THE NEW JAPANESE POLICY FOR TRU-WASTE MANAGEMENT

M. Yamamoto
Power Reactor and Nuclear Fuel Development Corporation
1-9-13, Akasaka, Minato-ku
Tokyo 107 Japan

ABSTRACT

In July 1991, the Advisory Committee on Radioactive Waste of the Japan Atomic Energy Commission announced its report on a new Japanese policy for TRU-waste management. The total volume of radioactive wastes which contain TRU nuclides has reached the equivalent of about 40,000,200-liter drums, and is expected to grow to about 300,000 drums by the year 2010.

Further development is required to reduce the volume of the existing waste and to decrease the amount of waste being generated. Wastes with concentration levels exceeding a threshold limit of 1 Giga-Becquerel per ton will be disposed in an underground facility. Those wastes with lower activities will be sent to a shallow-land burial facility. The goal of research and development is the completion of the disposal system by the late 1990's.

INTRODUCTION

Japan intends to develop a closed nuclear fuel cycle. The number of operational reactors presently is forty with a capacity of about thirty-two million kilowatts. Wastes will begin to return from overseas reprocessing in the near future. Furthermore, the development of the fast breeder reactor has been proceeding.

The Advisory Committee on Radioactive Waste of the Japan Atomic Energy Commission announced a report in July 1991 titled "Treatment and Disposal of Radioactive Wastes Including Some of the TRU Nuclides"(1). This report considers the policy for treating and disposing radioactive wastes containing transuranic (TRU) nuclides.

The radioactive wastes generated by spent-fuel reprocessing and by MOX (mixed uranium/plutonium oxide) fuel fabrication contain some TRU nuclides. These nuclides are alpha emitters with long half lives. The wastes also contain other gamma- and beta- emitting nuclides. We call these residual wastes TRU-bearing wastes.

Most of the TRU nuclides remaining from waste reprocessing will be vitrified and disposed as high-level wastes in a geologic repository. The geologic repository is an engineered disposal facility in a stable rock formation at a depth greater than several hundred meters. Not all of the TRU materials can be included in the vitrified wastes. These residual wastes from the fuel reprocessing system lie within the definition of TRU-bearing wastes. The higher-activity TRU-bearing wastes will be disposed in an underground facility which may or may not be part of the geologic repository. These higher-level wastes are called "TRU wastes". TRU-bearing wastes which have low TRU activities will be considered part of the low-level waste inventory and disposed in a shallow-land burial facility. A major focus of this paper is the description of the sources and types of these TRU-bearing wastes and the criteria for separating them into TRU waste and low-level waste categories.

The Japan Atomic Energy Commission announced its "Long-Term Program for Development and Utilization of Nuclear Energy"(2) in 1987. The program addressed the need for separating the various TRU-bearing wastes according to the most appropriate methods for their disposal. A system for classifying these wastes is an important part of the management and disposal policy.

The amount of radioactive waste containing TRU nuclides is expected to increase as reprocessing and MOX fuel fabrication operations expand. Hence, the treatment and disposal of these wastes must be carried out efficiently and systematically. This paper presents the fundamental approaches for the treatment and disposal of radioactive waste containing TRU nuclides in Japan.

TYPES OF TRU-BEARING RADIOACTIVE WASTE AND THE CURRENT STATE OF TREATMENT

Types of Radioactive Waste Containing TRU Nuclides

Most of Japan's radioactive waste containing TRU nuclides is currently generated at the Tokai reprocessing plant and the MOX fuel fabrication facility of the Power Reactor and Nuclear Fuel Development Corporation (PNC). Currently, these TRU-bearing wastes are kept at storage facilities such as those at the Tokai reprocessing plant and the MOX fuel fabrication facility.

The amount of waste containing TRU nuclides is expected to increase as wastes return from overseas reprocessing and as domestic commercial reprocessing plants come into operation in the near future.

The characteristics of the TRU-bearing wastes generated at each facility differ according to the structure of the plant and the plant's system of radioactive waste management. The principal types of radioactive waste containing TRU-nuclides generated at PNC's Tokai reprocessing plant are as follows:

- hulls and end pieces;
- concentrated liquid waste from reprocessing (which is divided into two groups according to radioactive concentration -- low level and very-low level);
- spent solvent;
- sludge; and
- miscellaneous solid waste from reprocessing.

The miscellaneous solid wastes are further divided by radioactive concentration into low-level and very-low level, and by incineration capability into "combustible" and "non-combustible" categories. A sixth category, miscellaneous solid waste from PNC's MOX fuel fabrication facility, also is

divided into "combustible" and "non-combustible" categories for incineration purposes.

The Present State of Treatment

The treatment methods currently utilized at the Tokai reprocessing plant are

- volume reduction through the evaporating and concentration of liquid waste from reprocessing,
- bituminization of the concentrated liquid waste, and
- plastic solidification of spent solvent.

Methods used at the MOX fuel fabrication facility are:

- incineration of combustible miscellaneous solid waste,
- microwave solidification by melting of ash from incineration, and
- solidification by melting of miscellaneous non-combustible waste

The Characteristics of TRU-Bearing Wastes

Radioactive waste containing TRU-nuclides is generated in relatively large volumes as compared with other waste types, such as high-level waste, and its concentrations of alpha nuclides and beta/gamma nuclides may vary greatly.

The radioactive wastes presently generated by PNC include:

- wastes whose concentration of alpha nuclides is very low, such as concentrated liquid waste from reprocessing;
- wastes, such as low-level concentrated liquid waste, whose concentration of alpha nuclides ranges from a few hundred to a few thousand Becquerels per gram and whose concentrations of beta and gamma nuclides are low; and
- products, such as hulls/end pieces, with high concentrations (several hundred thousand Becquerels per gram) of not only alpha- but also beta- and gamma-emitting nuclides.

There also is a category of miscellaneous solid wastes. These include reprocessing wastes with alpha concentrations below several hundred Becquerels per gram and similarly low beta- and gamma-nuclide concentrations. Also in this category are miscellaneous solid wastes with alpha-nuclide concentrations ranging from several to several hundred thousand Becquerels per gram and low beta/gamma-nuclide concentrations.

Most of the TRU-bearing wastes are non-exothermic; however, there are some products, such as hulls and end pieces, that have been made slightly exothermic by the activated products inside. Each facility and each treatment produces a radioactive waste possessing physical and chemical properties particular to that process. Each waste type must be processed using a method suited to that waste type's properties. Even solidification, for example, uses a variety of materials, such as asphalt, plastic, cement, metals, and ceramics, to fit the waste characteristics.

CURRENT WASTE INVENTORY AND FUTURE PROJECTIONS

Currently, Japan has a TRU-bearing waste inventory which is equivalent to forty-thousand, 200-liter drums. The actual volume is larger, however, as much of this waste is awaiting processing to reduce its volume.

The estimates of the future amounts of waste are based on the following:

- the operational results obtained up to the present at PNC's Tokai reprocessing plant and MOX fuel fabrication facility:
- the calculated amounts of waste generated and the radioactive concentration for each process at the various facilities;
- and the expectations, based on the 1987 "Long-Term Program for Development and Utilization of Nuclear Energy"(2), for domestic and overseas reprocessing and fuel fabrication.

According to these estimates, the second half of the 1990's will see a considerable increase in the amount of waste produced. The cumulative volume is forecast to reach the equivalent of approximately three-hundred thousand, 200-liter drums by the year 2010. Additional radioactive wastes containing TRU nuclides also are expected to be produced by the future decommissioning of nuclear-fuel facilities.

THE PRESENT STATE OF RESEARCH AND DEVELOPMENT IN TREATMENT AND DISPOSAL

Essentially, TRU-bearing waste can be treated using existing technology. A portion of this waste is already being treated on a demonstrational scale by PNC. PNC and the Japan Atomic Energy Research Institute (JAERI) are both performing research on solidification with the aims of stabilization and improvement of cost-effectiveness. These two organizations are also studying methods to decrease waste generation through volume reduction. At the Tokai reprocessing plant, applications of research results have already reduced the volume of the concentrated liquid-wastes generated during reprocessing. Significant reductions in waste generation have also been achieved through decontamination of miscellaneous solid wastes. The commercialization of these technologies is expected to be feasible in near future.

Research and development efforts are improving the sampling and measurement of nuclide concentrations. Some areas of emphasis include forms of direct measurement and non-destructive assay techniques, such as passive-neutron and active-neutron methods.

PNC and JAERI are currently engaged in fundamental research and development on disposal on the shallow-land burial and geological disposal methods. These efforts include research on

- long-term integrity of solidified waste,
- long-term characteristics of concrete and other engineered barrier materials,
- migrational behavior of nuclides inside engineered barriers, and
- interactions -- through ground water -- between nuclides and soil or rock.

Additionally, performance-assessment models are investigating the relative importance of the individual nuclides, their properties, and the processes related to the safety of waste disposal. The results obtained from the research programs on high- and low- level wastes are being applied to

research related to the disposal of wastes containing TRU nuclides.

TRENDS IN POLICIES OF FOREIGN GOVERNMENTS REGARDING TREATMENT AND DISPOSAL

Trends in Treatment

Besides the Japanese nuclear program, other countries with active reprocessing facilities, such as U.K. and France, have programs for TRU-bearing waste treatment. The approaches include cement solidification and other existing technologies. The development programs for new technology emphasize advanced methods which generate less waste and reduce volume through further separation of radioactive nuclides from the radioactive wastes.

Trends in Disposal

There are a variety of policies regarding the disposal of radioactive waste containing TRU nuclides.In the United States and France, the wastes are designated for either shallow-land burial or geological disposal depending on a fixed concentration level of alpha-emitting nuclides. Although Switzerland and Germany classify their wastes, geological disposal has been selected over shallow-land burial as the primary method of disposal for all radioactive wastes. Thus each country's plans for specific methods of disposal reflect the basic national policy toward disposal. Most national programs are using the research and experience from the disposal of reactor wastes to guide the planning for TRU-bearing wastes. The disposal of TRU-bearing wastes is expected to begin around the year 2000. High-level waste disposal will begin later in the twenty-first century.

FUNDAMENTAL IDEAS REGARDING TREATMENT AND DISPOSAL

Fundamental Ideas Regarding Treatment

As stated earlier, radioactive wastes containing TRU nuclides are generated in relatively large amounts and from a variety of sources. It is therefore important to use such methods as decontamination and volume reduction to reduce the amount of radioactive waste being generated. It is also important to implement treatments which are suited to the physical and chemical qualities of each type of waste. Although treatment technology is sufficiently advanced to be commercialized now, further research and development efforts are important to continually improve treatment technology and to develop more advanced methods.

Research programs on decontamination and radionuclide-removal methods are an important part of the strategy for abating the generation of waste. These methods may be applicable to both theconcentrated-liquid and the non-combustible-solid types of TRU- bearing wastes.

Fundamental Ideas Regarding Disposal

As with low-level reactor waste, shallow-land burial is considered suitable for those TRU-bearing wastes which have low concentrations of alpha nuclides and relatively low concentrations of beta and gamma nuclides. On the other hand, radioactive waste with relatively high concentrations of alpha nuclides will be isolated using methods other than shallow land burial. Such methods (hereafter referred to as "underground disposal other than shallow land burial") will employ advanced engineered barrier systems to assure isolation from the environment. Radioactive waste for which such disposal methods have been deemed appropriate are hereafter referred to as "TRU waste".

Low-Level Radioactive Waste for Which Shallow Land Burial Is Possible: This section of the paper considers criteria for selecting the TRU-bearing wastes which may be disposed by shallow-land burial. Since 1986, laws have been passed regulating the shallow-land burial of low-level radioactive waste generated by nuclear reactors. These regulations define radioactive-concentration ceiling values for shallow-land burial. Among these various ceiling values which have been proposed is a concentration of all alpha nuclides of 1.11 Giga-Becquerels per ton (0.03 curie per ton). The consequences of exposures from each nuclide form the basis for the ceiling value calculation. The type of facility which generates the waste is generally not taken into consideration. As with the radioactive materials generated by nuclear reactors, the evaluation of exposure from each nuclide is the basis for the policy on the disposing the TRU-bearing wastes from reprocessing and other facilities. Thus, the reactor-waste criterion is an appropriate tentative criterion. This threshold concentration for all alpha nuclides is set at approximately 1 Giga-Becquerel per ton.

Before the actual implementation of shallow-land burial, it will be necessary to replace the tentative criterion with final ceiling-concentration values for disposing TRU nuclide-containing waste by shallow-land burial. The Atomic Energy Safety Commission will deliberate the issue of this threshold value, while also considering such aspects as the composition of nuclides contained in waste and the evaluation of safety.

Some reprocessing wastes have concentrations of alpha nuclides lower than the tentative criterion for threshold concentration. They also have very low concentrations of beta and gamma nuclides. These very-low level wastes are solidified from some liquid-waste concentrates and some miscellaneous solid wastes. Their low concentration makes these wastes candidates for shallow land burial.

TRU Waste:Specific disposal policies must be investigated for miscellaneous solid wastes generated from MOX fabrication, hulls/end pieces, and other waste for which shallow land burial is not appropriate (that is, TRU waste). TRU waste will be disposed in an underground facility. In order to ensure the long-term prevention of environmental contamination by TRU nuclides, which have long half-lives, it is crucial that the investigation of specific disposal alternatives for TRU waste include safety measures that take into consideration the special characteristics of TRU waste. These characteristics include the radioactive concentration, exothermicity, and the physical and chemical properties of the solidified form. Among the important safety measures are the necessary depth of underground disposal and properties required of engineered barriers.

FUTURE IMPLEMENTATION OF SPECIFIC DISPOSAL POLICIES

It is important to base the implementation of the shallow-land burial of TRU-bearing waste on experience in the disposal of low-level radioactive waste generated by nuclear reactors. It is also advisable to investigate the possibility of trench disposal and other reasonable means of disposal for

radioactive waste with particularly low levels of radioactive concentration.

The amount of low-level radioactive waste for which shallow-land burial is possible will be affected by such factors as future developments in treatment technology. It has been estimated that approximately 40% of the current waste inventory will be eligiblefor shallow-land disposal. This estimate is based on present treatment techniques and the types TRU nuclide-containing radioactive wastes which have been generated to date at PNC's Tokai reprocessing plant and MOX fuel-fabrication facility.

After making all efforts to reduce the volume of wastes which are generated, there will still be a portion which must be sent for underground disposal. For underground disposal of TRU waste,it is also necessary to determine in detail what the future disposal methods will be. For this reason, and to prepare for the eventual implementation of commercial reprocessing, it would seem appropriate to speed up investigations so that a more precise appraisal of the situation will be possible by the second half of the 1990's. Furthermore, the securing of funds, the development of a system organization, and the preparation of a schedule for the implementation of actual disposal all must also be accelerated.

Because TRU wastes include a wide range of radioactive concentrations and a variety of solidified forms, it is first necessary to determine which disposal methods are best suited to each waste type's radioactive concentrations, physical attributes, chemical properties, and other characteristics. However, making a separate determination of disposal method for each type of radioactive waste is not realistic in terms of the overall rationalization of TRU waste disposal. It would therefore seem appropriate to integrate where possible and optimize separate disposal methods while ensuring that safety is maintained.

ISSUES IN RESEARCH AND DEVELOPMENT RELATED TO TREATMENT AND DISPOSAL

Points To be Given Consideration in Research and Development

The development of advanced treatment technology can be expected to contribute to improvements in cost-effectiveness and to considerable reductions in the generation of TRU waste. These advanced methods include (1) decontamination of non-combustible miscellaneous solid waste and (2) removal of radioactive nuclides from the low-level concentrated liquid wastes generated during reprocessing. Also, it would seem appropriate to proceed with the development of technology for removing radioactive nuclides from wastes. Such research is being carried out under the "Long- Term Program for Research and Development on Nuclide Partitioning and Transmutation Technology"(3). This program was announced in October 1988 by the Japan Atomic Energy Commission's Advisory Committee on Radioactive Waste. Improvements in the stabilization of solids produced by the melting of miscellaneous solid reprocessing wastes would also contribute to improving cost-effectiveness and savings.

Technologies related to quality assurance and to the measurement of TRU nuclides are valuable for the proper analysis of the radioactive concentration of solidified substances. The measurement technologies are necessary for classifying the waste according to radioactive concentration before solidification. The following three research issues are basic to the creation of a definite system for disposal of radioactive waste containing TRU nuclides:

- assessment of the physical properties of radioactive waste,
- issues related to specific disposal methods, and
- the development of techniques for performance assessment

These areas share many common aspects with the research and development programs for high-level radioactive waste and low-level radioactive waste generated by nuclear reactors and other facilities. It would be effective and efficient to take into account the extent of progress made in the research and development related to such radioactive waste. PNC is working with the cooperation of JAERI to fulfill the "Long-Term Programfor Development and Utilization of Nuclear Energy"(2).

Issues in Research and Development Related to Treatment

Technology for Reduced Waste Generation, Further Volume Reduction and Stabilization: Reducing the volumes of waste generation requires the development of new technologies. Among the technologies to be developed are the following: decontamination of non-combustible miscellaneous solid waste, removal of radioactive nuclides from concentrated liquid waste generated during reprocessing, and the decomposition of spent solvents.

Also, to improve safety and cost-effectiveness in storage and disposal, technology is to be developed for the following:

- further volume reduction of hulls/end pieces through high- pressure compression and hot isostatic pressing, etc.,
- stabilized solidification of residue from nuclides removal process and of non-combustible miscellaneous solid waste, and
- other forms of treatment.

Measurement and Quality Assurance: For measurements such as those of radioactive concentration of solidified substances and for classification of waste according to radioactive concentration, measurement technology will be developed to improve the accuracy and reduce the time required for measurement. Technology will also be developed for quality assurance of solidified substances, which is important to control of their physical and chemical properties.

Issues in Research and Development Related to Disposal

Projections on Factors Related to Each Type of TRU Waste: Amounts Generated, Radioactive Concentration and Physical and Chemical Properties etc: More precise projections will be made of (1) the amounts and concentrations of the various types of TRU waste, (2) physical and chemical properties etc. of solidified material and radioactive nuclides. These projections will be based on plans for the start-up of reprocessing and other facilities, the return of waste from overseas, and the development of new treatment technologies. Moreover, a system for management and utilization of these data is to be created.

Investigations Into Disposal Methods Based on Each Type of TRU Waste's Characteristics: The use of separate disposal methods for each type of TRU waste will be

deliberated from the standpoint of assuring safety using the above-mentioned data on each type of TRU waste. Investigations into the necessary qualities for such a disposal system will be made while simultaneously developing techniques for performance assessment. It will also be necessary to take into consideration such related factors as how much progress has been in investigating methods for disposal of waste such as (1) low-level radioactive wastes from nuclear reactors that exceed the ceiling values for radioactive concentration, (2) wastes from the decommissioning of nuclear power plants, and (3) wastes containing radioactive isotopes.

Optimization Through Integration of Separate Disposal Methods: The management system for TRU wastes must balance the special requirements of each waste type against the costs of implementing a large number of separate waste-processing and disposal streams. The development of the system must reduce the variety of handling and disposal approaches to as few as possible without compromising safety. This scope of this system optimization should not be limited to the TRU wastes, but should consider other low-level and high-level radioactive wastes as well.

PNC'S RESEARCH AND DEVELOPMENT PROGRAM ON TREATMENT AND DISPOSAL

PNC has begun research and development to meet the guidelines of the policy report announced by the Advisory Committee on Radioactive Waste. In treatment aspects, the research areas are as follows: (1) decontamination, (2) removal of TRU nuclides, (3) non-destructive assay, and (4) volume reduction etc.In disposal aspects, they are as follows: (1) source term evaluation and (2) performance assessment method.

SUMMARY AND CONCLUSIONS

This paper has been a summary of the new policy on TRU waste for treatment and disposal in Japan. This policy has been announced in the report of the Advisory Committee on Radioactive Waste of the Japan Atomic Energy Commission.The basic features of the new policy are the following. Further development is required to reduce the volume of the existing waste and to decrease the amount of waste being generated. Wastes with concentration levels exceeding a threshold limit of 1 Giga-Becquerel per ton will be disposed in an underground facility. Those wastes with lower activities will be sent to a shallow-land burial facility. The goal of research and development is the completion of the disposal system by the late 1990's.

REFERENCES

1. Japan Atomic Energy Commission Advisory Committee on Radioactive Waste, "Treatment and Disposal of Radioactive Wastes Including Some of the TRU-Nuclides," (July 1991)
2. Japan Atomic Energy Commission, "Long-Term Program for Development and Utilization of Nuclear Energy", (June 1987)
3. Japan Atomic Energy Commission Advisory Committee on Radioactive Waste, "Long-Term Program for Research and Development on Nuclide Partitioning and Transmutation Technology", October 1988.