Development of simple evaluation method for human exposure to magnetic fields near electric power facilities

Background

Guidelines *1 for limiting human exposure to magnetic fields have been used to judge their safety, and induced currents inside human bodies exposed to uniform magnetic field are the key factor. However, the actual distribution of magnetic fields is highly non-uniform, especially in the immediate vicinity of sources of magnetic fields, such as electric power facilities. For such cases, massive numerical computation of the induced current using an anatomically correct human model is necessary. Therefore, an alternative simple method to investigate conformity with the guidelines is desirable.

Objectives

To develop a simple estimation method and software to investigate conformity with the guidelines, that is applicable to human exposure to non-uniform magnetic fields, such as electric power facilities;

Principal Results

1. Development of investigation method for non-uniform magnetic fields

A simple method using a homogeneous sphere (radius of 20cm) was developed to calculate the induced current inside human bodies exposed to non-uniform magnetic fields *2. It was shown that the maximum (worst case) of the normalized induction factors *2 for a numerically correct human model *3 exposed to practical non-uniform magnetic field exposures, such as near a single line current, a double-line current, and a magnetic dipole, can be estimated by the developed method (Fig.1, Fig.2). By the method, one can easily estimate the induced currents inside human body without conducting conventional massive computations.

2. Compliance testing with guidelines by software based on the developed method

To calculate the normalized induction factor for a human body, software was created based on the developed simple method by incorporating such functions to an existing software that calculates the magnetic fields *4. With the software, the compliance testing with the guidelines can be achieved by multiplying the obtained normalized induction factor by the maximum magnetic field at the space occupied by the human body (equivalent uniform magnetic field) (Fig.3).

Main Researcher: Kenichi Yamazaki, Ph. D.,
Research Scientist, High Voltage and Electromagnetic Environment Sector, Electric Power Engineering Research Laboratory

References

K. Yamazaki, et al., 2005, “Simple evaluation method for human exposure to non-uniform magnetic field,” CRIEPI Report H04003 (in Japanese)
K. Yamazaki, et al., 2006, “Simple evaluation method for human exposure to non-uniform magnetic field: Part II -Verification by induced current calculation using anatomically correct human model,- CRIEPI Report H05005 (in Japanese)
K. Yamazaki, et al., 2007, “Simple evaluation method for human exposure to non-uniform magnetic field: Part III -Application to various exposure conditions and development of EMF integrated tool,” CRIEPI Report H06004 (in Japanese)

*1 : In the ICNIRP (International Commission on Non-Ionizing Ratiation Protection) guidelines, “basic restriction” of induced current inside humans is determined as a limit value to be observed, and “reference level” of uniform magnetic field is shown as its equivalence.

*2 : A normalized induction factor was introduced as an index of induced current in non-uniform magnetic field. The factor represents the degree of electromagnetic coupling between magnetic field and human body based on induced current, and the factor is unity for uniform fields while the factor is less that unity for non-uniform fields. Using the factor, one can calculate an equivalent uniform magnetic field that can be comparable with reference levels in the guidelines. In the study, it is proposed that the normalized factor K_J can be expressed by a simple formula ($K_J=K_B^{0.2}$) where K_B is a reduction rate of magnetic field inside a sphere to be exposed to magnetic field.

*3 : An anatomically correct human male model developed by NICT (National Institute of Information and Communications Technology, Japan) was used. The model contains cubic cells of 2 mm resolution, which simulates electrical property of several tissues inside a human body.

*4 : “Calculation Program for Magnetic Field near Power Lines”, CRIEPI, #973005 (1997.9)

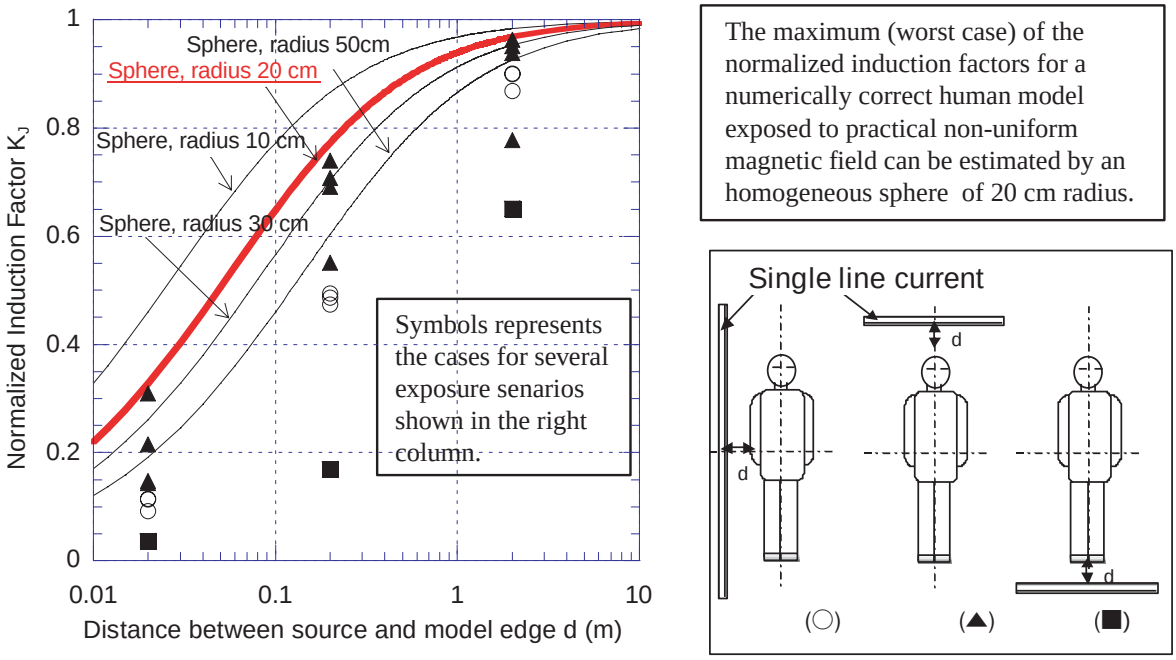

Fig.1 Normalized induction factors for non-uniform magnetic field exposure using an anatomically correct human body (example of a single line current)

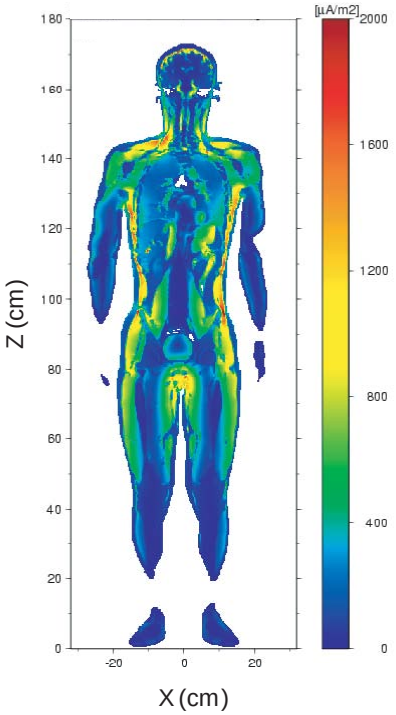

Fig.2 An example of induced current distribution inside Japanese human model

The human model has resolution of 2 mm. The number of the elements is about 8 million. About 50 types of tissues are modeled. The picture shows the case of uniform magnetic field exposure of 0.1 mT, 50Hz from front to back.

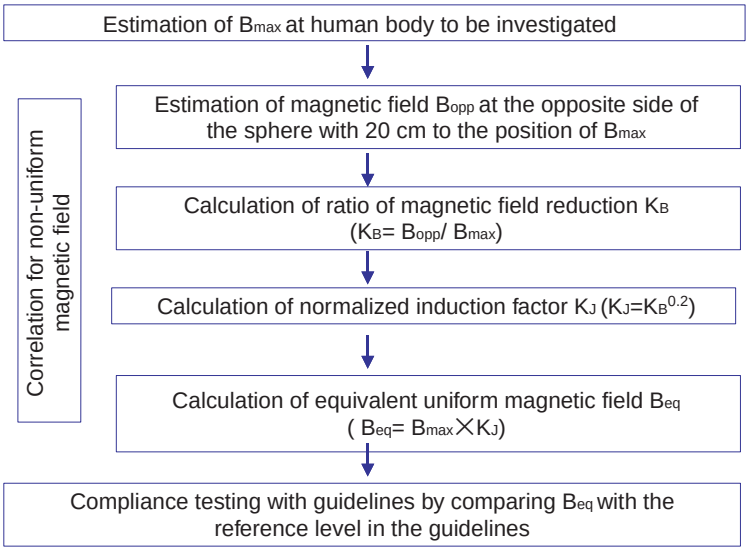

Fig.3 Proposed procedure for compliance testing with guidelines