SURVEY OF NON-IONIZING RADIATION LEVEL IN THE JRR-3M

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ABSTRACT

Measurements of the free space levels of magnetic field in the Japan Research Reactor No.3 Modified (JRR-3M) and computer simulation of generating electromagnetic fields are presented. Extremely low frequency (ELF:50Hz) and very low frequency (VLF) field levels in the JRR-3M were fairly lower than applicable guidelines or standards. Simulation of generating electromagnetic fields would suggest that the generators were electrical devices, such as semiconductor power converter and video display terminal (VDT). These devices could produce not only ELF but also VLF electromagnetic fields.

INTRODUCTION

There has been a considerable development of science such as accelerator, superconducting magnetic energy storage (SMES) and nuclear fusion. Now VDTs are widespread among the general public in Japan. These man-made sources have increased chance of occupational and public exposure to non-ionizing radiation (NIR). The International Radiation Protection Association (IRPA) created the International Non-Ionizing Radiation Committee (INIRC) in 1977, and published some reports as to NIR(1).

In Japan, public concern has been growing about possible adverse effects of low frequency electromagnetic fields on human health. The Ministry of Posts and Telecommunication (MPT) indicated guidelines on protection standards for exposure to NIR in 1990(2). However, there are not many scientific data in Japan for the Japanese guidelines on limits of exposure to NIR. It is very important to measure magnetic field levels in workplace and home. There are also concerns about electromagnetic interference and compatibility (EMI/C) of electromagnetic fields. In the nuclear facilities, electronic personal dosimeter is adopted for personal dose measurement for the workers at radiation controlled areas, but the electronic personal dosimeter is not always independent of electromagnetic fields. For the purpose of personal dose monitoring for workers, it is necessary to measure the normal levels of magnetic field.

In the present work, measurements and simulation were carried out so as to obtain knowledge of NIR risk.

METHODS

Measurements of magnetic flux densities were made in the JRR-3M while it was not in operation. The JRR-3M attained its first criticality in March 1990 as a high-performance multi-purpose research reactor and started operation with maximum output of 20MW in November of the year. There are various utilization facilities installed in the JRR-3M, magnetic fields caused by these facilities influenced not only radiation workers but also instruments.

Two types of instruments were used for measuring ELF magnetic flux densities and VLF magnetic field strengths. One is ELF/power frequency EMF survey meter MODEL HI-3604 (HOLADAY) which has 6.5 inch diameter 400 turn electrically shielded magnetic field sensing coil. Its sensitivity for magnetic fields ranges 0.1mG-20G. The other is VDT/VLF radiation survey meter MODEL HI-3603 (HOLADAY) which has 8 inch diameter magnetic field sensing loop. Its

sensitivity for magnetic fields ranges 1-1999mA/m. Magnetic fields were measured along three orthogonal axes, since both instruments did not have three orthogonal field sensors. The magnetic flux densities and magnetic field strengths were expressed by the root of the sum of these mean squared mutually orthogonal components. All the measurements were taken at a height of 1m above the floor except for some cases. Temperature and relative humidity in the JRR-3M were 18.8℃ and 54.0%, respectively.

Recently there has been widespread VDT in workplaces and homes. A survey was made of VDT. This model is 15 inch cathode ray tube (CRT). The vertical deflection frequency is 56.4Hz, the horizontal deflection frequency 24kHz.

Root mean square (RMS) electromagnetic fields were determined by measurements as variation of the distance from centre of the VDT's surface. In order to reduce the proximity effect, the distance between the electromagnetic field strength meter and operator had to be at least 2.5m. Measured time period for ELF electromagnetic fields was over 1 second, for VLF fields 6 minutes. VLF electromagnetic field strengths were averaged over 6 minutes. The VDT's brightness was adjusted to an average level. The survey meter and the VDT were mounted on each non-conductive tripod.

There has been a tendency for fluorescent light and air conditioner etc. to be equipped with inverter which would produce electromagnetic wave. A computer simulation was performed for a double-way rectifier circuit using PSPICE (P Simulation Program with Integrated Circuit Emphasis, MicroSim Co.) so as to make clear the sources of electromagnetic wave. Simulated circuit consisted of four semiconductor controlled rectifiers, two FETs and SMES, and was controlled by pulse width modulation (PWM). Electromagnetic fields generated by semiconductor were estimated by Fast Fourier transform (FFT) of alternating-current.

RESULTS AND DISCUSSION

As shown in Figure 1, the magnetic field levels measured in the JRR-3M are low. The maximum magnetic flux density at the near surface of the electrical devices is fairly lower than applicable guidelines. These data were found by measurements at the distance 10cm from devices' surface. There are relatively high levels of magnetic field of vacuum device for a adiabatic tub and automatic voltage regulator which contain semiconductor elements. Observation of the magnetic fields using oscilloscope indicated that 50Hz frequency and higher harmonics of the magnetic flux densities were generated from electrical devices. As for high frequency, harmonics of the magnetic flux densities due to frequency-conversion at the electrical devices were observed.

Figure 2 shows ELF electric field strengths generated by VDT. The distances between the survey meter and the VDT are 0.1,0.2,...,1.0m. Table 1 shows the electric and the magnetic fields at 10cm from the VDT's surface and IRPA guidelines. Using these field strengths value, induced current density in human head was found from calculation. Its current density was 0.6mA/m^2 as worst case assuming a 7.5E-2m radius loop and conductivity 1S/m. Normally,, the spontaneous endogenous current density in body is about 10mA/m^2. The health risk caused by electromagnetic fields of VDT is not necessarily considered.

Computer simulation indicated that electronic circuit consisted of nonlinear elements and controlled by PWM emitted not only ELF but also VLF electromagnetic wave.

CONCLUSIONS

[1] The magnetic field levels measured at JRR-3M were fairly lower than IRPA and Japanese guidelines. VDT electromagnetic fields were also lower than these guidelines.

[2] Electrical devices, such as semiconductor power converter and VDT could produce not only ELF but also VLF electromagnetic fields.

REFERENCES

1. IRPA/INIRC:"Interim guidelines on limits of exposure to 50/60Hz electric and magnetic fields",Health Physics Vol.58 No.1(1990).
2. The Japan Ministry of Posts and Telecommunication:Radiofrequency-Exposure Protection Guidelines(1990).

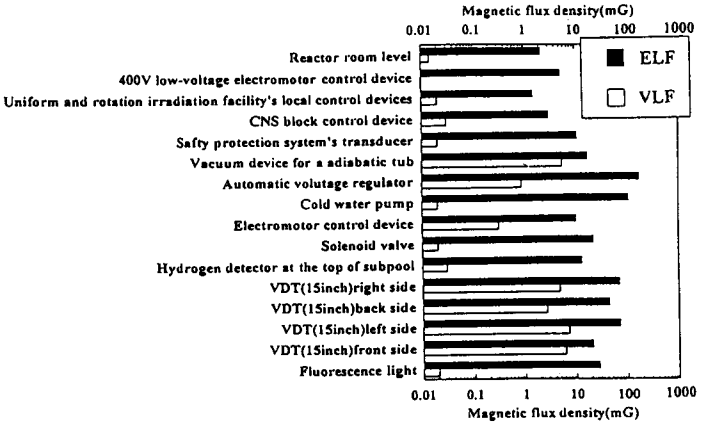

Figure 1. Magnetic flux density produced by electrical devices.

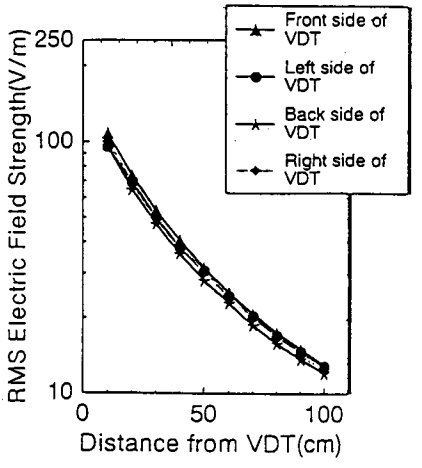

Figure 2. Electric field strength(ELF) variation with distance from VDT.

Table 1. Electric and magnetic field levels, IRPA Guidelines and Japanese Guidelines

	measured levels*)	IRPA	JAPAN(P)
ELF electric field strength (V/m)	9.5E+1~ 1.1E+2	1.0E+4	
ELF magnetic flux density (mG)	2.1E+1~ 7.2E+1	5.0E+3	
VLF electric field strength (V/m)	3.3 ~ 6.0E+1		6.1E+2
VLF magnetic field strength (mA/m)	2.1E+2~ 5.8E+2		1.6E+5

*) at 10cm from VDT.