EMF ISSUE IN RAILWAY SYSTEMS

- Evaluation of Biological Effects and Trends of Regulation in Japan-

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Introduction

Last 30 years, biological effects of non-ionizing radiation have been strenuously investigating because of its uncertainty of adverse health effects. In 50/60 Hz power frequency magnetic field, findings in epidemiology show weak evidences of relationship between exposure to magnetic field and a risk of child leukemia[1]. Similarly, a few studies show weak evidences of relationship between exposure to radio frequency electromagnetic field used in mobile telephony (or duration of mobile telephone usage) and a risk of brain tumor [2]. These two fields are both categorized its carcinogenicity as Group 2B by the International Agency for Research on Cancer (IARC) [3,4]. Then, the World Health Organization reviewed scientific evidences and published their monograph (Environmental Health Criteria No. 232 in static field and No. 238 in low frequency field.) and recommended to imply international guideline for limiting exposure to protect people from acute effects and also to promote further fundamental research.

Following this, various responses are seen in the world. In EU, EU adopted the ICNIRP guideline and the EU recommendation for general public was released and EU directive for workers have been discussed. Then, each EU member countries and other countries such as Korea, Israel, etc. including Japan have their own implementation.

In basic scientific knowledge, there is still a little information about biological/health effects by exposure to an intermediate frequency magnetic field (IF-MF, IF; 300Hz-10MHz by the description of WHO) although several devices or technologies that uses intermediate frequency magnetic field have already been installed in our society. Especially, induction heating (IH) cooktops that commonly uses 20kHz to 100kHz magnetic field to heat metallic pans became widely used at home in Japan recently. Besides, several sources are existed such as transportation systems that use inverters to drive main motors on electric railway cars.

In my talk, following three topics 1. trends of regulation in Japan, 2. evaluation of biological MF, 3. evaluation of dosimetry in human body will be presented.

1. Trends of regulation in Japan

In Japan, the regulations of MF for protection of general public from short term health effects such as nerve stimulation were enforced for electric utility company and railway business operator

recently. Power frequency (50Hz or 60Hz in Japan) MF emitted from Substation, transformer, power line, etc. was the target of these regulations.

Table Summary of ELF-MF regulations in Japan

Responsible ministry	**Ministry of Economy, Trade and Industry**	**Ministry of Land, Infrastructure, Transport and Tourism**
Type	Ordinance of the Ministry	Ordinance of the Ministry
Name of Ordinance	Ministerial Ordinance setting technical standards concerning electrical facilities and its interpretation	Ministerial Ordinance to Provide the Technical Standard on Railway and its interpretation
Target MF	Power frequency (50/60Hz)	Power frequency (50/60Hz)
Limit value	200μT	－（200μT is noted in interpretation）
Target facilities	Electric installations such as Substation, Power line, Transformers, etc except consumer	Fixed electric installations such as substation, catenary, electric devices, etc.
Measurement method	Adopted IEC62110	Adopted IEC62110 and IEC/TS62597

2. Evaluation of biological effects by exposure to MF

Besides the recommendation of short term effect, the WHO also recommends further research to elucidate scientific uncertainty about health effects of long term exposure. In fact, there are a few reports on biological effects of various EMFs that exist in railway systems, such as intermediate frequency (IF) MFs that are related to variable-frequency drive (VFD) installations in rolling stock and combined MFs with different frequencies. To respond this, we've been performed biological studies for years.

For example in our study, mutagenicity, that related to cause cancer, and hormonal effect by 21kHz IF-MF were evaluated. Mutagenicity was evaluated in *in vitro* micronucleus assay (MN) using Chinese hamster lung derived CHL/IU cell that is a part of the standard test battery for genotoxicity in the OECD guideline. For evaluation of hormonal effect, MCF-7 cell (human breast adenocarcinoma cell line) modified with an estrogen response genetic element (luciferase) as a reporter of gene expression was used. The cells exposed to 21 kHz, IF-MF up to 3.9mT (144 times higher than reference level for public in the ICNIRP guideline) for up to 4 days. Frequency of micronucleus was analyzed by microscopic observation and hormonal effect was determined as expression of luciferase in the cellular extract measured by its chemiluminescence assay.

As the result, there is no significant effect by exposure to 21 kHz, up to 3.9mT IF-MF in both

biological assays. Therefore, with taking into account these results and practical situation that will be much weaker MFs than experimental conditions exist where person can be in railway environment, it would suggest that IF-MFs in railway have no or extremely small mutagnic and hormonal potential that will be not able to be detected in general biological assays. Thus, it should not be considered that IF-MFs in environment have any adverse health effect.Other data in strong DC MF, 50Hz and their combined exposure condition will be presented at the conference.

3. Evaluation of dosimetry

For plausible safety evaluation of MFs should include clarification of MF that are generated in our environment and estimation of the induced current/voltage using the numerical model of human whole body. So far, we studied two types of numerical human model are used to construct model condition in an electric train car. One model is heterogeneous whole-body voxel models of Japanese adult male (Taro) and female (Hanako) that developed by National Institute of Information and Communications Technology (NiCT) and the other is homogeneous numerical human model Quete (OGIS-RI, Japan). Two types of magnetic field source were examined. One is the magnetic field by line current that considered the power cable under the floor. The other is the magnetic field by magnetic dipole that considered the equipments such as reactor. Induced current was calculated by impedance method [5]. In this calculation, voxel size was 2mm and amount of voxels ranged 24,243,520 to 52,115,960. In addition, the compliance of “reference level” of ICNIRP guideline for these magnetic fields was evaluated. Maximum or average magnetic field density to expose human body was normalized to the “reference level” and calculated the induced current in head and trunk. These data compared with basic restriction (2 mA/m^2) of ICNIRP1998 guideline.

Standing and seated position was examined in Quete. In each position, induced current concentrated at bending region such as ankle, knee, crotch, armpit. On the other hand, strong induced current was observed in organs that contained high water content such as cerebral fluid and blood within bladder in inhomogeneous model Taro and Hanako. However, the density of induced current in inhomogeneous model is lower than homogeneous model Quete. Highest density of induced current was observed in the magnetic field of line current because attenuation of the magnetic field lower than that of magnetic dipole. Induced current by normalized average/maximum magnetic field to “reference level” of ICNIRP guideline shows approx. 10^{-1} mA/m^2 (average) or approx. 10^{-2} mA/m^2 (maximum) in head and trunk. These results suggest that allowance in basic restriction of ICNIRP guideline will be 10 times (average) and 100 times (maximum) respectively. Evaluation of induced voltage is under evaluation.

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