Richard A. Tell
U.S. Environmental Protection Agency
Office of Radiation Programs
P.O. Box 15027
Las Vegas, Nevada 89114

Parker

VIII - B

AN ANALYSIS OF RADIOFREQUENCY AND MICROWAVE ABSORPTION DATA WITH CONSIDERATION OF THERMAL SAFETY STANDARDS

An analysis of existing radiofrequency and microwave energy absorption data has been performed to examine the frequency dependent phenomenon of biological tissue heating. This analysis restricts itself to thermal considerations and examines the exposure field intensities associated with various levels of RF and MW induced thermal loading on both the body as a whole and specific, selectively absorbing tissues in adult humans and infants. An underlying absorption factor of 1W/kg, this being equivalent to the basal metabolic rate for the adult averaged over total body mass, is used for comparative purposes in the analysis. A method of specifying safety standard limits based on the electromagnetic field energy density rather than the plane wave, free-space equivalent power density is presented. The analysis reveals a particularly important resonance frequency range, $10 \leq f \leq 1000$ MHz, in which RF and MW absorption may lead to whole body thermal loads several times the whole body basal metabolic rate for exposures equal to the present safety standard in use in the United States. A discussion is developed for applications of this analysis to occupational environments and short duration exposure conditions. Some implications of this thermal analysis of RF and MW energy are discussed in terms of existing safety standards in use in the United States and the Union of Soviet Socialist Republics (USSR) and to typically encountered exposures in the United States.

AN ANALYSIS OF RADIOFREQUENCY AND MICROWAVE ABSORPTION DATA WITH CONSIDERATION OF THERMAL SAFETY STANDARDS

SUMMARY

This paper discusses an analysis of the existing RF and MW absorption data for man as these data relate to specifying electromagnetic power deposition in tissues of the body. A limiting power absorption rate of 1W/kg for any tissue within the body was assumed as a conservative criterion for the development of thermally based RF and MW radiation protection guides, this specific tissue absorption rate being equal to the basal metabolic rate of a human on a whole body basis. The analysis examines the frequency dependent nature of total body absorption, includes the important information on the distribution of absorbed power throughout the body and determines values of the exposure field intensity corresponding to a maximum possible thermal load of 1W/kg placed on selectively absorbing body tissues or on the body as a whole. Ground plane and body reflection effects which can lead to enhanced power absorption are incorporated in the analysis. Base curves are provided, relating given exposure intensities to thermal loading at both the specific tissue and whole body levels, which may be used for convenient thermal evaluation of safety standards. By describing field intensities in terms of the electromagnetic field energy density the ambiguity

of specifying near field exposure in terms of power density is removed and the importance of the magnetic field component, particularly at low frequencies is taken into account. A method for modification of limiting values is suggested which incorporates the duty cycle of the irradiation field for short term exposure.

The results reveal serious reservations for applying the currently used ANSI standard (5) to the population as a whole in that localized power deposition could, under proper conditions of exposure, apparently lead to substantial thermal burdens in various parts of the body. It is noted that the adoption of more conservative limits would not appear in general to impose undue hardships on existing facilities inasmuch as environmentally encountered RF and MW field intensities are rarely above 4 nJ/m^3.

The formulation presented provides one possible approach to considering limitations on RF and MW exposure of the population. It is founded on a sound base of analytically and experimentally derived dosimetric data for man and uses the fundamentally attractive thermal concept as a basis for describing electromagnetic radiation effects in man.