(3) Fusion Reactor System and Safety

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 tritium would be trapped in oxide layer on the SS-316 surface and tritium retention would be increased by the formation of O-T bond.

(b) Hydrogen retention in deposition layers
The basic study about the hydrogen trapping behaviors in the re-deposition layer of SS316 has been carried out as collaborations with Kyushu University. Thermal desorption data show that hydrogen atomic ratio in the deposition layer formed from stainless steel is in agreement with the values in tungsten deposition layers.

(c) Hydrogen isotope separation system in gas phase
Two collaborating developments have been carried out. One is the study with Kyushu University on gaseous hydrogen isotope separation and purification system by pressure swing adsorption (PSA). The H2-HD-D2 three components experiments have been carried out. Obtained data suggest that a pressure and thermal swing adsorption process (PTSA) can be expected to realize a extremely high performance system of hydrogen isotope separation and enrichment. The other is the study with Kyushu University on application of honeycomb type adsorbents to the tritium recovery system instead of the conventional pebble type of synthetic zeolite. It has been demonstrated that the adsorption amount of water vapor on the honeycomb MS4A adsorbent by Kankyo Ceramics Research Co., Ltd. is comparable to that of the pebble type MS4A and MS5A.

(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 and Kyushu University. The simulation study for the detailed performance analyses has been carried out for the optimum design of the actual dehumidifier. The membrane dehumidifier is planning to be applied to the tritium recovery systems in the DD experiment of LHD.

(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 with JAEA 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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