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Comments for the FCC On ET Docket No 13-84 and 03=137

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Introduction

The purpose of these comments are to point out some of the changes in exposure that can occur under the proposed changes in exposure standards form 1.6 W/kg average over one gram to 4 W/kg averaged over ten grams. It is to be noted that examples shown below are likely to be extreme cases that may not occur with any wireless devices now in use. Additionally some data is referenced that shows that peak electric fields from 1.7 to 3.9 KV/cm at 2.7 GHz for 1 micro second at 330 pulses per second can cause cell membrane damage in mitochondria when the calculated temperature rise was less than 4^{o}C. Also see the attached figures for a view of some of the membrane damage that can be caused by short high power pulses.(1)

To start with by increasing the exposure standard from 1. 6 W/kg to 4W/kg the allowed SAR increases by 2.5 times over a larger volume. If we take the density of tissue to be approximately that of water then one gram of tissue is approximately equal to one cubic centimeter and 10 grams corresponds to a little more than two cubic centimeters. To estimate the power that is absorbed we need to look at the absorption coefficient and the geometry of the source and the absorbing body. If we assume a plane wave incident on muscle at 6 GHz the depth of penetration is about 0.8 cm (2). Thus if our 10 grams of material is in a cube 1 centimeter by 2 centimeters deep most of the power would be absorbed in the first O.8 cm so the peak SAR would be multiplied by a little more than a factor of 5 more than the current 1.6 W/kg as we are averaging over twice the volume. Other geometries will give different numbers. At lower frequencies the depth penetration is large and the multiplication factor is smaller. At higher frequencies the absorption depth can become much smaller and the peak power densities can increase by a large factor. It is also to be noted that time division multiplexing leads to higher peak powers. For example for some ultra wide band systems typical pulses may be 2ns long and there may be 15 channels so that a burst of pulses may be transmitted only 1/15 of the times. Thus the peak power may be more than 15 times the average power and lead to peak SAR of 75 times a 1.6 W/kg average.

The current SAR limits are based on limiting an increase in temperature in the tissue to less that is to be expected under normal activity. Resting adults and be expected to generate from 75 to 100 watts of metabolic energy. If we assume a weight from 70 to 100 Kg then we are talking about a watt per kilogram. When exercising we can dissipate several times this amount of energy. The amount of temperature rise will depend on the total input energy the given volume and the rate at which the energy is transferred to other parts of the body and dissipated. The body has an efficient control system for maintaining it close to 37.5^{o}C. However, the proposed change in standards could allow the local addition of RF energy in the example cited above at more 5 times the expected metabolic rate. Depending on the location and exposure pattern it is not clear how much of a temperature rise this would lead to without detailed computer modeling of the antenna location with respect to the body, the transmission pattern, radiated power etc. .

It is to be noted that raising the temperature by 4^o C to 41^{o}C can lead to cell deaths. My experience says that if you have a temperature increase of 2^o C or 39.5^{o}C (approximately 102 F) for a period of hours or more you are quite sick. We also know that the body can sense smaller changes in temperature and many of the chemical reaction rates vary exponentially with temperature. We have measured significant reductions in the velocity of neutrophils at and above 40^{o}C. [3].

There is significant data that indicates biological system can detect electric and magnetic field that are below the levels that are expected to lead to temperature changes that less than 4^{o}C however, it is less clear that these exposures lead to adverse health effects or not. An example of this kind from our lab shows that we can change the direction and approximately double the speed of human neutrophils moving up a concentration gradient of C-AMP with the exposure of these cells to 900 MHz fields of less than a few volts per meter(3). The speed at 37^{o}C was double what we measured at any temperature in the controls with no RF applied. The measured temperature rise in these experiments was less than 0.1^{o}C and calculated to be less than 10^{-4} ^{o}C. These experiments on over 160 cells only worked about 70% of the time. That indicates to me that we had an unknown variable in the system for the students who blood was being tested, such as their stress level or what they had for dinner the night before. This data other data in the literature indicates biological systems can detect and respond to RF signals that lead to temperature rises of less than 4^{o}C.

Lack of an accepted mechanism that goes from the exposure to RF electric and magnetic field through the biochemistry to a biological effect and then on to an adverse health effect may be justification for not lowering the present exposure standards at this time. However, experimental data showing biological changes in cell growth, free radical concentrations etc. may well be sufficient to warrant caution in raising the allowed exposure levels. Even though they are not currently generally accepted by the scientific community there are plenty of theories circulating on possible mechanisms that could turn out to predict possible health effects from RF exposure to low level signal strengths. One of these that may turn out to be significant is the effects of magnetic fields on free radical concentrations. The detailed work required go from the physics to health effects in the presence of multiple feedback loops and repair mechanism to prove or disprove at least one of these theories is likely to some years in the future.

The FCC is presented a classical problem in setting standard in the presence of developing scientific understanding. With any new phenomena the first observed hazards are like to be observed over short times and at high power levels. For example it is clear to me that a peak power limit is needed in addition to an average power limit. We do not want membrane damage as shown in the figure below (1) or the heating that might occur as the frequency goes to 300GHz and the very short depths of penetration. As our understanding of the physics and biology gets better biological effects are likely to be observe at lower levels of exposure and longer exposure times. The question becomes how much of a safety factor do you allow below the power levels known to be dangerous and to what fraction of the public under what conditions. Additionally it needs to make a decision on how much responsibility is placed on the standards and how much is placed on the individual user. To a large degree this is a matter of philosophy. For example we know electricity can be dangerous and the electric chair is clearly not good for your health. On the other hand we distribute electric power at 110V and 220V and expect that public knows that these voltages can be dangerous and will take reasonable precautions. At the same time we have wiring and other standards to protect the public from insulation breakdowns in places where they can see or monitor them. It is clear that short term exposures to the current cell phones, WiFi and base stations, etc. are not leading to immediate health problems for a large fraction of the users. However it is likely that some of biological effects that have been found at SARs below the current exposure levels for repetitive exposure over long periods of time may turn out to lead to health effects under limited set of conditions such as impaired body defense and repair mechanisms, young rapidly growing children and old age with other adverse health conditions

The open question is what are the long term effects and how much of a safety factor should be built into the regulations. This answer is made more difficult as the usage pattern and the exposure levels are changing with each new generation of wireless communications devices.

References

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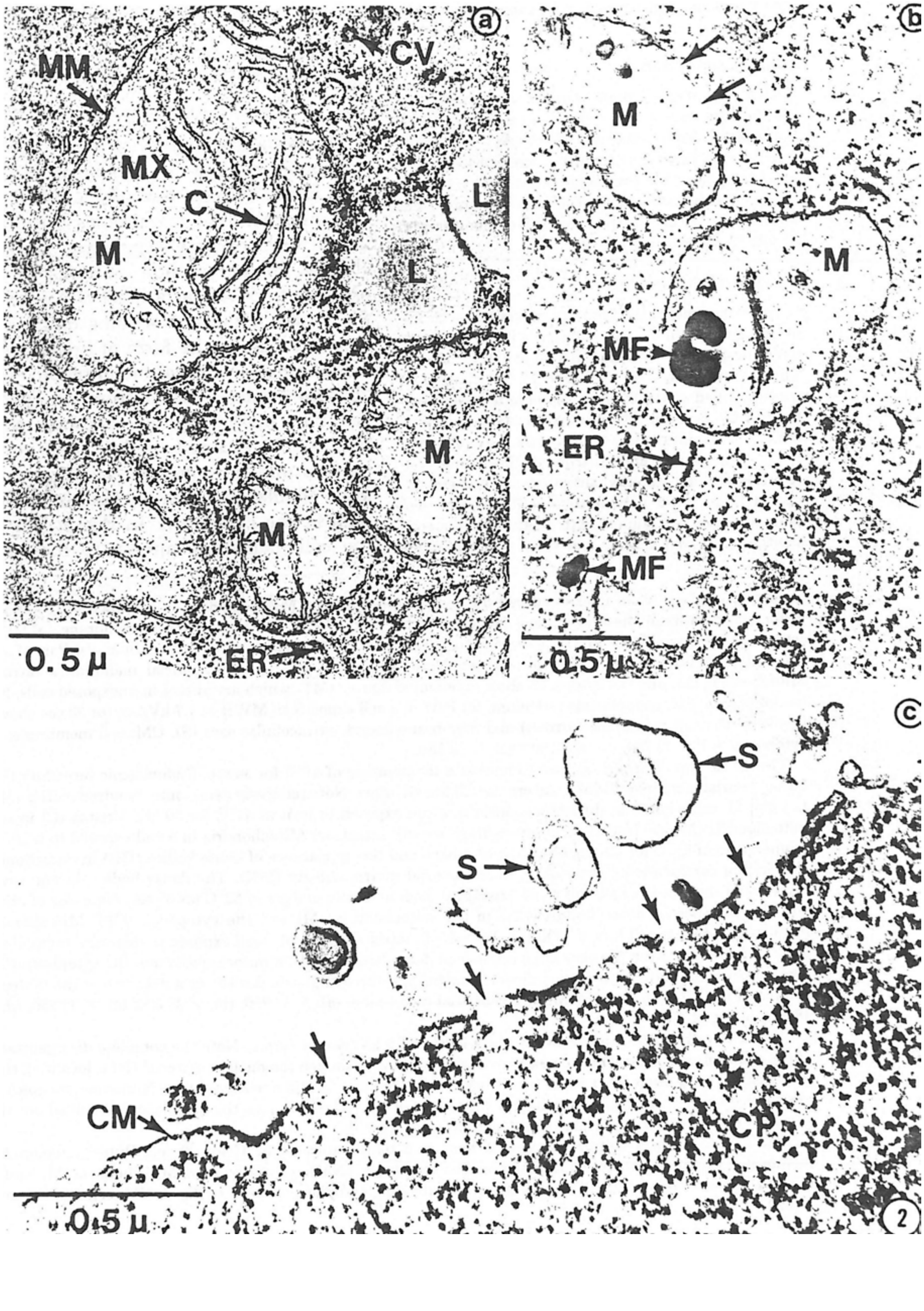
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FIG. 2. (a) Part of an unexposed cell for comparison with the MWR-exposed cells shown in (b) and (c). Mitochondria (M) in these cells have few cristae (C). Note the intact mitochondrial membrane (MM) and relatively dense matrix (MX). CV, C-type virus particles; ER, endoplasmic reticulum; L, lipid. (b) Part of a cell exposed to MWR at 1.7 kV/cm for 30 sec. Note the breaks in the mitochondrial membranes (arrows). Mitochondria (M) and the cytoplasm show myelinated figures (MF) which are absent in unexposed cells. Note loss of cristae. ER, endoplasmic reticulum. (c) Part of a cell exposed to MWR at 1.7 kV/cm for 30 sec showing breaks in the cell membrane (arrows) and membrane-bound, extracellular sacs (S). CM, cell membrane; CP, cytoplasm. (a), × 33 750; (b), × 37 500; (c), × 63 750.