standard were measured. All of the 13 selected ANFR-tested devices of Table 1 will not pass the US/FCC safety compliance requirement of 1.6 W/kg for any 1 g of tissue [3]. In the last column of Table 1 we give the calculated increase of SAR per millimeter of reduced spacing for each of the wireless devices from manufacturer-recommended distance D to zero and from 5 mm to zero, respectively. The increase in SAR for each millimeter of proximal placement of the wireless device varies from 10 to 30% which is higher than our previously reported results of 10-15% based on a very limited number—only three cell phones. However the ANFR results do reinforce our additional previously published observations [5] that Standard Anthropomorphic Mannequin (SAM) with tapered plastic

spacer that creates an artificial separation of the wireless device by 6-10 mm will reduce the measured SAR and cannot be trusted as a method for SAR compliance testing. Another thing to observe from the data in columns 4 and 5 is that the SAR is higher by a factor of 2 to 3 for a 5-millimeter closer placement of the wireless device. In [6] we have also proposed this as the reason for a higher SAR for children and for women and men with thinner pinna and skulls resulting in radiating wireless devices being placed closer to the brain in stronger radiated EM fields.

IV. INTERPRETATION OF THE ANFR TEST RESULTS OF TABLE 1

All 13 of the selected telephones of Table 1 fail the SAR requirements mandated by the ICNIRP/European Standard and the US FCC Standard because of the following considerations:

1) The ICNIRP guidelines state that the 10-g SAR for conditions of actual use be no more than 2 W/kg and FCC requires compliance with IEEE Standard C95.1-1991 [1] which is set in terms of 1 g SAR of 1.6 W/kg. It has been shown in peer-reviewed published literature [4], [6] that because of the fairly shallow penetration of RF energy coupled to the tissues, the 1 g SAR is typically 2.5-3 times the 10-g SAR.
2) For cell phones held against the pinna, the measured 1 or 10 g SAR will also be much higher if SAM had not used the lossless artificial plastic spacer in lieu of the tissue-simulant human pinna. As pointed out in [5] and [6], the tapered plastic spacer artificially separates the radiating cell phone antenna by up by up to 10 mm additional spacing for the RF coupled regions of the head resulting in underestimation the 1 g and 10 g SAR by a factor to 2-4. This factor of 2-4 higher SAR is also borne out by the ANFR the ANFR measured results in Table 1 where higher values of SAR are reported in columns 3 and 4 that are for separation distances of 15 and 5 mm respectively.

V. CONCLUSIONS

It is important that safety compliance testing be done under realistic conditions of actual use of the cell phones by the present day users. This should include telephones held close to the body at 0 millimeter spacing and against the tissue-simulant pinna rather than a pinna simulated by a tapered plastic spacer. For the latter, phantom models of the actual users such as children and women and men of smaller head sizes should be used rather than the large head size of Army Recruits used for SAM. The children and women are known to have thinner pinna and skulls which results in closer placements by several millimeters of the radiating antennas to the brain. It is not sufficient for manufacturers to start recommending that the microwave radiating devices be held at distances of 5 to 25 millimeters away from the body to reduce measured SAR to meet the safety standards since these suggested distances cannot be maintained correctly without use of properly attached spacers. Even though ANFR of France has to date released the higher SAR data that does not meet the safety compliance standards when the telephones are held against the body, similar results have also been obtained by independent testing in Canada [11].

Because of the increasing popularity of wireless phones all over the world with use by over 90-95% of populations, it is important that the regulatory agencies in various countries define correct conditions for SAR testing that will cover a majority of users including children.

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