Energy Deposition in Simulated Human Operators of 800-MHz Portable Transmitters

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Abstract—The measured values of energy deposited in simulated human tissue exposed for one minute in the immediate vicinity of 800 MHz portable radio transmitters are presented. The deposited RF energy was evaluated by temperature measurements. The portable radio used in the tests had a 6-W experimental transmitter operating at 840 MHz. Two different antennas were tested for energy deposition: a sleeve dipole and a resonant whip. The two antennas have given substantially different results indicating different field structures near the two radiators. The experiments with flat slabs have shown that the sleeve dipole deposits higher levels of power density than the resonant whip in the near field although the length of the latter radiator is about half the size of the former. The temperature profiles generated by both antennas inside the head of the simulated operator indicate the presence of a "hot spot" about 1 in below the surface of the temporal bone. This phenomenon was not detected previously at lower frequencies. The short antenna exposes the eye of the operator to more intense power deposition than the sleeve dipole. The temperature increases measured during the investigation are so small that no thermal damage to tissue should be caused by normal use of the portable radio.

I. INTRODUCTION

NEW TECHNOLOGIES are rapidly developing for mobile and portable communication systems at 800-900 MHz. In the near future, a large number of operators are expected to be using equipment at these frequencies, recently made available for communication purposes. The 800-900 MHz band is very close to the frequencies used for medical diathermy (918 MHz). Diathermy applicators at 918 MHz are well known for efficiently depositing energy deep into human tissue. This fact may create some concern about the exposure of the head of a portable transmitter operator, because the radio is held close to the mouth in normal use.

Since previous work [1], [2] had shown that E-field probes do not give reliable information about RF exposure near portable radios, expected power deposition levels in operators have been determined by temperature measurements in simulated humans. Two well-known antennas have been used in the measurements of energy deposition. Both types of radiators are expected to be widely used at 800-900 MHz.

At these frequencies, it was found that commercially available field hazard probes do not read high values of power density at a 2-in distance from portables, as they do at lower bands [1]. However, given the large differences between penetrating power in simulated tissue and E-field probe readings detected at 450 MHz, this experimental investigation was necessary to determine any possible relation between instrument readings and deposition levels. A simple E-field measurement would still be the most attractive way to determine a hazard level, but at 800-900 MHz, this method cannot be used in the near field of a transmitting antenna.

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II. SIMULATED OPERATORS

Two different simulated operators have been used to evaluate power deposition near portable transmitters in the 800-900 MHz band. A flat double layer slab of simulated tissue was employed to investigate the deposition properties of the electromagnetic fields in the immediate vicinity of the antenna. This flat phantom, completely analogous to the one used at 450 MHz [1], is a simple structure which gives results rapidly interpretable in terms of power flow at the surface of the "dummy." As mentioned, the flat phantom is used only for the purpose of investigating the EM fields in close proximity of the radio. Relevant data about the possible exposure of an operator are collected by means of a more sophisticated structure. The phantom operator consists of a real human skull stuffed with simulated brain tissue [3], [4].

The skull is supported by a shell of bone mixture approximately 0.3-in thick and 9-in high, shaped to simulate the contour of the neck and shoulders of the operator. The supporting bone structure is filled with simulated muscle tissue [2]. The skull belonged to a young human adult. It is approximately 6-in high, 6-in wide (cranial index approximately 86), and has a maximum diameter of over 8 in. The "dummy" operator is shown in Fig. 1. The phantom is sealed by stretching a very thin rubber membrane (<0.003 in) over the skull and the first 2 in of the neck. A thin layer (<1 mm) of clear epoxy coating could be used to simulate a layer of skin, if the epoxy were mixed with other materials to obtain the proper dielectric constant and conductivity. The need to introduce a layer of skin on the phantom may arise at higher frequencies (e.g., 2500 MHz), but, for tests at the 800-900 MHz band, the present "dummy" is very adequate. Fig. 2 shows a close-up of the phantom before filling with brain material. The picture gives a good idea of the sealing method.

III. EXPERIMENTAL PROGRAM

An experimental portable transmitter of 6-W radiated power at 840 MHz was used throughout the program. The radio case (with batteries) was 8-in long. The power deposition properties of two different antennas have been evaluated: a

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