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 the 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 2009 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 2009. Also the environmental radiation has been measured every three months using thermo- luminescence dosimeter TLD and radiophoto-luminescence dosimeter RPLD.

The electrical personal dosimeter (EPD) was started to use at some measuring posts, because EPD has several advantages to monitor environmental radiation compare with the RPLD. 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. We have a plan to prepare the EPD for all monitoring posts.

(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.

Automatical tritium monitor using a plastic scintillator and photon counter was developed by the collaboration with the Kaken company. The advantage of this system is not generating organic radioactive liquid waste like liquid scintillator.

Tritium compounds contained in exhaust gases in nuclear fusion and nuclear power generation facilities are tritium gas (HT), tritiated water vapor (HTO), tritiated methane (CQ_4), etc. Radiation effect of tritium is considerably different in the chemical form of tritium compounds. The memory effect of these tritium compounds in ion chamber used for the continuous monitoring system of tritium concentration for each chemical form was investigated by the collaboration with Niigata University.

(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 a proton conducting oxide as a hydrogen pump, hydrogen and methane oxidation performance of honeycomb hybrid catalyst for a tritium removal system, an application of membrane dehumidifier for gaseous tritium recovery system, and the development of μ TAS system for remove of tritium and isotope separation.

(iv) Neutron measurements

It is also important to develop an accurate evaluation method of neutrons produced by fusion reaction. Based on a previous multi-layer type spherical neutron dose monitor, a new type dose monitor with hexagonal cylindrical shape has been designed and tested. This monitor showed more accurate results than the commercial REM counter. For the evaluation of the neutron monitor, H*(10) method was developed.

Passive personal neutron dosimeters based on CR-39 have tried for measurement of dose from external neutron exposure at various nuclear facilities. The research to increase the sensitivity of CR-39 was developed by the collaboration with the University of Tokyo.

(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 and other activities

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.

Before the start of D experiments in LHD, it is necessary to know the behavior of environmental neutron flux. We start the detail estimation of the neutron flow in all wholes on the floor and the walls using DORT code and MATXLIBJ-33 nuclear data base. It is useful for the detail design of additional neutron shieldings. After the start of D experiment, immediate and precise on-the-spot measurements are desired for the safety and convenient work in the experimental areas. An on-site radiation monitoring cart has been conceptually developed to satisfy such demands.

Recently, The electrical dosimeter has been widespread. On the other hand, work environment in a nuclear fusion facility is filled with the certain electro-magnetic field. The effect of electro-magnetic field on electronic dosimeters was investigated by the collaboration with Tokyo Metropolitan University and Fujita Health University.

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List of Reports

1. "Measurement of natural background radiation in LHD building," Yamanishi, H. (NIFS)
2. "Measurements Survey of Radioisotope Concentrations in Air in Radiation Workplaces," Kawano, T. (NIFS)
3. "A Level Transition of Environmental Atmospheric Tritiated Gas Activities in 2004 - 2009 at Toki Site," Uda, T. (NIFS)
4. "Sensitivity of plastic scintillator to measure the tritium in water for gaseous tritium monitoring," Uda, T. (NIFS)
5. "Memory effect of tritium compounds in ion chamber (3)," Ohta, M. (Niigata Univ.)
6. "Electrochemical Hydrogen Pump using a High Temperature Type Proton Conductor under Reduced Pressure," Tanaka, M. (NIFS)
7. "Comparison of the Oxidation Characteristics of Metal honeycomb Catalyst with Difference Sizes," Tanaka, M. (NIFS)
8. "Application of Membrane Dehumidifier for Gaseous Tritium Recovery in LHD," Asakura, Y. (NIFS)
9. "Development of μ TAS System for Remove of Tritium and Isotope Separation," Hazama, R. (Hiroshima Univ.)
10. "Design of an integrating type neutron dose monitor," Yamanishi, H. (NIFS)
11. "Method of H*(10) evaluation using a developed spherical type neutron dose," Bhuiya, S.H. (Grad. Univ. for Advanced Studies)
12. "Radiation Measurements using CR-39 in wide energy range Neutron Fields," Iimoto, T. (Univ. of Tokyo)
13. "Measurement of static and time varying electromagnetic fields considering occupational safety management," Uda, T. (NIFS)
14. "Measurement and Wideband Exposure Evaluation of Environmental Electromagnetic Fields," Fujiwara, O. (Nagoya Inst. of Tech.)
15. "Radiation Sources Fabricated from Kelp Powder for Educational Purposes," Kawano, T. (NIFS)
16. "Radiation shielding analysis for LHD deuterium plasma experiment," Yamanishi, H. (NIFS)
17. "Conceptual Design of On-Site Monitoring Cart Available for Fusion Facility," Kawano, T. (NIFS)
18. "Effect of Electromagnetic Field in Fusion Facility on Electromagnetic Personal Dosimeter," Kawano, T. (NIFS)