Basic Technology Subjects

Nuclear Technology Research Laboratory

Brief Overview

The Nuclear Technology Research Laboratory aims at positively contributing to the solving/alleviation of energy and global environmental problems by means of developing nuclear technologies, including base technologies to support the safety and stable operation of LWRs as well as the recovery from the accident at the Fukushima Daiichi nuclear power plant, so that the use of nuclear energy is accepted by society in a positive manner.

Achievements by Research Theme

Nuclear Power Generation Technology

To contribute to the safety/stable operation of existing reactors, nuclear power generation technologies including fuel/core safety assessment technologies, technologies for risk-informed safety analysis, and thermal hydraulics, etc., are established.

- In order to evaluate the irradiation effect on the corrosion resistance and hydrogen absorption of fuel claddings, we investigated the chemical composition of Zircaloy-2 cladding, which is irradiated in a commercial BWR. We succeeded in obtaining elemental concentration in the specimens precisely and observed the precipitates, which improve the corrosion resistance dissolved in a matrix by neutron irradiation (L11021).
- The methodology for analyzing common-cause failures (CCFs) for the probabilistic risk assessment (PRA) of nuclear power plants (NPPs) is established. The process is to evaluate the possibility of CCFs by investigating component failure records and to estimate the CCF model parameters using the evaluation results. With this methodology, the domestic CCF parameters are calculated for the major safety components at Japanese NPPs (L11018).

Advanced Nuclear Fuel Cycle

The elemental and advanced technologies for aqueous reprocessing and the basic technologies for metal fuel cycles are developed aiming at starting the commercial operation of the Rokkasho reprocessing plant and at realizing the followed FBR fuel cycle. In addition, we contribute to the technical development of contaminated-water treatment systems at the Fukushima Daiichi Nuclear Power Station.

- In order to study the chemical reaction system in a glass melter at the reprocessing plant, we tried to visualize the series of chemical reactions in which high-level liquid waste is evaporated to dryness and consequently melted into the glass. The change of the physical property of the glass including noble metals is also studied (for example, viscosity).
- A conceptual design study for a metal fuel cycle facility (having a capacity for four units of 15-GW FBR reactors) is conducted based on the results obtained during elemental technologies development. It is concluded that adequate, lower fuel cycle costs can be attained compared with the same capacity facility for oxidized fuel (L11009).
- By applying the technologies developed for pyro reprocessing, the removal characteristics of Cs by zeolite are studied and the calculation code is also developed in a very short time for operation support. These results contribute to the construction of the contaminated-water treatment system.

Reactor Systems Safety

To reduce uncertainty regarding the safety evaluation of a nuclear reactor including a severe accident, validation data on the two-phase flow that influences core cooling is obtained, the analysis precision of the safety evaluation is improved, and a new analytical model is proposed.

- A three-dimensional bubble-velocity-determination algorism that can obtain validation data for nuclear power plants is developed. This algorism enables the direct measurement of the bubble behaviors and the bubble-velocity differences that are caused by bubble interactions (L11014).
- Three-dimensional flow dynamics in a rod bundle, which simulates a BWR fuel rod bundle, were measured by a developed void sensor, and this demonstrated the transition boundary of a flow regime (L11011).
- A TRACE code was validated against an experimental stability database based on the test facility, which simulates a BWR. The results indicate that the boiling correlation needs to be improved in the code (L11006).

Human Factors Research

In order to contribute to building an organization that exhibits good performance without any human errors during both normal times and during an emergency, we will develop measures toward preventing human errors and fostering safety culture by bringing out the features of individuals, teams, and organizations.

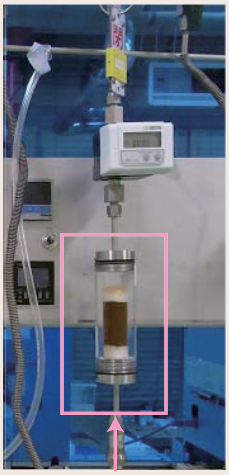
- We found that a High Reliability Organization (HRO), which can properly deal with unexpected events, has both an excellent ability to cope with emergencies and an excellent culture of safety, focusing on preventing human errors and accidents. We also clarified the roles of such a safety culture to build an HRO.
- We improved the method of analyzing human-factor events with emphasis on analyzing the causal factors of rule deviations. This method enables analysts of human-factor events to consider reasonable corrective actions, taking into account the actual conditions of rule deviations within an organization.

Nuclear Power Technology Applications/Innovative System Assessments

Innovative technologies obtained from nuclear power R&D are applied to other industrial fields, and technological assessments on the key technologies of the power system are carried out for the settlement of R&D strategies for future nuclear power systems.

- The present technological gap to be made up for by fusion energy development was evaluated by using the Technological Readiness Level (TRL) method developed by NASA, and the fusion power control method by changing the density ratio of a fuel particle (hydrogen) and a fusion-product (helium) was also proposed.

The Cs adsorption performance of the single-column test and the series-column test, simulated for an actual system, can be evaluated by opening or closing the valve in this system.



Cs adsorption column

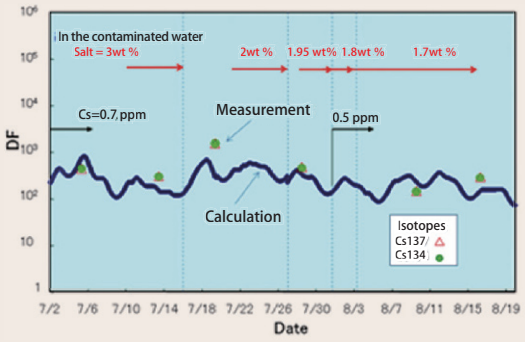


Fig. 1: Small zeolite column test equipment for the Cs adsorption apparatus at the Fukushima Daiichi Nuclear Power Station (left) and the calculated analysis using the developed code in CRIEPI (right)

The adsorption performance of KURION media was evaluated using the small-column test. The calculation code developed in CRIEPI accurately evaluated the actual Cs adsorption system. These results have been used to support the determination of an optimized operation schedule and have contributed to minimizing radioactive waste and the exposure of workers to radiation at the Fukushima Nuclear Power Station.