Safety and environmental research and development are important to design and construction of a future nuclear fusion reactor and to secure sufficient safety. Major issues are as follows.

(1) Fundamental concept to secure safety in fusion reactor.
It includes studies of radiation protection considering radiation generating devices and radioactive materials in a nuclear fusion reactor.
Safety analysis presuming a helical type power reactor had been made considering engineering safety systems, functions, and sequential schemes presuming abnormal events.

(2) Safety consideration of tritium fuel cycle.
The fusion reactor system includes large amount of tritium in the vacuum vessel and fuel cycle. So safety handling technology and robust confinement system are required. Major safety issues are to prevent tritium release accident and to recovery of the tritium released to a radiation control room. Also research of tritium behavior in the environment and its biological effect is important considering radiation protection for occupational health hazard.

(3) Biological shields and radiation monitoring.
Much induced radioactive materials are produced in a nuclear fusion reactor. Shielding analysis of neutron and radiation from the radioactive materials are required. Also radiation measurements and monitoring are important for radiation protection.

(4) Radioactive waste management.
Waste management of tritium containing gas, liquid and contaminated solid are important problems. Major issues are recovery of tritium, decontamination or volume reduction of the wastes.

(5) Safety and public consent.
Comprehensive safety analysis and risk analysis should be made and the accountability is required.

Major safety issue specific for a future fusion reactor is to avoid the release accident of large amount of tritium. Fundamental safety of tritium processing would be secured by low tritium inventory, tritium dispersion to various partitioned components, and multiple protection systems.

Results of some collaborating studies are shown as follows. They will be useful not only for the DD experiment of LHD, but also for a future fusion reactor.

(a) Tritium behavior in cooling pipe of stainless steel
This basic study has been carried out as collaborations with Shizuoka University. The chemical forms of hydrogen isotopes on/in SS-316 were studied by TDS (thermal desorption spectroscopy). It has been suggested that the tritium retention will be accumulated by interaction between SS and hydrogen isotopes, indicating the desorption of O-T bonds will be important for the tritium decontamination.

(b) Hydrogen isotope separation system in liquid phase
Two collaborating developments have been carried out. One is the study with Nagoya University on higher performance tritiated water volume reduction system by chemical exchange reactions between hydrogen gas and liquid water. The other is the study with Kyushu University on advanced catalysts for the chemical exchange reactions between hydrogen gas and liquid water. It has been demonstrated that the homogeneous bed where Kogel catalysts and Dixon gauze ring are mixed in the optimum ratio and filled in the chemical exchange column homogeneously is more efficient than the conventional layered type bed. Benchmark tests using tritiated water have also been carried out at FZK(Forschungszentrum Karlsruhe, Germany) since September 2006.

(c) Hydrogen isotope separation system in gas phase
The basic study about the gaseous hydrogen isotope separation and purification system by pressure swing adsorption(PSA) has been carried out as collaborations with Kyushu University. It is expected that the new findings in this basic studies will lead to the development of the simple and efficient tritium recovery systems for a future D-T burning reactor.

(d) Atmospheric tritium recovery system
Recovery of released tritium gas in working area is a major safety system. The conventional tritium recovery process is to oxidize the tritium to water with catalyst and to dehumidify with dry absorber. To develop more compact and cost-effective system, the collaborating development on the polymer membrane type dehumidifier has been carried out with Shizuoka University. It has been confirmed that the membrane dehumidifier is applicable to the tritium recovery systems in the DD experiment of LHD. The simulation study for the detailed performance analyses has also been carried out for the optimum design of the actual dehumidifier.

(e)Database concerning tritium safety
The tritium safety data are related to the various fields in nuclear fusion research such as, basic tritium characteristics, fuel processing and safety handling technologies, monitoring methods and biological hazard of tritium. These data have been obtained through the studies on tritium in Japanese universities and institutes for a long period. The construction of the database for the tritium safety from the data previously obtained in Japan has been carried out as the joint work in NIFS for the D-D experiments of LHD. It is also expected that the database should become a baseline of the tritium safety guideline for a future fusion demo reactor in Japan.

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