Comment on "A New IEEE Standard for Safety Levels with Respect to Human Exposure to Radio-Frequency Radiation"

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We wish to comment on Dr. James C Lin's recent article entitled "A New IEEE Standard for Safety Levels with Respect to Human Exposure to Radio-Frequency Radiation," published in the February issue of the *IEEE Antennas and Propagation Magazine* [1]. Dr. Lin discusses the recently published IEEE RF safety standard C95.1-2005 [2], developed by the International Committee on Electromagnetic Safety (ICES); specifically, differences between C95.1-2005 and C95.1-1991 [3] and differences between these standards and the 1998 guidelines developed by the International Commission on Non-ionizing Radiation Protection (ICNIRP) [4].

We believe that statements in Dr. Lin's article, such as "...the new IEEE standard [basic restriction] of 0.08 W/kg averaged over the whole body for the general public is based on restricting heating of the body during whole-body exposure" and "...these values were established to protect against tissue heating," are somewhat misleading, and may leave the casual reader with the impression that tissue heating was the sole criterion considered during the revision process. While it is true that the basic restrictions limit temperature increase within the body, other reported effects, so-called "non-thermal" effects, were not ignored. The *entire weight of evidence* was carefully considered during the extensive scientific review that led to C95.1-2005, including the large number of citations in the database reporting effects occurring at exposure levels far below those that would be associated with tissue heating. Low-level ("non-thermal") effects were considered extremely important during the development of C95.1-2005, and a large portion of the informative annexes is devoted to detailed discussions of studies reporting such effects. Such reported effects were not considered established, however, i.e., there were no consistent findings of that effect published in the peer-reviewed scientific literature with evidence of the effect being demonstrated by independent laboratories, and in many cases the effect could not be related to human health. Therefore, the revised standard is not directly based on these studies because the studies fail to meet the criterion that the revision would protect against *established* adverse health effects in humans. ICNIRP reached essentially the same conclusions following their review of the literature that led to their 1998 guidelines [4].

The C95.1-2005 and the ICNIRP guidelines are substantially harmonized and, perhaps more importantly, both are very conservative regarding protection of the public. In his comments, Dr. Lin highlights apparent inconsistencies between ICES C95.1-2005 and the ICNIRP guidelines regarding the relationship between derived incident field limits and the basic restrictions (SAR). These differences are minor and can be attributed to assignment of different factors to account for uncertainties in dosimetry. While the magnitude of the SAR and the averaging mass for local exposure are now consistent between C95.1 and the ICNIRP guidelines, the shapes of the averaging volumes are not. ICNIRP chose "any 10 grams of contiguous tissue;" C95.1-1991 and C95.1-2005 specify an averaging volume in the shape of a cube. (An averaging volume in the shape of a cube is also specified in the European Committee for Electrotechnical Standardization (CENELEC), International Electrotechnical Commission (IEC), IEEE, and other SAR measurement standards.)

Dr. Lin devotes considerable discussion to the basic restriction for local exposure of 2 W/kg and the 10-gram averaging volume in C95.1-2005 and the 1998 ICNIRP guidelines versus the 1.6 W/kg value and 1-gram averaging volume in C95.1-1991. As explained in detail in the rationale of the revised C95.1 standard, ICES increased the peak spatial-average SAR for localized exposure from the 1991 value based upon better biological and theoretical evidence than was available in 1991; the 1991 value was a simple dosimetric extrapolation from whole body values. In support of this change, local temperature increase rather than local SAR is found to be more important biologically, and numerical simulations that take into account factors such as blood flow have shown that in most situations 10-gram averages in SAR track local temperature increases better than 1-gram averages up to about 3 GHz [5, 6]. That is, because of rapid thermal diffusion, small-scale variations in SAR do not necessarily lead to small-scale variations in temperature that are large enough to be biologically significant. Consequently, for the practical exposure situations that ICES considered, there is no biological reason to determine SAR over very small distance scales.

Finally, the relaxation of the SAR value for localized exposure for the pinna to the level of other extremities (e.g., lower leg, lower arm) did not originate in the C95.1-2005 revision, as stated by Dr. Lin, but was introduced in a 2004 amendment to the C95.1-1991 standard following a request by IEEE Standards Coordinating Committee 34 to specifically evaluate the safe threshold of exposure to the ear [7]. Evaluation indicated that since the pinna consists of tissues (mainly cartilage) with heat sensitivity comparable with that of the extremities, and is normally subject to wide temperature excursions without harmful effects, it would be appropri-

ate to follow the same limits as those for the extremities. The amendment resolved an ambiguity relating to conformity assessment.

We hope that these comments are helpful in clarifying issues raised by Dr. Lin's article. The C95.1-2005 standard was approved by the affirmative vote of 96% of the ICES balloting group, and we believe it is based on the best scientific evidence available at the time. The work of ICES is ongoing and future discussion and further scientific studies may lead to further revisions in the C95.1-2005 standard.

References

1. J. C. Lin, "A New IEEE Standard for Safety Levels with Respect to Human Exposure to Radio-Frequency Radiation," *IEEE Antennas and Propagation Magazine*, **48**, 1, February 2006, pp. 157-159.

2. IEEE C95.1-2005, *IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz.*

3. IEEE C95.1-1991, *IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz.*

4. ICNIRP (International Commission on Non-Ionizing Radiation Protection), "Guidelines for Limiting Exposure to Time-Varying Electric, Magnetic, and Electromagnetic Fields (up to 300 GHz)," *Health Physics*, **74**, 1998, pp. 494-522.

5. Robert L. McIntosh, Vitas Anderson, Raymond J. McKenzie, "Observations from Electromagnetic and Thermal Human Body Computational Analysis" (to be published).

6. Akimasa Hirata, Masaki Fujimoto, Takayuki Asano, Jianqing Wang, Osamu Fujiwara, and Toshiyuki Shiozawa, "Correlation Between Maximum Temperature Increase and Peak SAR with Different Average Schemes and Masses," *IEEE Transactions on Electromagnetic Compatibility* (in press).

7. IEEE C95.1-1991, *IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz – Amendment 2: Specific Absorption Rate (SAR) Limits for the Pinna.*

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[The views expressed by the authors are their own and not those of ICES or the IEEE.]

Reply to Letter to the Editor from Chairman Petersen and Vice Chairman Bodemann of IEEE-ICES

It should be noted that statements made in the subject article in my column are factual and do not contain any error. Nevertheless, I thank Chairman Petersen and Vice Chairman Bodemann for their interest and for supplying some of the nuances. Since I do not have access to the yet-to-be-published manuscripts (their references [5, 6]), from which they had quoted, I would refrain from commenting on these items.

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