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 producers which are LHD, CHS, and their plasma heating devices like NBI and ECH, a Tandem type accelerator for plasma diagnostic device which is called as Heavy Ion Beam Probe (HIBP), 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 to plan the safety management system and to develop precise radiation monitors considering the deuterium (D) plasma experiments in LHD, especially protection of neutron and tritium. 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 2007 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 on the site boundary. To ensure the 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 2007. 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 for application to environmental monitoring because there are some differences of sensitivity with RPLD [1].

(ii) Tritium measurements

It is important to grasp tendency of the environmental tritium concentration level in water and atmosphere before start DD 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 DD experiments [2]. 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 he most effective trapping method for collecting water vapor in air was the Passive method with molecular sieve [3]. 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. [4]. A monitor using proton conducting oxides, which function as an electrochemical hydrogen pump at elevated temperature has been proposed, and the performance tests of the one-end-closed tube made of $CaZr_{0.9}In_{0.1}O_{3-\alpha}$ with wide electrode area is carried out [5]. An evaluation of analyzer that is able to detect extremely small concentration of dideuterium in diprotium gas has been done [6]. A tritium gas feed unit which enables us to feed the calibration gas with a constant composition in safe and for a long time has been developed [7].

(iii) Studies of tritium treatment system and safety

The tritium and neutron are key issues from view point of radiation safety for the DD experiment of LHD and for a future nuclear fusion facility. The specific technologies are extremely low level tritium monitoring and removing or separation 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 [8], remove of tritium from tritiated water and isotope separation by microchips [9], extraction characteristics of hydrogen into vacuum from a proton conducting oxide, which is one of the candidate materials for hydrogen isotope recovery [10], evaluation of bend points of hydrogen partial pressure curves obtained by tritium removal simulation tests [11], and Hydrogen and methane oxidation performance of honeycomb hybrid catalyst for a tritium removal system [12].

(iv) Neutron measurements

It is also important to develop an accurate evaluation method of neutrons produced by fusion reaction. Before the start of DD 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 [13]. A method using imaging plate has been investigated. Although imaging plate is not directly sensitive with neutron, actual radiation fields around the reactors and accelerators are usually the mixed radiation fields of photons and neutrons so it is necessary to develop the method for neutron dosimetry by using IP [14]. A new spherical neutron detector using TLD has been developed [15].

(iv) 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. High power electromagnetic waves are utilized for plasma heating in LHD. Electric and magnetic field strength around the ICRF power source devices, and all data were less than the occupational regulation level proposed as guide line by the ICNIRP [16]. 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 [17].

(iv) Education

Some materials contain natural weak radio-active components, such as sinter (hot sprig deposit) and dried seaweed. The method is proposed to make a disk-shaped radiation source by compressing and shaping the original material. This will be a weak radiation source easy to be handled for educational use [18].

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List of Reports

1. “Application of EPD to environmental radiation measurement,” Yamanishi H. (NIFS)
2. “Atmospheric Tritium Measurement with Discriminate Sampling of Water, Hydrogen and Methane Gases,” Uda T. (NIFS)
3. “Trial production of monitor for tritium in vapor of atmospheric air,” Ogata Y. (Nagoya Univ.)
4. “Performance Evaluation of a High Sensitivity Tritium Gas Monitor Using a Pulse-Shaping Analyzer,” Kawano T. (NIFS)
5. “Effect of Methane Gas in the Cathode Compartment on the Electrochemical Hydrogen Pump,” Tanaka M. (NIFS)
6. “Performance Evaluation of the Analyzer developed for detection of dideuterium in pure diprotium,” Kawano T. (NIFS)
7. “Development of a Tritium Gas Feed Unit for Calibration of a Tritium Monitor,” Tanaka M. (NIFS)
8. “APPLICATION OF MEMBRANE DEHUMIDIFIER FOR GASEOUS TRITIUM RECOVERY IN LHD,” Asakura Y. (NIFS)
9. “Remove of Tritium from Tritiated Water and Isotope Separation by Microchips,” Hazama R. (Hiroshima Univ.)
10. “Extraction Characteristics of Hydrogen into Vacuum from a Proton Conducting Oxide,” Tanaka M. (NIFS)
11. “Bend Points of Hydrogen Partial Pressure Curves Obtained by Tritium Removal Simulation Tests,” Kawano T. (NIFS)
12. “Hydrogen and methane oxidation performance of honeycomb hybrid catalyst for a tritium removal system,” Uda T. (NIFS)
13. “Measurements of Environmental Neutrons in Toki Area,” Urabe I. (Fukuyama Univ.)
14. “Investigating the ability of using imaging plate BASMS for neutron dosimetry in the mixed radiation field,” Urabe I. (Iimoto T. Univ. Tokyo)
15. “Development of an improved spherical type neutron dose monitor,” Bhuiya, S.H. (Graduate University for Advanced Studies)
16. “Monitoring of static and varying electromagnetic fields for safety management in a large plasma experimental facility,” Uda T. (NIFS)
17. “Study of EM Coupling between EM Fields and Electronic Circuits in Plasma Experimental Environment,” Wang J. (Nagoya Inst. Of Tech.)
18. “Disk Shaped Radiation Sources Fabricated by Compression and Formation of Sinter Powder,” Kawano T. (NIFS)