PROGRESS IN RADIOACTIVE WASTE MANAGEMENT IN JAPAN

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ABSTRACT

Nuclear power has become the major source of electric power generation in Japan. For this reason, technology development for radioactive waste treatment and disposal is one of the most important concerns in Japan's nuclear power policy.

In Japan, management of radioactive wastes has been conducted in accordance with the "Long-term Nuclear Energy Development and Utilization Program" (June, 1987) determined by Japan Atomic Energy Commission and with the policies regarding the regulation given by Japan Nuclear Safety Commission to ensure safety.

This paper describes the Japanese management policies for radioactive wastes with emphasis on the present status of research and development for treatment and disposal of high-level radioactive wastes (HLW) and TRU wastes.

INTRODUCTION

The first commercial nuclear reactor in Japan commenced its operation in July 1966. Since then 36 nuclear reactors have been put into operation by 1988 and their total capacity is about 28 GWe which is equivalent to approximately 30% of the total electricity supply. By the year 2000, nuclear power total capacity in Japan is expected to reach 54 GWe which is equivalent to 40% of the total electricity supply.

By the end of March 1988, the volume of LLW generated in Japan reached the equivalent of 710,000 drums of 200 litre capacity. A LLW disposal by shallow land burial is scheduled to commence operation around 1991 in Rokkasho Mura, Aomore Prefecture.

HLW currently stored at the reprocessing plant as liquid form is to be vitrified into a stable form. By the year 2030, the number of such vitrified HLW will be 40,000 canisters of 110 litre capacity. The HLW is to be disposed of into geological formations deeper than several hundreds of meters ("geological disposal") after 30 to 50 years of cooling period.

The geological disposal of the HLW is to be carried out in four stages: "Selection of Effective Formations" (First Stage); "Selection of the Candidate Disposal Site" (Second Stage); "Demonstration of the Disposal Technology at the Candidate Disposal Site" (Third Stage); and "Construction, Operation and Closure of Disposal Facilities" (Fourth Stage). The First Stage was completed in 1984. Currently the second stage is on going with the following objectives:

1. research and development (R&D) aimed at consolidating the geological disposal technology:
2. surveys to evaluate the appropriateness of such things as the geological environment; and
3. selection of candidate disposal site.

Under the guidance of STA (Science & Technology Agency), PNC (Power Reactor & Nuclear Fuel Development Corporation) takes a major role of executing such R&D activities.

TREATMENT OF HLLW

In accordance with the national policy that the research should be performed by placing emphasis on vitrification of HLLW with borosilicate glass, PNC has carried out the basic tests on glass composition, cold engineering tests for processing technology development and hot performance tests. The development works have been done in close cooperation with the universities, governmental institutions and private companies as well as with the groups of West Germany and the United States.

To demonstrate the vitrification technology based on the results obtained until now, Tokai Vitrification Facilities (TVF) is currently under construction aiming at its startup in F.Y. 1991. The details of works mentioned above are explained in the succeeding sections.

1. Compositions of Vitrified Wastes

   Borosilicate glass was selected as the basic glass material and about 600-type glasses which were subjected to melting tests to develop a glass composition, to optimize waste contents, to confirm the variation allowance in waste components and thereby to determine the basic vitrified waste composition.

2. Properties of Vitrified Wastes

   The chemical stability of vitrified wastes was evaluated by a series of long-term leaching tests under conditions of various temperature, pressures, time, leach rate, composition pH, and flow rates.

The radiation stability was evaluated by a-rays utilizing the reaction $^{10}B(N,\alpha)^{7}Li$ to simulate α decay, indicating

that only a little changes were found in the physical properties of the waste glasses.

Development of Process Technology

The vitrification process consists of pretreatment, glass melting, off-glass treatment, and package handling. The structure of melter is shown in Fig. 1.

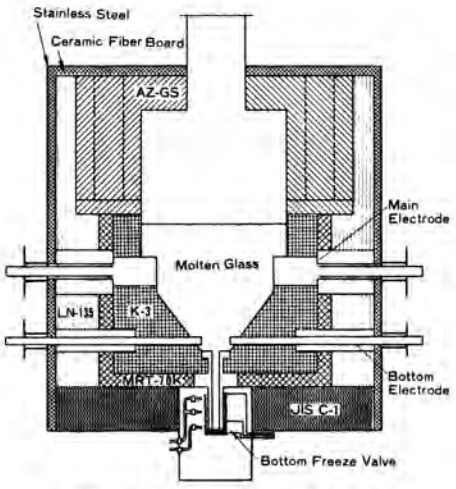

Fig. 1. Melter Cross Section.

Since 1979, the vitrification process has been developed to demonstrate its performance by using a full-scale testing system and simulated solutions.

Hot Tests

Hot vitrification tests have been performed since 1982 in Chemical Processing Facility (CPF) by using actual HLLW generated in Tokai Reprocessing Plant. These hot tests with Liquid Fed Ceramic Melter (LFCM) has been carried out and characteristics of the resultant vitrified wastes were observed.

Tokai Vitrification Facility (TVF)

The purpose of TVF is to demonstrate the vitrification technology by compiling the results of development carried out to date.

The treatment capacity of HLLW (melter capacity) is 0.35 m3/day and the storage capacity for vitrified waste is 420 packages.

As to the plant design, LFCM equipment are placed in a large remote-maintenance cell with rack module systems. The construction schedule of TVF is shown in Table I. The bird's eye view of TVF is shown in Fig. 2.

TABLE I
Schedule of TVF

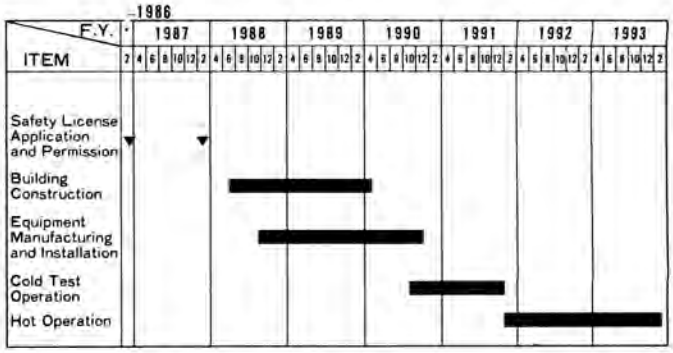

Fig. 2. Bird's eye View of TVF.

DISPOSAL OF HLW

PNC has promoted the research and development on the geological disposal of HLW since F.Y. 1977. The first stage research and development (selection of potential geological formations) was terminated in 1984, followed by the second stage (selection of candidate disposal sites) being conducted at present.

According to "Long-term Nuclear Energy Development an Utilization Program" (June 22, 1987)(see Fig. 3)., the role of PNC at the second stage includes:

1. to be the leading organization of the research and development for establishing the geological isolation technology, and
2. to conduct investigation for evaluating the adequacy of geological environment.

On the basis of these situation, the second stage was divided into two parts. In the first part, "PNC will clarify the premises for geological disposal in Japan, feasibility of the geological disposal system, and its long-term performance", and in the second part, "PNC will determine the basic specifications for the geological disposal system, and carry out geological investigations to provide background for the selection of candidate disposal sites". The following sections

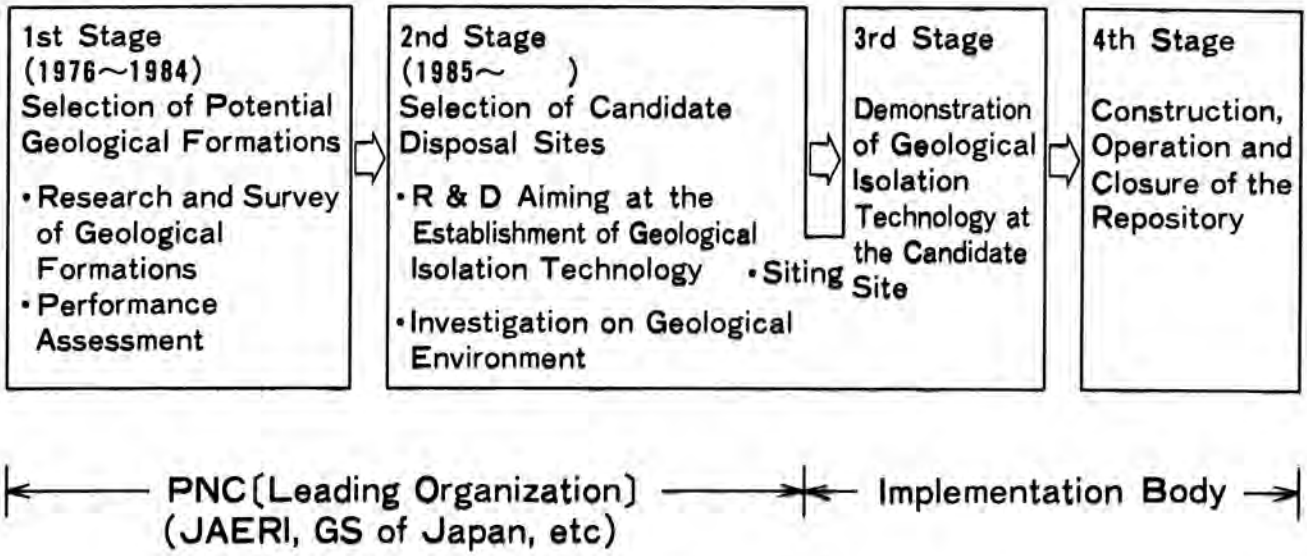

Fig. 3. National Program for Geological Isolation.

summarize the Research and Development activities carried out to date, and will be performed in the future.

Studies on Natural Barriers

A natural analogue study has been carried out in the uranium deposit of Tono Mine. The study includes measurements of retardation factors, evaluation of concentrations, colloid and speciation, and disequilibrium of uranium series.

In-situ experiments in the mine was initiated in Kamaishi in 1988 to investigate hydraulic mechanism, and effects of heat and excavation on hydraulics and mechanical properties of rocks, and adequacy of various site-investigation equipments.

Laboratory-scale tests for evaluating adsorption characteristics of radionuclides to rocks are also in progress in Tokai Works, whereas adsorption tests of the solutions leached out from actual vitrified wastes in CPF has been carried out.

Studies on Engineered Barriers

The leaching tests for actual vitrified wastes under simulated-disposal conditions, corrosion evaluation for candidate overpack materials, and evaluation of long-term stability of buffer materials and migration of nuclides have been carried out in Tokai Works. As a part of natural analogue study on the engineered barriers, alteration in quality of natural glasses were investigated and compared with those of the waste glasses.

Modeling of the performance of various engineered barriers will be carried out. In addition, thermodynamic data will also be acquired for evaluation of migration behavior of the nuclides.

Development of HLW Disposal Systems

Investigation of design system, development of design program, establishment of design concept, and the repository layout are under way.

Studies on Performance Assessment

To evaluate long-term performance of geological disposal systems, evaluation codes are under development (see Fig. 4).

Some of the sub codes have been subjected to international comparison (INTRAVAL PSACOIN).

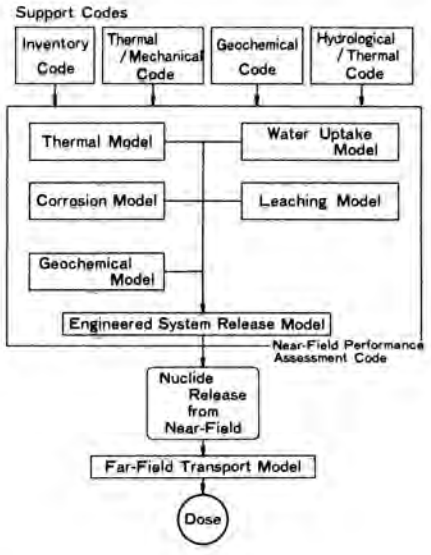

Fig. 4. Structure of Performance Assessment Model.

Efforts will be made to improve into a more realistic model which can evaluate uncertainties in data andrepresent details of phenomena.

Investigation of Geological Environment

Literature survey and geological reconnaissance on a nation wide basis have been conducted to outline the geological environment from the viewpoint of geological disposal. In parallel with such activities, development of equipments to investigate geological environment have been carried out.

Since F.Y. 1988, permeability test equipments for low permeable layers nad the deep groundwater sampling have been developed.

International Collaboration

PNC participates in the Phase III of the OECD/NEA International Stripa Project as well as OECD/NEA International Arigator Rivers Analogue Project. The joint research between PNC and Atomic Energy of Canada Limited (AECL) has been continued for the migration of groundwater in crystalline rocks. Collaboration with Belgian Nuclear Research Center on migration of nuclides in sedimentary rocks has also been active. General information exchange on the management of radioactive wastes has started between PNC and NAGRA Switzerland.

TREATMENT OF TRU WASTES

Technological demonstration of conventional incineration and melting-solidification of plutonium contaminated wastes has been carried out in Plutonium contaminated Waste Treatment Facility (PWTF). The treatment process flow of PWTF is shown in Fig. 5.

Plutonium contaminated wastes include combustibles, Cl contained materials and metallic materials generated from the plutonium fuel fabrication processes and by dismantling equipment and glove boxes.

These wastes received in PWTF are sorted, volume-reduced by the several methods depending on the properties of the wastes, and solidified into ceramics or metal ingots.

Low-level concentrated wastes generated from TRP are subjected to bituminization and the resultant solid wastes, which account for a significant percentage of the TRU wastes, are stored safety in the storage facilities.

DISPOSAL OF TRU WASTES

The major part of Research & Development for the disposal of TRU wastes has been considered as a part of such activities for the HLW. The research and development currently being performed specifically for TRU wastes are as follows:

1. Characterization of solidified wastes such as leaching rates and strength are carried out in PWTF, NDA technique are also being developed for measurement of the amounts of TRU nuclides.

2. To obtain basic data of plutonium diffusion and adsorption in buffer materials and rocks.

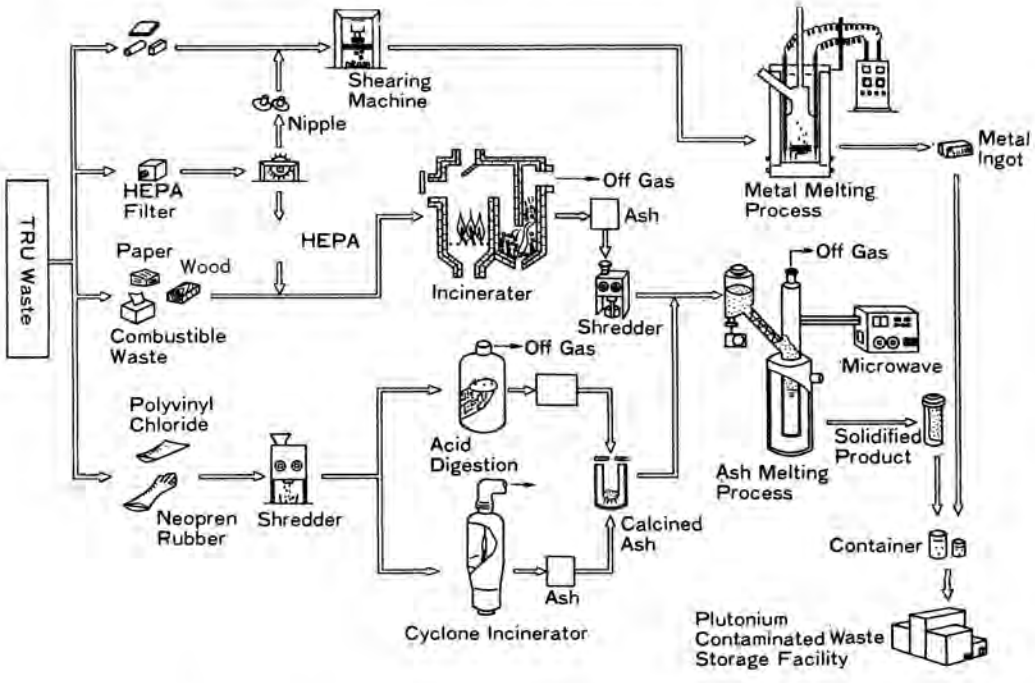

Fig. 5. Plutonium Contaminated Waste Treatment Process Flow.

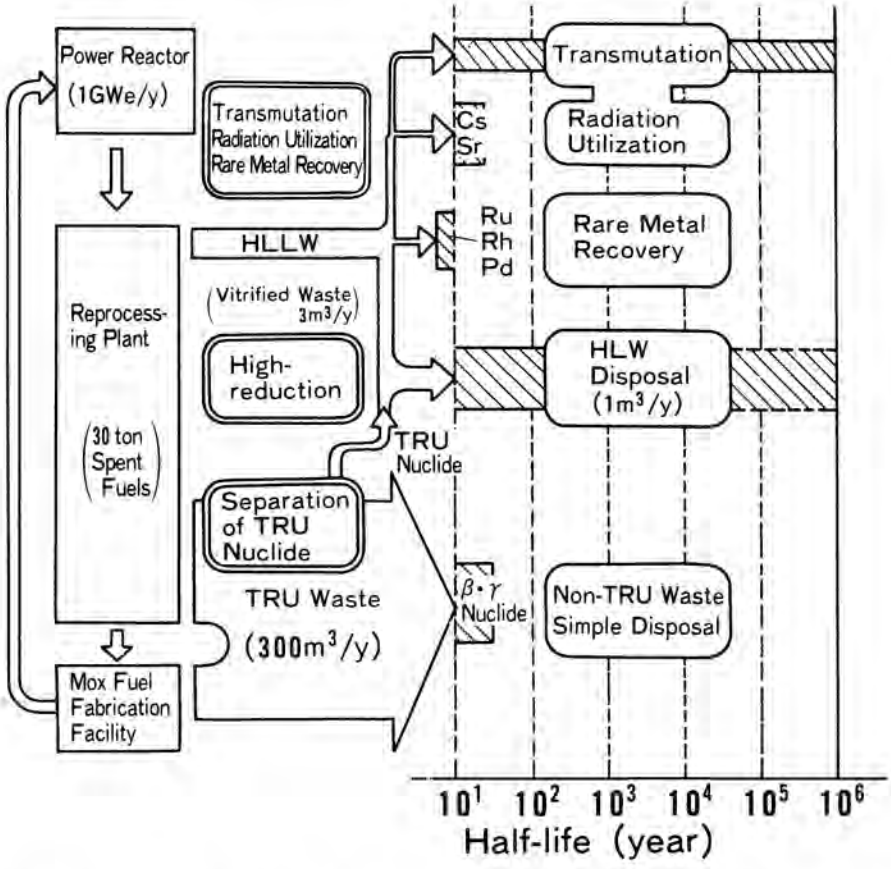

Fig. 6. Systematical Summary of Technological Development Related to HLW and TRU Waste.

To reduce the burden, PNC has tackled positively with the systematization of waste treatment technology as shown in Fig. 6.

CONCLUSION

In Japan, high-level liquid waste treatment technology has been developed through a significant cold tests and hot tests conducted by PNC in these 10 years. On the basis of these R&D results, Tokai Vitrification Facility (TVF) with LFCM process is designed and now under construction aiming at starting hot operation in F.Y. 1991.

National program for geological isolation of HLW in Japan consists of 4 sequential stages. In 1985, the 2nd stage was initiated in order to accomplish a steady back ground for scientific, technical and social issues involved in this area on which "siting" and subsequent stages will stand on, PNC has been assigned the principal role of planning, executing and evaluating the R&D which includes studies on performance assessment, engineered barriers, natural barriers and so on.

In the field of TRU waste treatment, waste conditioning technologies such as acid digestion, melting solidification are being demonstrated at the PWTF since December 1987.

Technology regarding TRU waste disposal is also under study as well as innovative waste treatment technologies.

REFERENCE

1. T. Tsuboya, N. Tsunoda, "The Japanese Vitrification Program", Proceeding, Waste Management '88.