§9. Measurements of Static and Variable Magnetic Fields in a Large Plasma Experimental Facility

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Although the LHD is plasma confinement device with strong static magnetic field, not less magnetic field is leak out around the device. Except the superconducting magnetic systems, many electromagnetic devices are applied for fusion plasma experiments. Various frequencies of electromagnetic devices are used like NBI and its electric power source of a motor generator (60Hz), heating systems of ICRF (25-100 MHz), and ECH (84-168 GHz). Also for discharge cleaning, resonance frequency (2.45 GHz) system is used. As above mentioned, static magnetic field and wide spectrum of frequencies electromagnetic waves are concerned. Safety issues seem to be not only strong electromagnetic field but also complex of static magnetic field and variable frequencies of magnetic fields, which are from extremely low frequency (ELF) of 60 Hz to high frequency of 168 GHz. Considering the safety and health effects for workers in the plasma experimental facility, leakage of magnetic field strength around the LHD and related devices have been measured.(1) Static magnetic field has been measured since the first plasma experiment of the LHD in 1998. The fixed monitoring point is 23 m far from the center of LHD in south direction. The measurement instrument is Gauss Meter 9900 (F.W. Bell Co) and three axial probe ZOA99-3208. The magnetic field strength measured in the period of 8th cycle of LHD operation, 9/1(2004)-1/31(2005) is shown in Fig.1. Background on not-operation is about 0.06 mT, which is a double of terrestrial magnetic field. It caused by magnetization of steel materials in the monitoring room. The data shown in Fig. 1 is already subtracted the back ground. When the LHD plasma magnetic field is 3 T, it increased to 0.1 -0.2 mT.

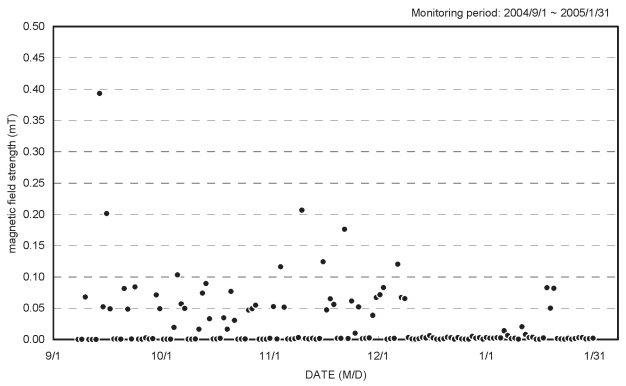

Fig.1 Result of magnetic leakage monitoring in 9/1(2004)-1/31(2005) outside of the LHD hall.

As major issues of the super conducting magnetic coil system, it decreases quickly for protection of the coil system on quenching or on abnormal event occurrence. According to our experiences magnetic field strength at the fixed point was spontaneously increased to about 0.5 mT on such a coil protection mode. Small variation of magnetic field strength less than 0.01 mT was observed according to the local island divertor (LID) operation.

Except the coil system of the LHD, there are some kinds of static magnetic field producing devices. For example a gyrotron, of ECH has a super conducting magnet coil, of which strength is 7 T at the center of coil. Leakage of magnetic field strength is measured with the gauss meter. Although entrance of workers in the ECH device is regulated by the leakage of magnetic field, high electric voltage and X-ray radiation is more important safety issues.

There are many kinds of ELF related devices in the laboratory. Major devices are electric power source for super conducting magnetic coils system and a motor generator for power supply to the NBI device. The ELF magnetic field strength around the electric equipments in the laboratory was distributed between 0.2-40 μT. The average ELF level in office is about 0.1 μT.

There are many types of microwave generator for plasma heating such as ICRF and ECH and for discharge cleaning of plasma facing walls. We begin continuous monitoring around the ICRF wave generator using a data logging system. The measurement instrument is EMC-300 and three axes electric field probe Type 18 (Narda Co.). Result is shown in Fig. 2. The maximum electric field was 8 V/m that is about 1/10 of the occupational regulation level proposed as guide line by the International Conference for Non-Ionizing Radiation Protection (ICNIRP). Exposure dose measurement and estimation to such high frequencies of electromagnetic fields is an important issue. So we have studied in collaboration with Nagoya Institute of Technology and Utsunomiya University.

Reference

1) Uda, T. et al., EMC'04 Sendai, 2(2004) 853

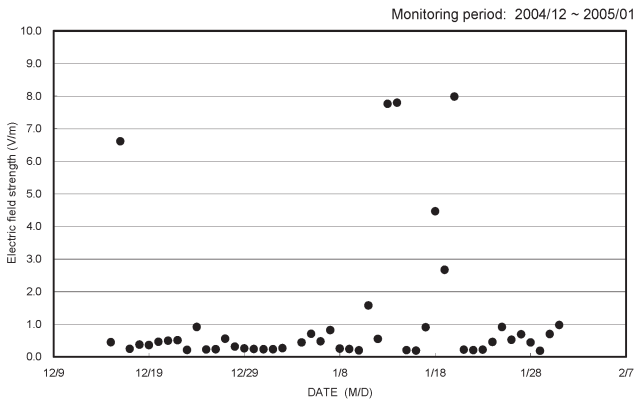

Fig. 2 Electric field strength monitored around the ICRF electromagnetic wave generator.