SAFETY RESEARCH PROGRAM OF NUCEF

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To contribute the safety and establishment of advanced technologies in the area of nuclear fuel cycle, Japan Atomic Energy Research Institute (JAERI) has constructed a new research facility NUCEF (Nuclear Fuel Cycle Safety Engineering Research Facility) as the center for the research and development, particularly on the reprocessing technology and transuranium(TRU) waste management.

NUCEF consist of three buildings, administration building, experiment building A and B. Building A has two experiment facilities STACY(Static Experiment Critical Facility) and TRACY (Transient Experiment Critical Facility). The experiment building B is referred to as BECKY(Back-end Fuel Cycle Key Elements Research Facility). Researches on the reprocessing and the waste management are carried out with spent fuels, high-level liquid waste, TRU etc. in the $\alpha\gamma$ cell and glove boxes(see Fig.1).

NUCEF was constructed with the following aims.

Using STACY and TRACY, are aimed

(1) research on advanced technology for criticality safety control,

(2) reconfirmation of criticality safety margin of the Rokkasho reprocessing plant.

Using BECKY, are aimed,

(1) research on advanced technology of reprocessing process,

(2) contribution to develop the scenario for TRU waste disposal,

(3) development of new technology for TRU partitioning and volume reduction of radioactive waste.

To realize the above aims, following 5 research subjects are settled in NUCEF,

(1) Criticality safety research,

(2) Research on safety and advanced technology of fuel reprocessing,

(3) Research on TRU waste management,

(4) Fundamental research on TRU chemistry,

(5) Key technology development for TRU processing.

Criticality Safety Research

Criticality experiment facilities in NUCEF: STACY and TRACY, provide criticality data of solution fuels such as nitrate solutions of low-enriched uranium, plutonium, and their mixture.

Research items using STACY are,

- Expansion of knowledge on criticality safety,
- Revision of criticality safety handbook,
- Realization of rational criticality safety design and control,
- Verification of criticality calculation code and nuclear data,
- Demonstration of criticality safety margin in the design of process equipment.

In STACY, criticality is attained by increasing solution fuel level. Using this facility, are measured basic criticality data such as critical volume temperature coefficient of reactivity and kinetic parameters as well as effectiveness of neutron absorber or neutron interaction effect. For the above experiments, several kinds of core tanks are prepared as shown in Fig.2.

Research items using TRACY are,

- Study on nuclear thermal fluid behavior in the reactor core,
- Improvement of the accuracy in a site evaluation,
- Development of estimation method of exposed radiation dose,
- Demonstration of confinement capability of radioactive materials.

In TRACY, reactivity is added by two ways, feed of solution fuel and control rod withdrawal. Major specifications of TRACY are shown in Table−1. Integral power limit is 32MW · sec($1x10^{18}$fissions).

Criticality safety research in chemical process is performed for,

- Verifying the phenomena under abnormal conditions and studying of "the third phase" to clarify its formation mechanism, etc.,
- Development advanced technology, i.e., application of organic neutron absorber to chemical process of nuclear fuel,
- Development of high precision inline monitor technique for measurement of nuclear fuel solution,
- Experiments to obtain the requisite data for criticality safety design and analysis.

For development of advanced technology, organic neutron absorber, m−carboran, is searched whose structure is shown in Fig.3. The features of it are soluble in organic phase, physically and chemically stable, and little influence on extraction performance. In Fig.4.

reactivity change by the concentration of organic boron compound is shown. Infinite neutron multiplication factor, K_∞ of solvent (30% TBP−dodecane) containing 30g/l plutonium decreases from 1.7 to 0.5 by adding 10g/l of organic boron compound. K_∞ being 0.5 means that the solvent never attain critical instead of its volume or geometry. So that large scale of extraction process can be constructed without concerning nuclear criticality.

Research on Safety and Advanced Technology of Fuel Reprocessing

Fundamental behaviors of radioactive nuclides are studied focusing the long−lived nuclides in particular. Assessment of radioactivity confinement capability under the nominal PUREX condition is conducted to verify the source term which has been assumed for the environmental safety assessment of reprocessing facility.

A new process PARC(Partitioning Conundrum Key Process) is developed aiming at the further reduction of waste generation and radioactivity releases in the future reprocessing. Separation efficiencies are enhanced for I−129 and C−14 in head−end, and Np−237 and Tc−99 in extraction. Am and Cm are recovered from highly radioactive raffinate. Figure 5 shows schematic flow diagram of the PARC process. As shown in this figure, Np and Tc are separated at extraction process.

Research on TRU Waste Management

TRU waste arising from reprocessing and MOX fabrication are treated and disposed into the geological matrix. New types of ceramics are developed as TRU waste forms. Migration behavior of TRU elements is studied in various substances composing engineered and natural barriers. Non−destructive measurement technique using active and passive neutron assay and quality inspection method by CT equipment are developed from the view point of the safety management of TRU waste.

Fundamental Research on TRU Chemistry

Fundamental data on elements are collected and evaluated by conducting characterization of high burn−up spent fuels and basic study on reprocessing based on new principle.

Key Technology development for TRU processing

Key technologies of TRU processing are developed focusing on TRU waste treatment method and process operation system, using the fuel treatment facility for critical experiment in NUCEF. The technologies are applied to enhance the safety operation of reprocessing facility.

Research Collaboration

Since NUCEF is a large research complex for the studies on safety and development of basic and advanced technologies of fuel cycle back−end with a wide variety, it is important to maximize the effectiveness of research activities in the facility by conducting cooperative research with other organizations. For examples, JAERI and CEA of France signed a General Cooperation Agreement, and JAERI and IPSN are cooperating under the general agreement. As shown in Fig.6, under the JAERI−IPSN cooperation agreement, research on criticality safety is carried on. JAERI and CEA are cooperating in the field of fuel cycle radioactive waste and fuel management. NUCEF is expected to play important roles for research collaboration and aims to be new research center as shown in Fig.7.

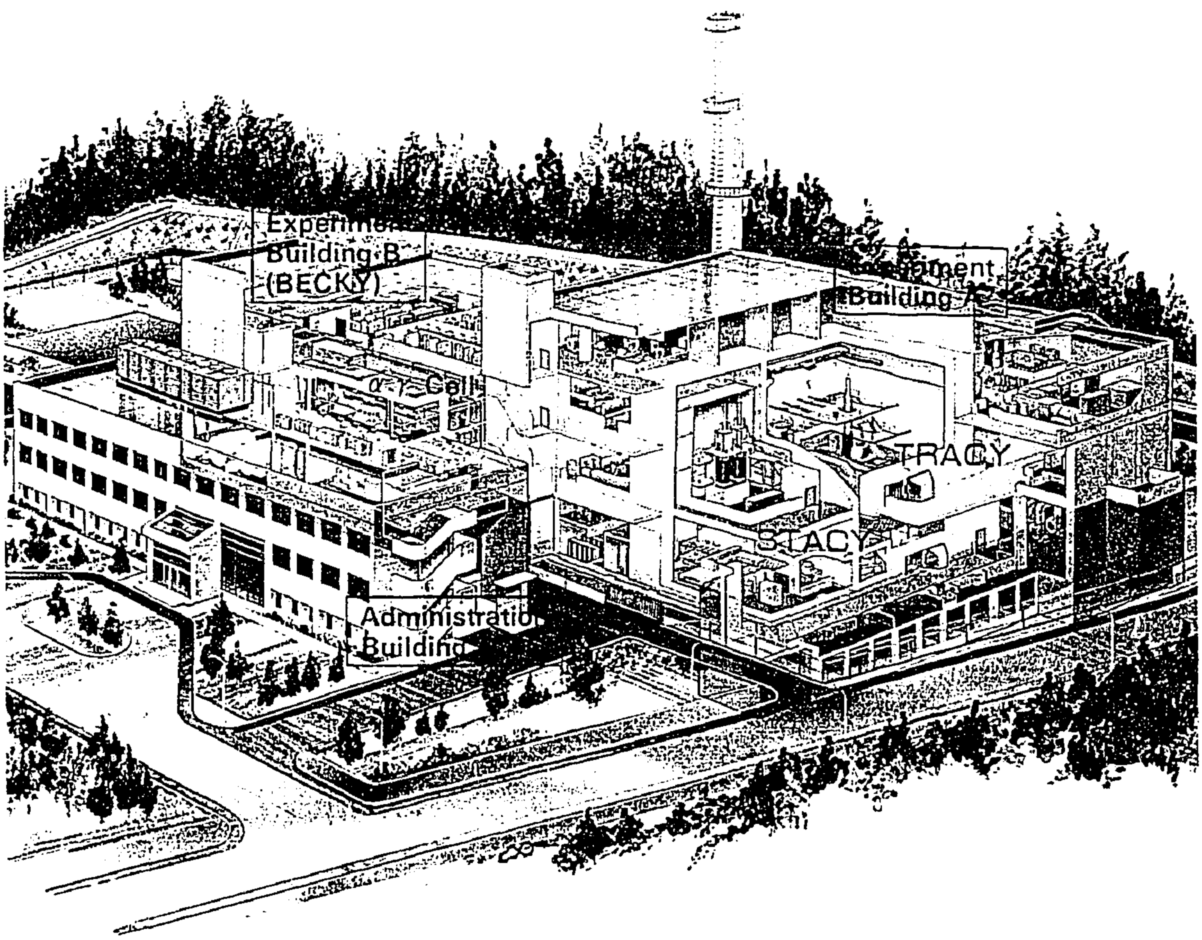


Fig.1 ▲ NUCEF buildings
NUCEF is composed of Administration Building, Experiment Building A and B.

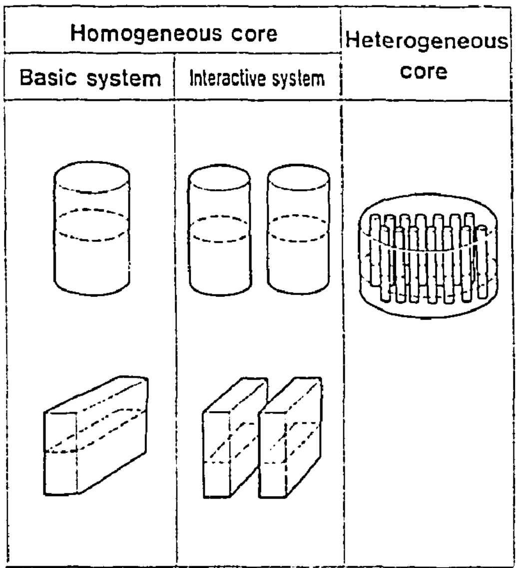


Fig.2 Shape of STACY core tank

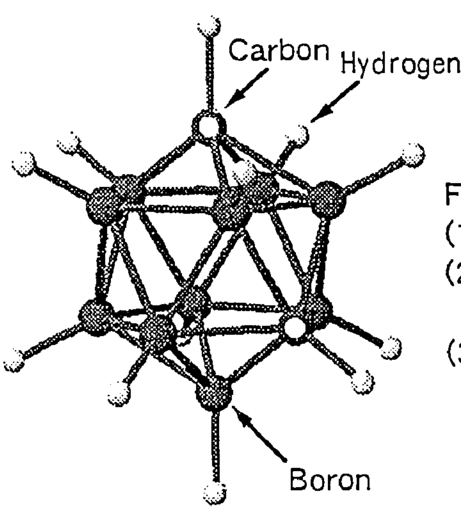
Table.1

TRACY

Transient Experiment Critical Facility

Power	Max. 10kW (stationary operation) Max. 5000MW (transient operation)
Excess Reactivity	Max. 0.8$ (stationary operation) Type T50 Max. 3$ Type T80 Max. 2$ (transient operation)
Core volume	Type T50 Max. 0.2m³ Type T80 Max. 0.5m³
Reactivity control method	Feed and drainage of solution fuel Withdrawal of a transient rod

Major specification of TRACY



Features;
(1) Soluble in organic phase,
(2) Physically and chemically stable, and
(3) Little influence on extraction performance

Structure of m-carborane ($H_{12}B_{10}C_2$)

Fig.3 Criticality Safety Design by Using Soluble Neutron Poison

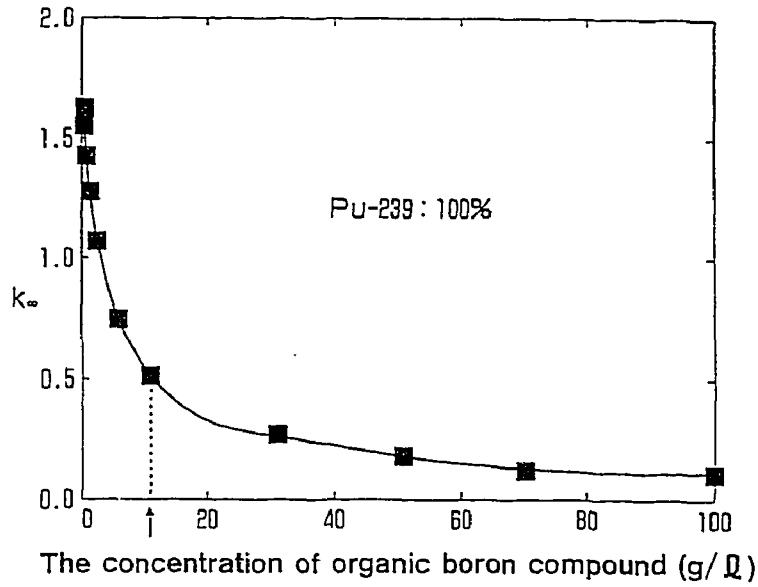


Fig.4 Effect of organic neutron absorber

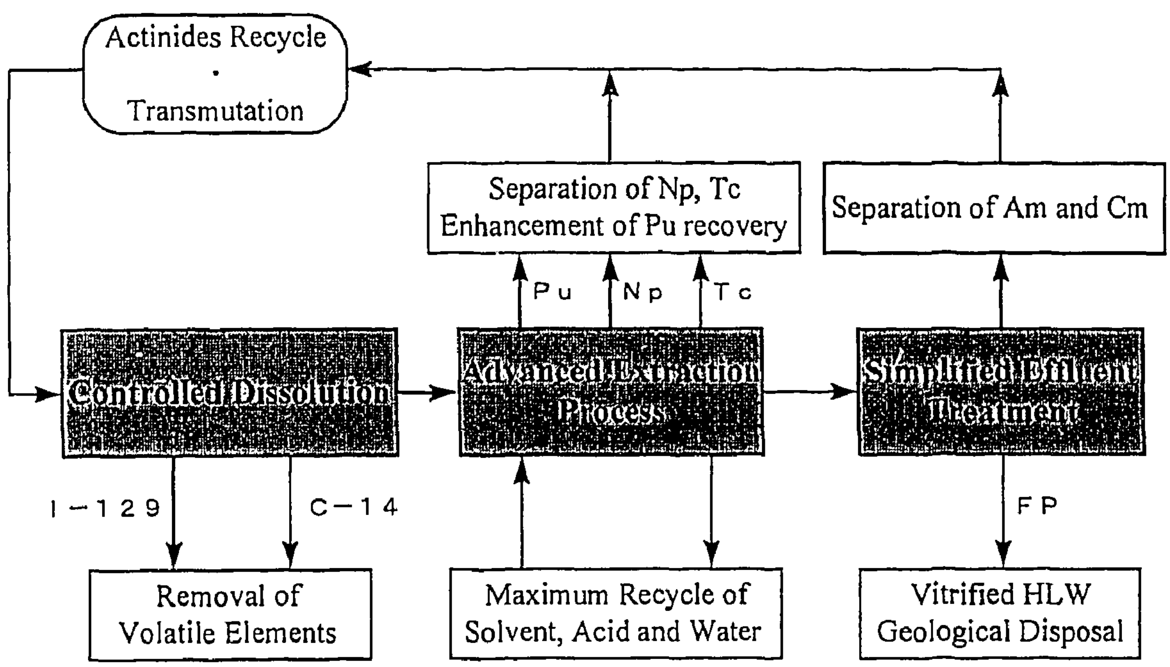
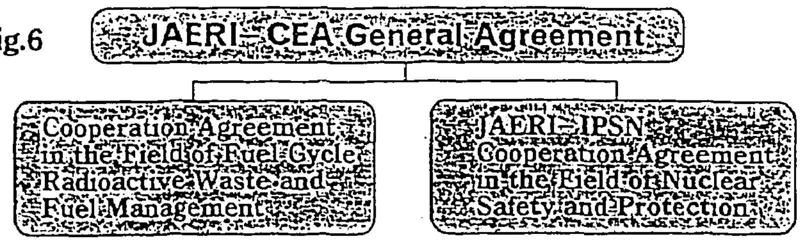


Fig.5 Advanced Reprocessing Incorporated with Partitioning Function (PARC PROCESS)

Fig.6



Specific Topic of Cooperation	Specific Topic of Cooperation
(1) Research on TRU and long-lived radionuclides partitioning	(1) Criticality Safety

(2) Migration Behavior of long-lived nuclides in geological media

(3) Studies on nondestructive measuring and testing techniques of TRU waste packages

Fig.7 **New Research Center NUCEF**

Research Promotion by Cooperation with Other Organization