12. Safety and Environmental Research Center

The Safety and Environmental Research Center (SERC) has been studying to promote and to implement radiation safety issues in NIFS. The major mission of SERC is radiation safety management of X-ray emission devices which are LHD, CHS, their plasma heating devices like NBI and ECH, a Tandem type accelerator for Heavy Ion Beam Probe (HIBP) which is a plasma diagnostic device, and other small experimental apparatuses. For safety operation of LHD and related devices, radiation management system and access-control system were well integrated. Radiation monitoring by the Radiation Monitoring System Applicable to Fusion Experiments (RMSAFE) has been working successfully. The other radiation safety issues are a plan of the safety management system and development of precise radiation monitors considering the deuterium (D) plasma experiments in LHD, especially neutron protection and tritium treatment. The SERC is also engaged in the research and development regarding fusion safety, so that variety of issues should be surveyed not only in the field of radiation safety management and radiation protection but also in the field of general safety science, health and environment. It should be pointed out that some of these scientific investigations have been successfully carried out as collaboration with researchers of many universities, research institutes and companies. Topics of these activities of the SERC during FY 2008 are summarized as follows:

(i) Radiation management and monitoring

For the occupational workers in radiation control area, educational training and registration system have been established. The radiation management had been performed by radiation safety management office in the health and safety promoting division in NIFS and management issues have been discussed and proposed by the SERC.

It is required that the annual exposure dose caused by operation of some radiation emission devices should not exceed 50 μSv in a year on the site boundary. To ensure this limit, a monitoring system RMSAFE works to detect burst X-ray and to discriminate the radiation caused by plasma experiment from the natural radiation and to accumulate the exposure dose. The annual radiation dose level caused by experiments of LHD and CHS at the site boundary was less than 1 μSv in FY 2008. Also the environmental radiation has been measured every three months using thermo- luminescence dosimeter TLD and radiophoto-luminescence dosimeter RPLD.

The sensitivity of the electrical personal dosimeter (EPD) was compared with that of RPLD in the environmental radiation measurement, because EPD has several advantages to monitor environmental radiation. The dose rates measured by these two have good linearity and high correlation. However, an appropriate correction to EPD is required to apply to environmental monitoring because there are some differences of sensitivity with RPLD.

(ii) Tritium measurements

It is important to grasp tendency of the environmental tritium concentration level in water and atmosphere before start D experiments in LHD. Atmospheric tritium levels have been monitored in each chemical form (assumed in three forms) of water, hydrogen and methane at Toki area as a background data before D experiments. To estimate the tritium concentration in the water vapor in air, the water vapor trappings with both the cold trap method and the solid collecting method were performed and the characteristics of the methods were compared, and the most effective trapping method for collecting water vapor in air was the Passive method with molecular sieve. A tritium gas monitor is developed at NIFS, which employs a proportional counter using pulse-shaping analyzer. It can measure as low as 2.0×10^{4} Bq/cm^3 and 4.3×10^{4} Bq/cm^3 in exhaust gas for 60 min and 5 min measurements, respectively. A monitor using an electrochemical hydrogen pump which consists of proton conducting oxide ($CaZr_{0.9}In_{0.1}O_{3-\alpha}$) has been developed and investigated its performances.

(iii) Studies of tritium treatment system and safety

The tritium and neutron are key issues from view point of radiation safety for the D experiment in LHD and for a future nuclear fusion facility. The specific technologies are extremely low level tritium monitoring and removing or recovering of tritium from the vacuum pumping gas or exhausting air from the large plasma vacuum vessel. The main topics of research and developments are application of membrane dehumidifier for gaseous tritium recovery system, removal of tritium from tritiated water and isotope separation by microchips, extraction characteristics of hydrogen into vacuum from a proton conducting oxide which is one of the candidate materials for hydrogen isotope recovery, and Hydrogen and methane oxidation performance of honeycomb hybrid catalyst for a tritium removal system.

(iv) Neutron measurements

It is also important to develop an accurate evaluation method of neutrons produced by fusion reaction. Before the start of D experiments in LHD, it is necessary to know the behavior of environmental neutron flux. Measurements of environmental neutrons energy spectrum in Toki area has been carried out continuously.

A method using imaging plate (IP) has been investigated. Since actual radiation fields around the reactors and accelerators are usually the mixed radiation fields of photons and neutrons, it is necessary to make the precise energy response of IP clear for neutron dosimetry.

(v) Non-ionizing radiation monitoring and management

Leakage of static magnetic field and variable frequencies of electromagnetic fields are concerned in a magnetic fusion plasma experimental facility. Although high power electromagnetic waves are utilized for plasma heating in LHD, electric and magnetic field strength around the LHD hall were less than the occupational regulation level proposed as guide line by the ICNIRP. Modeling the EM environment in the fusion facility and deriving a circuit model for the personal dosimeter from the view-point of EM coupling in order to clarify the mechanism of malfunction has been performed as collaboration with Utsunomiya University and Nagoya Institute of Technology.

(vi) Education

Some materials contain natural weak radio-active components, such as sinter (hot sprig deposit), chemical fertilizer, and dried seaweed. The method is proposed to make a disk-shaped radiation source by compressing and shaping the original material. These disks are used as easy hand-able weak radiation sources for educational use.

To look over the current measurement of radioactivity concentration in working environment of many radioisotopes facilities, a questionnaire survey was carried out. The main results were obtained by aggregate analysis of the answers for questionnaires.

(Nishimura, K.)

List of Reports

1. "A transition of Environmental Tritiated Water Vapor, Hydrogen and Methane Gases in 2004 – 2008 at Toki Site," Tanaka, M. (NIFS)
2. "Measurement of natural background radiation in LHD building," Yamanishi, H. (NIFS)
3. "Measurements of Environmental Neutrons in Toki Area," Urabe, I. (Fukuyama Univ.)
4. "Application of Membrane Dehumidifier for Gaseous Tritium Recovery in LHD," Asakura, Y. (NIFS)
5. "Recovery of Tritium from Tritiated Water Vapor Using a Proton Conductor," Tanaka, M. (NIFS)
6. "Remove of Tritium from Tritiated Water and Isotope Separation by Microchips," Hazama, R. (Hiroshima Univ.)
7. "Experimental and analytical research on temperature rise of an oxidation catalyst due to the combustion heat of hydrogen," Tanaka, M. (NIFS)
8. "Hydrogen Pump Characteristics of an Intermediate Temperature Type Proton Conducting Oxide," Tanaka, M. (NIFS)
9. "Study o radiation measurement using imaging plate in photon-neutron mixed field," Kosako, T. (Univ. Tokyo)
10. "Feasibility study of gaseous tritium sampling and measurement system," Uda, T. (NIFS)
11. "Monitoring of static and varying electromagnetic fields for safety management in a large plasma facility," Uda, T. (NIFS)
12. "Measurement and Wideband Exposure Evaluation of Environmental Electromagnetic Fields," Fujiwara, O. (Nagoya Inst. of Tech.)
13. "Disk Shaped Radiation Sources for Education Purposes made of Chemical Fertilizer," Kawano, T. (NIFS)
14. "Measurement of Radioactivity Concentration in Working Environment of Radioisotopes Facility," Kawano, T. (NIFS)