Simple Evaluation Method for Human Exposure to Non-uniform Magnetic Fields

Background

Guidelines for limiting human exposure to electromagnetic fields have been developed by several guideline setting bodies *1. In these guidelines, magnetically induced currents inside human body are used as "basic restrictions", that are the value not to be exceeded. Since these internal values are not measurable, equivalent magnetic fields ("reference levels") are derived. In these derivations, the magnetic field is assumed to be uniform while the actual distributions of magnetic fields are highly non-uniform, especially in the direct vicinity of sources of magnetic fields such as electric power facilities and domestic appliances. Therefore, it is not appropriate to apply the reference levels for these situations, and an alternative simple method is desirable.

Objectives

To propose a simple estimation method to investigate human exposure to non-uniform magnetic fields.

Principal Results

1. By investigating scientific literature and existing guidelines, a comparison was made focusing on conversion between induced currents and uniform magnetic fields (Fig.1). The result showed that there exist considerable variations depending on human models and conditions of calculations.
2. A method aimed at comparing with reference levels of guidelines was proposed. In the method, an equivalent uniform magnetic field that produces maximum induced current identical to the actual non-uniform magnetic field exposure, was calculated. At first the normalized induction factor K_J defined below *2 was calculated for several exposure situations (Fig.2).

$$K_J = \frac{\text{Maximum induced current in actual exposure}}{\text{Maximum induced current for uniform magnetic field whose amplitude is identical to maximum in actual exposure}}$$

In the next step, a simple homogeneous spherical model (Fig.3) was introduced to obtain the normalized induction factors. The results showed that it estimates maximums of the factors for precise human model *2 (Fig.2)

3. As a general index to account for non-uniformity of magnetic field, a "magnetic field decay factor" K_B was proposed. The factor is defined as the ratio between minimum and maximum magnetic fields inside the assumed spherical model placed in actual exposure situation. A simple equation ($K_J = K_B^{0.2}$) was obtained to know the normalized induction factors for homogeneous spherical model.

Based on these investigations, a simple and proper estimation method for human exposure to actual magnetic field was obtained.

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Reference

K. Yamazaki, et.al., 2004,"Investigation of magnetically induced current in human body exposed to non-uniform magnetic field", CRIEPI Technical Report T03018 (in Japanese)
K. Yamazaki, et.al., 2005, "Simple evaluation method for human exposure to non-uniform magnetic field", CRIEPI Technical Report H04003 (in Japanese)

*1 : Investigated guidelines are: (1) ICNIRP (1998), (2) IEEE (2002), (3) Health Council of Netherlands (2000).
*2 : The results for precise human model were obtained from a published article, T.D. Bracken et al: "Evaluation of nonuniform 60-hertz magnetic-field exposures for compliance with guidelines", *J. Occupational and Environmental Hygiene*, 1, 629-638 (2004).

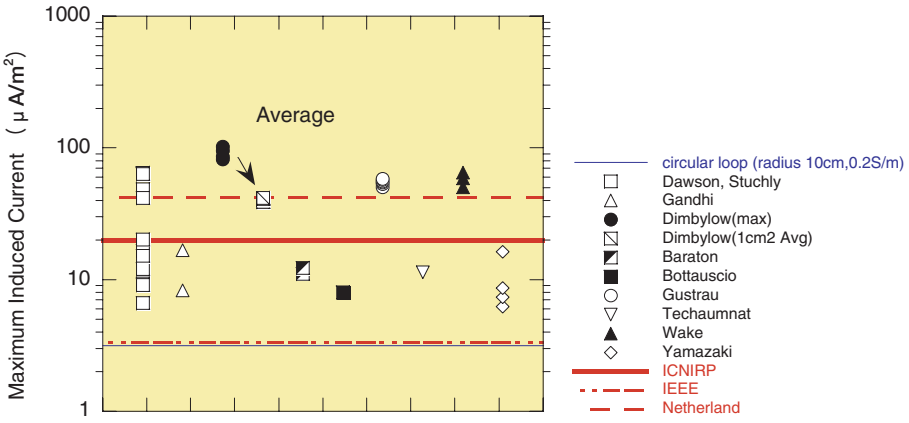

Fig.1 Induced current in human by uniform magnetic field (1 μT, 50 Hz)

Comparison between the results shown in scientific articles and guidelines. Symbols show maximum values. The "average" means averaged value over 1 cm^2 cross section.

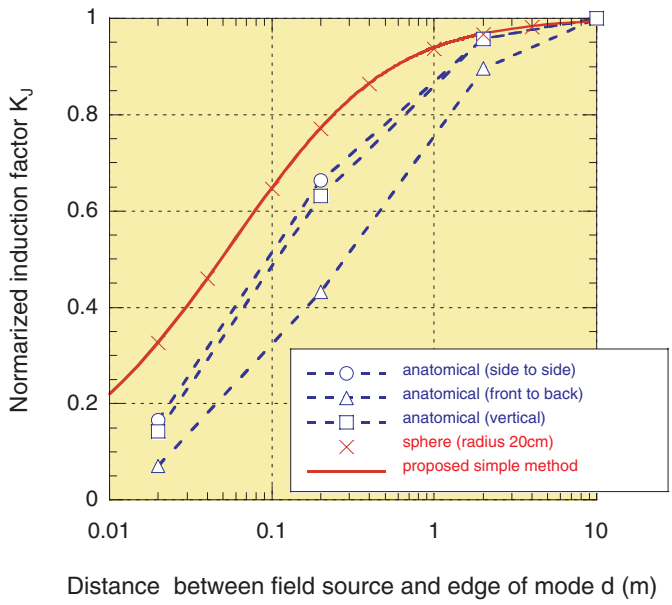

Fig. 2 Normalized induction factors for single line current source

Proposed simple method estimates maximums of the factors for precise human model.

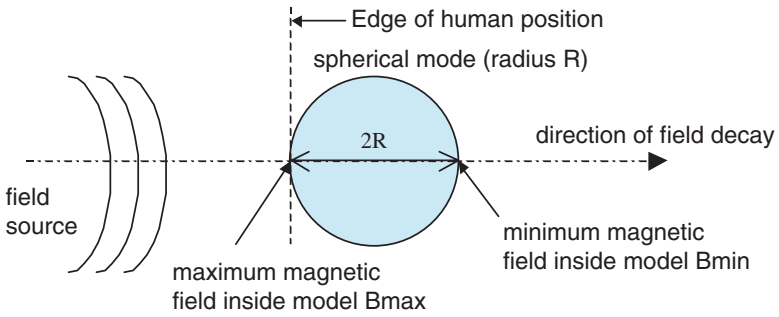

Fig.3 Placement of homogeneous spherical model to investigate non-uniform magnetic field exposure.