§13. Measurements of Static and ELF Magnetic Fields in a Large Plasma Experimental Facility

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Although the LHD is possible to confine the plasma with strong static magnetic field, not less magnetic field is leak out around the device. Except the superconducting magnetic systems, many electromagnetic devices are used 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 historical data of magnetic field strength on the LHD operation since 1998 to 2003 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. When the LHD plasma magnetic field is 3 T, it increased to 0.1 m.

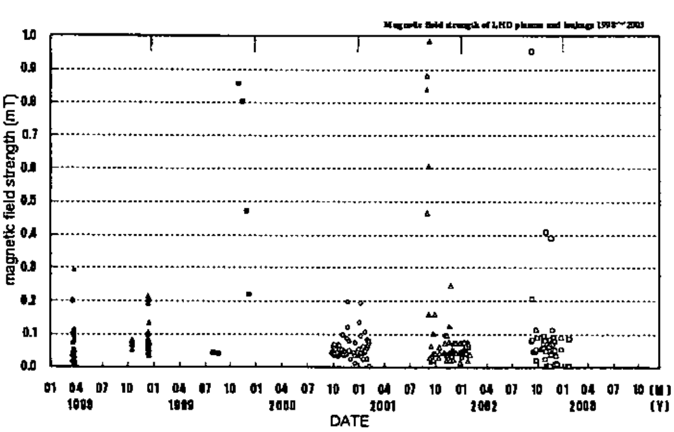

Fig.1 History of magnetic leakage monitoring in 1998-2003 outside of the LHD hall.

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 1 mT on such a coil protection mode.

Except for the LHD, there are some kinds of static magnetic field producing devices. For example a gyrotron, of ECH has a super conducting magnet, of which strength is 7 T at the center of coil. Leakage of magnetic field 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.

The estimation of exposure level to the ELF environments had been tried. The ELF magnetic fields in the laboratory and home were measured with collaboration of 23 voluntary workers. The volunteers were carrying an EMDEX-II monitor in 24 hours. Then average exposure level was 0.18μT, and almost all the monitors were less than 0.22μT. But a few volunteers were exposed to 6-12 μT. It is found that beside the experimental devices there are some electric exposure sources like transportation and home electric equipments. For example, an electric carpet shows high strength.

Considering health effects to workers in our research institute, the magnetic field strength is less than guidelines proposed by the International Conference for Non-Ionizing Radiation Protection (ICNIRP).

Except static and ELF magnetic fields, there are many types of microwave generator for plasma heating such as ICRF and ECH and for discharge cleaning of plasma facing walls. Exposure dose estimation to such high frequencies of electromagnetic fields is important and much difficult problems. These problems are studied with Nagoya Institute of Technology as collaboration.(2)

References

(1) T. Uda, et al., EMC'04 Sendai, Vol.2, pp853-856 (2004)
(2) J. Wang, et al., EMC'04 Sendai, Vol.2, pp593-596 (2004)