IEEE Committee on Man and Radiation Home

TECHNICAL INFORMATION STATEMENT ON:

Human Exposure to Microwaves and Other Radio Frequency Electromagnetic Fields

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Notice:

Summary

Although there are many beneficial applications of radio frequency and microwave technology, the Institute of Electrical and Electronics Engineers - United States Activities (IEEE-USA) recognizes that there are concerns about possible health effects associated with exposure to microwaves and other radio frequency electromagnetic (RFEM) fields (3 kHz - 300 GHz) emitted by various facilities and devices. Safety standards, recommendations and guidelines for exposure to radio frequency and microwave energy have been developed independently by a number of international and national organizations including the American National Standards Institute (ANSI) and the IEEE (ANSI/IEEE C95.1-1992). These guidelines have been developed by panels of scientists and medical experts to protect human beings from known harmful levels of exposure to RFEM fields. Based on present knowledge, the IEEE supports the conclusion that exposure at or below the levels recommended in ANSI/IEEE C95.1-1992 is not harmful to human health. The IEEE recognizes, however, that some gaps remain in our knowledge of biological effects. Therefore, the IEEE-USA supports continuing research to ensure the safe use of RFEM energy.

Human beings utilize and depend on devices that generate microwaves and other radio frequency electromagnetic (RFEM) fields (3 kHz to 300 GHz) for their personal, social, and economic well-being. Applications of RFEM energy that are readily recognized include radio and television broadcasting, point-to-point microwave radio (long-distance telephone and data transmission), mobile radio including cellular telephone, paging and radio dispatch, ship to shore radio, amateur radio, and citizen's band radio, navigation (ship and aircraft), and radar (military and civilian use for detection and guidance, flight surveillance around airports, weather surveillance and prediction, traffic speed control). Applications in the home (cooking), industry (sealing and drying), and medicine (diagnosis and treatment) are burgeoning.

The strengths of fields to which most of the North American population is exposed are hundreds of times below current guidelines for safe exposure as recommended by several national and international organizations, with the exception of individuals in some occupational specialties. However, the prevalence of man-made RFEM fields and their relatively recent introduction into the environment have led to concerns about possible adverse health effects. The answer to such concerns lies in rigorous research and objective assessment of laboratory and epidemiologic data.

The IEEE recognizes that the perception of risk is an important aspect of the public's well being, because even the belief that a benign agent poses a danger may have an adverse effect on the believer. The well-known destructive effects of X-rays and other ionizing radiation on biological tissues have led some to a mistaken belief that the effects of non-ionizing RFEM fields might be similar. In reality, the effects and the mechanisms involved are very different. Cumulative irreversible damage can occur in tissues that are continuously or repeatedly exposed to ionizing radiation at low levels. There is no reliable scientific evidence that continuous exposure to low intensity RFEM fields with whole-body averaged energy absorption rates (i.e., specific absorption rates or SAR) less than 0.4 W/kg results in damage, irreversible or otherwise, to biological molecules and tissues.

A large body of data exists on the biological effects of exposure to RFEM fields. Much of this literature describes experimental investigations with laboratory animals, tissue preparations, or cells. There are also several epidemiologic studies. Consequences of exposure to RFEM energy that have been reported in the literature at various exposure levels include effects on behavior, the central nervous system, blood parameters, the immune response, the endocrine system, metabolism and thermoregulation, reproduction, the auditory system and the eyes.

Several standard-setting organizations have evaluated the data on biological effects and have determined that a threshold SAR of about 4 W/kg averaged over the whole body is the level at or above which adverse health effects may occur in human beings. This SAR is equivalent to about 2.5 times the resting energy production rate of the human body. Organizations that have used 4 W/kg as a basis for standard-setting include the ANSI (ANSI, 1982), the IEEE (ANSI/IEEE, 1992), the National Council on Radiation Protection and Measurements (NCRP, 1986), the American Conference of Governmental Industrial Hygienists (ACGIH, 1993), the National Radiological Protection Board (NPRB, 1993), and the International Radiation Protection Association (IRPA, 1993). However, in 1984 the U.S. Environmental Protection Agency (Elder and Cahill, 1984) concluded that:

> the review of the currently available literature on RF radiation provides evidence that biological effects occur at an SAR of about 1 W/kg; some of them may be significant under certain environmental conditions." Therefore, although biological effects may occur at SARs in the range 1 to 4 W/kg, 4 W/kg is the consensus threshold level of potentially harmful effects.

Evaluation of the experimental data on biological effects in laboratory animals does not provide convincing evidence that prolonged RFEM exposure at low whole-body-averaged SARs (0.4 W/kg or less) can be harmful to human health; further, the available evidence indicates that moderate absorption rates (approximately 1 W/kg) can be tolerated by human beings. However, unless properly supervised and controlled in a medical setting, prolonged whole-body exposure at specific absorption rates high enough (e.g., greater than 4 W/kg) to elevate the body's core temperature in excess of 1 degree C should be avoided. The ANSI/IEEE (1992), NCRP (1986) and IRPA (1993) standards and recommendations are based on a SAR of 4 W/kg threshold. Each incorporates safety factors to derive the recommendation that whole-body average exposure levels not exceed 0.4 W/kg in environments designated either occupational or "controlled", or 0.08 W/kg in environments designated either general-public or "uncontrolled". Detailed definitions of controlled and uncontrolled environments can be found in the ANSI/IEEE C95.1 guidelines (1992).

Although individual standards may differ somewhat in the specifics, they generally all converge on similar threshold values of SAR. Some standards also provide data on maximum allowable partial body exposures and criteria for avoiding RF shocks and burns. It should be noted that SAR criteria do not apply to exposures at low frequencies (less than 100 kHz) for which nerve stimulation (shock) occurs, or at frequencies higher than 6 GHz for which surface heating prevails.

The IEEE recognizes the concerns of some industrial workers, engineers, or technicians who work in proximity to emitters of high intensity RFEM fields. Training, engineering controls and work practices can ensure that exposures in the work place do not exceed current safety guidelines. While readily implemented, these practices require surveillance by technically competent specialists to ensure safe operation of such emitters.

The ANSI/IEEE C95.1 guidelines (1992) were developed over a period of nine years by 125 scientists, engineers, and physicians with extensive expertise in the area of RFEM fields and their biological effects. These guidelines were approved by the IEEE in 1991, and were subsequently adopted by the American National Standards Institute (ANSI) in 1992 as a replacement for the previous ANSI RF protection guides (ANSI C95.1-1982). The Federal Communications Commission has proposed (April 1993) using the 1992 ANSI/IEEE guidelines for evaluating environmental RFEM fields created by the transmitters it licenses and authorizes. These guidelines also have gained wide acceptance by other organizations for purposes of evaluating safe exposure to RF energy. The IEEE believes that these guidelines represent the most scientifically based and up-to-date exposure recommendations available.

Although a substantial body of data exists on the presence or absence of biological effects of RFEM, the IEEE realizes that some controversy still remains, and it is generally acknowledged

that the data base is incomplete. Specifically, continuing interdisciplinary research involving medical and life scientists, physicists, and engineers is needed to fulfill the following objectives:

1. To assess the biological effects of intermittent or continuous exposure to weak RFEM fields (capable of inducing SARs less than 0.4 W/kg) over very long time periods (months to years).

2. To determine the comparative biological effects of exposure to continuous wave and modulated (including pulsed) RFEM fields at equivalent power densities and exposure durations, both in the near and far field of the source, and for partial body as well as whole-body exposures.

3. To achieve a better understanding of the mechanisms of reported biological effects of RFEM. Although mechanisms for thermal interaction of RFEM energy with biological systems are well-documented, "low-level" effects have been reported and require verification and sufficient understanding to be able to assess any health implications.

4. To continue research on dosimetry, with the goals of correlating biological effects of RFEM fields with the rates of total energy absorbed, with the distribution of energy absorption within exposed organisms, and with exposure duration.

In summary, since there is a continuing increase in the beneficial uses of RFEM fields, there remains a need for continued research to ensure that human exposures at levels specified in present exposure standards are safe. The position of the IEEE-USA is that there is no cause for concern regarding the environmental levels of RFEM fields to which the general population are routinely exposed. Based on present knowledge, human exposure at or below the permissible levels recommended by the IEEE and other organizations is not harmful to human health.

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