Why Hardware Developers Should Support Continued Development of RF/Microwave Exposure Standards

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Abstract—Hardware developers often seem to view compliance with exposure standards as a necessary evil to be put off for fear a non-compliant outcome could end a project, or because it is assumed that the device poses no health risk. The public, on the other hand, continues to see health risks in even the lowest power devices, such as cell phones; while simultaneously adopting new technologies. If developers are to maximize the potential benefits of RF/MW technology, they must understand what drives the development of exposures standards, their acceptance by the public, and how they might play a role in improving the standards and their public acceptance.

I. INTRODUCTION

In developing a new RF/MW device or application consideration is first given to the primary function of the device. Somewhat later, electromagnetic compatibility with other devices is considered. Compliance with human exposure standards is seen as a deferrable, step in the development process. What is true is that, in the face of rapid technological development, the exposure standards evolve quite slowly, for example the IEEE C95.1 2005 followed its previous version by 14 years. This process has left a substantial portion of the public believing that they are being exposed to health risks which are not adequately addressed in the exposure standards.

In an environment where funding is project and product driven, most projects cannot pay for collecting bioeffects data which would contribute to a eventual revision of a standard which would benefit many projects. Furthermore, funding agencies seek projects which will improve their record of funding efforts which produce tangible results. Funding a project, which contributes to the bioeffects literature which may someday help the standard to evolve, is not high on their list either. When reminded of the potential benefits to all projects of more precise or even less conservative exposure standards, the response may be “Where are the bodies (reports of injury)?”.

The analogous behavioral trap is a mattress lying in the middle of a busy road. As each vehicle passes it must slow down to get around the mattress. All would benefit if one driver, stopped and removed the mattress. But the cost to that driver is much higher. So no one stops and the group as a whole pays a much higher total cost.

Like the mattress in the road, an overprotective, imprecise or poorly accepted standard leaves no reliable pattern of injury on the passing projects to drive the demand for a better standard. However, as we all know, if the affected projects provide any benefit to the public, then such a standard which reduces that benefit does cause damage. Unfortunately, it is not the sort which leads back to the standard. Thus, we have a behavioral trap in which, the short term benefit of doing no bioeffect research wins over the altruistic strategy of funding bioeffect research which in the long term would lead to better standards and greater public acceptance. How we might move the mattress requires that we consider how standards are developed.

II. HUMAN EXPOSURE STANDARDS

All exposure standards have at their base, two elements. First, some bioeffect threshold which sets the level around which regulations are set. And second, some scientific and statistical assumptions about the population being protected which determines how the threshold is defined and what safety factor is used.

In the RF/MW exposure standards (IEEE Std C95.1™-2005 and the ICNIRP Guidelines), the bioeffects is “work stoppage”. That is, the experimental observation that a trained rat or monkey working for food, will stop working after exposure to a field which produces roughly a one degree Celsius increase in its core body temperature. The animal is not injured and will start working again as soon as its core temperature drops back into the preferred range. There is no known damage, nor is the effect cumulative with repeated exposures.
Fig. 1. Summary of IEEE/ICNIRP whole body basic restrictions as compared to selected bioeffects. The safety margins are between defined limits and work stoppage at a SAR of 4 W/kg.

The statistical assumptions are that the bioeffect is a threshold phenomenon. A threshold is not an absolute number; rather, it is a single number description, such as a mean, of a distribution. Distributions describing a population by definition have no minimum or maximum. In other words, if the population is humans and the measure is height, there is no height below or above which humanity ends. The probability just becomes extremely small as you get farther from the mean (See Fig. 2).

This mean defining the threshold (4 W/kg) was selected using the best data and scientific judgments available. However, another definition is always possible either by selecting a different bioeffect upon which to base the standard, or by the publication of more and better bioeffects data which describes the distribution more accurately. That is, the value of the standard deviation is reduced. This variability indicates that the bioeffect upon which the standard is based may be observed a somewhat lower or higher doses in different individuals. To compensate for this biological variability as well as variability in actual exposure levels, a conservative safety factor is added, in the case of RF/MW standards a factor of 10 for the occupational limit and a factor of 50 for the general public. The lower safety factor for workers is due to their being aware of the exposure, having the benefit of training and an occupational safety program, and making an informed decision to work in the environment. These factors are also a judgment by the standard writers.

The RF/MW safety standard then is a level picked in hopes of protecting the human population based on a reversible bioeffect in animals. Clearly, the standard is protective in that there has been no great accumulation of injured people. But just as clearly, other approaches are possible.

III. OTHER POSSIBLE APPROACHES

Other approaches, may not necessarily increase the permissible exposure, rather, a great benefit would occur if the actual margin of safety between the standard and injury were established and the measure of exposure clearer to the public.

A. A Standard Based on Temperature Change

The established mechanism of RF/MW bioeffects is by heating the exposed tissues. While hardware developers may think in terms of the strength of the field, and bioeffects researchers in terms of specific absorption rate or SAR, neither of these metrics holds much meaning to the public. As a result their perception of 0.4 W/kg, for example, is entirely based on the context of its presentation. The public is used to dealing with temperature, changing weather, setting building thermostats, and cooking. So expressing an RF/MW exposure as a temperature change should communicate much more effectively. Thus, even translating the current standards into temperature changes should further acceptance. Thus, if the 4-W/kg threshold represents a one degree Celsius core temperature increase, the occupational limit of 0.4 W/kg would become a 0.1 degree Celsius increase, and the general public limit of 0.08 W/kg a 0.02 degree Celsius increase. This would also place RF/MW bioeffects data in the same terms as the extensive scientific literature on thermoregulation.

B. A Standard Based on Injury Threshold

In addition to changing the units for expressing the standard, it is also possible to consider changing the phenomenon upon which the standard is based. Most safety standards are based on the minimum exposure to produce injury. In contrast, the RF/MW standard is based on a behavioral change. Thus a single biological effect is used to unify all of the potential exposure parameters under one operational definition. It also uniformly limits the bioeffect to one which will permit self rescue.

An injury based standard makes clear the margin of safety between permissible exposure levels and an injurious exposure. This is in contrast to the behavioral change standard where the safety margin to injury is presumed to be larger, but may never be known.
The primary difficulty for an injury based standard is defining, with the kind of operational uniformity of work stoppage, exactly what constitutes an injury. Indeed, this may not be possible over a board band of frequencies where biological effects range from hyperthermia at the low end of the RF range up to surface burns at the upper end of the microwave range.

IV. SUPPORTING STANDARDS DEVELOPMENT

How can an individual project manager support the continued development of RF/MW exposure standards? Although no single project is likely to have the resources or the immediate need to alter exposure standards, there are a number of ways promote their continued development.

A. Incorporate Exposure Testing in Your Project Plan

Early testing allows more time for a more thorough test and if changes are required, they will be easier and cheaper to make. Plus, by including the assessment team in earlier, you can maximize their ability to prepare the most appropriate tests for your device.

B. Be forthcoming

Don’t hold back information which could make the test more accurate, or the number of frequencies or sources you need tested. Proprietary designs can be safely handled with non-disclosure agreements. Testers tend to err on the conservative side, so you could end up with higher SAR measurement as a result of a rushed test.

C. Let your funding sources know

If your application could be improved by a change or clarification in the standard, or by additional bioeffects data, then by all means let your funding sources know about the opportunity to enhance your efforts.

D. Support Standards Harmonization

Most products or applications of RF/MW technology have potential application in many nations. By supporting harmonization of exposure standards you will increase your market and decrease your safety assessment overhead. This may amount to allowing your testing group to attend standards setting meetings.

E. Funding Bioeffects Testing

1) Dosimetry Modeling: Computational modeling has become quite common not only as part of the development of new sources, but also in the assessment of bioeffects. By incorporating computational modeling into your safety assessment, you may provide additional information on the exposures your device will generate. This will help to focus the testing which could reduce the amount of testing required.

2) Support Testing Infrastructure: The cost of a test for a single device is reduced when the tests can employ test instruments which are repeatedly used. However, this means that the cost of your test must also include some portion of that infra-structure cost.

3) Support Bioeffects Research: Individual projects may not be capable of financing a research project; however, emphasizing the potential benefit of continuing support for bioeffects research, and standards development will pay off in the long term.

V. CONCLUSIONS

Safety assessments are a fact of life in the development of new RF/MW sources. Though they might generally be perceived as a burden by project managers, these assessments can be a positive part of the development process. In addition, the exposure standards which drive these assessments, need your support if they are to be improved through continued bioeffects research and updated to suit the latest technological application.

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DISCLAIMER STATEMENT

The views expressed in this article are those of the authors and do not reflect the official policy of the Department of the Navy, Department of Defense, or the U.S. Government.

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