RADIOACTIVE WASTE MANAGEMENT IN JAPAN

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ABSTRACT

Disposal aspects in Japan of low and high level radioactive wastes are given with emphasis on safety concept. The first shallow land burial repository of low-level waste is now under construction. The safety assessment has been made in a very conservative manner. The exposure dose limit used in the assessment, for instance, is 10 μSv/yr for the post-institutional control period, which is 1/10 of the exemption level for individual dose specified significantly, as is seen in other countries as well. Particularly, the siting problem is so tough that any underground research laboratories have not been built yet. The solidarity with local community is of great importance for the problem and some hints for it are observed in the case of the new nuclear facilities being now constructed at Tokai-mura. It is not impossible but promising, while it takes time.

NUCLEAR POWER DEVELOPMENT PROGRAM

The utilization of nuclear energy for power generation in Japan has advanced to such a stage that, today, 39 commercial power reactors are in operation, with a total generating capacity of 31.48 GW supplying 25.8% of the total electric power generation. Electric power generated by nuclear power plants accounts for about 10% of the total energy consumption of the country. Nuclear power is a major and indispensable source of energy for the daily life of the Japanese people and their economic and social activities.

According to the report issued by the Advisory Committee for Energy, Ministry of International Trade and Industry, in June, 1990, nuclear power generation is the core of the alternative-to-oil energy. It is expected that the role of nuclear energy in the future will be very important in tackling environmental issues since nuclear power generation does not result in the release of carbon dioxide to the biosphere. The total capacity of nuclear power generation is anticipated to reach 50 GW by the end of the year 2000, and 72.5 GW by the end of 2010.

Those who are involved with the energy policy-making in Japan regard the above targeted capacity as essential in balancing the energy supply and demand in the future. However, it is recognized that it will be difficult to attain such a target unless very considerable efforts are made to have the general public of Japan understand the need for nuclear power development.

In this regard, it is pointed out that there are two important policies to be implemented for the future development of nuclear power in Japan; one is the assurance of safety based on which the development programs can be carried out smoothly and the trust of the general public in nuclear power fostered, and the other the measures to close the back end of the nuclear fuel cycle, placing particular emphasis on the management of radioactive wastes.

RADIOACTIVE WASTE MANAGEMENT PROGRAM

A variety of nuclear facilities generate radioactive wastes in various forms, and the radioactivity contained in each type of waste varies significantly. These wastes are generally classified into high-level radioactive waste which is separated from spent fuel at a reprocessing plant, the beta-and gamma-emitting wastes which are mostly generated from nuclear power stations, the wastes that contain TRU (transuranic) nuclides, the wastes containing uranium that are generated in the handling of uranium fuels, and the RI (radioisotope) wastes generated in facilities such as hospitals and universities. Almost all these radioactive wastes are currently stored at the waste-generating sites, mostly being contained in a 200l steel drum. The amount stored accumulated up to March, 1990, totaled about 760,000 drums, of which 470,000 were those generated from nuclear power stations. The volume of high-level liquid waste stored at the Tokai Reprocessing Plant is about 365 m^3 as of March 1990.

In comparison with the estimate made by the Atomic Energy Commission, Japan in 1984, in which it was anticipated that the cumulative storage would be 950,000 drums by 1990, with those generated by nuclear power plants amounting to approximately 600,000 drums, the actual amounts so far generated are much less than expected. The low-level radioactive wastes generated from nuclear power plants and other nuclear facilities are processed in various manners. The liquid wastes and dry active wastes which account for most of the total wastes generated are either concentrated by evaporation or are volume-reduced. They are then solidified using cement, asphalt, plastics an so forth, and safety stored on-site in the storage facilities. These efforts result in the remarkable reduction of waste generation.

The basic principle applied to these low-level radioactive wastes is that of permanent disposal in a shallow land

repository. Although the total volume of low-level radioactive wastes generated every year decreases as more efficient volume-reduction methods are introduced, a large number of drums have already been accumulated. To meet this need, The Japan Nuclear Fuel Industrial Company (JNFI) is presently constructing a land disposal facility at Rokkasho-mura in Aomori Prefecture, 700 km north of Tokyo. It is scheduled to be put into service at the end of 1992. The licensing review of this facility by the administrative authority. Science and Technology Agency has been completed and subsequently authorized by the Atomic Energy Commission and the Nuclear Safety Commission. The business license was issued in November, 1990, and construction work has begun. The wastes to be disposed of at the Rokkasho-mura disposal site are those having uniform solid status and radionuclide concentrations below certain prescribed limits. The current plan is for the site to accept 200,000 drums, while the potential capacity of the site is estimated at more than 1 million drums.

The method of treating the high-level radioactive wastes is to vitrify them to safe forms, store the vitrified wastes for 30 to 50 years for cooling, and then to dispose of them deep underground by geological disposal.

The high-level radioactive wastes that have been generated at the Tokai Reprocessing Plant of the Power Reactor and Nuclear Fuel Development Corporation (PNC) have so far been stored in tanks on-site. In addition, more such wastes will be generated when the reprocessing plant, which is being planned for construction at Rokkasho-mura by the Japan Nuclear Fuel Services (JNFS), begins commercial operations. The development of vitrification technology has been implemented by the PNC. The PNC is currently constructing the pilot-scale vitrification plant, the test operation of which is scheduled for 1992~1993. The high-level radioactive wastes, which are generated by spent fuel reprocessing consigned to overseas reprocessing facilities, will be returned to Japan and stored at the commercial reprocessing plant at Rokkasho-mura, too.

For the geological disposal of high-level wastes, research and development programs are now being implemented by the PNC, with emphasis placed on scientific and technological demonstration of the feasibility of safe geological disposal. The PNC is conducting a number of small-scale in-situ tests, in addition to some engineering studies at Tokai-mura, and an underground research center at Horonobe-machi in Hokkaido is now being proposed to the local government. This, however, has not been fully accepted yet.

With regard to the geological disposal program, the Atomic Energy Commission has recommended that research and development activities for improving the reliability of the related engineering technologies should be continued incessantly and steadily. This is because one of the most crucial factors in overcoming the difficulty of selecting a disposal site is whether the technologies are reliable enough. As part of such activities, as a *minimum*, an underground research laboratory should be constructed and operated to demonstrate the feasibility of the disposal technologies. Once a candidate site is selected, a full-scale demonstration test will be conducted in addition to a site characterization study. The research and development activities required for making the final decision on siting should be completed in a timely manner.

DISPOSAL OF LOW-LEVEL RADIOACTIVE WASTE

As mentioned above, the first facility in Japan for shallow land disposal of low-level radioactive waste is now being constructed at Tokkasho-mura. It must be noted that the water table at the site is not deep enough for the wastes to be buried above the table. Hence, much attention has been paid to designing a facility strong enough to resist the flow of ground water and to performing safety assessment of the ground water contamination scenarios, even though the ground water itself is very small-in-volume and very low-in-velocity since it is brought about only by precipitation.

The basic concept of safety assurance in shallow land disposal is such that, until the radioactivity is reduced to a level which is not hazardous in terms of radiological safety, the waste package are placed inside solid structures such as concrete pits. As the radioactivity of the waste decreases, control can be stepwisely reduced while maintaining safety. Specifically, the following three-step-control approach is adopted at the Rokkasho waste disposal site, where modular-type disposal facilities are to be constructed and progressively filled with waste packages.

At the 1st stage, the radioactivity must be confined within the engineered barriers such as concrete pits, and the confinement is supported with suitable observation and measurement in order to ensure that no leakage or release occurs. If any leakage or release is detected, necessary actions must be taken without delay. As the Rokkasho site, it takes 10~15 years for the 1st stage.

At the 2nd stage, a system combining engineered and natural barriers provides a sufficient retardation effect against transfer of the radioactivity if any, and some observation and measurement are provided to ensure the safety of the public. Thirty years after the end of the 1st stage will be used for the 2nd stage at the Rokkasho site.

And at the 3rd stage, the general public can access to the burial site. But some specific acts such as digging up the soil or dwelling there are prohibited. The disposal company, the JNFI has a plan to stop the institutional control of the Tokkasho site after about 300 years. The technological

feasibility of the plan was already checked by the safety regulatory authority.

It has been decided that the radioactive wastes to be buried at the first repository will be limited for the time being to low-level solid radioactive wastes generated from nuclear power stations, being solidified by cement, asphalt, plastics, etc. in drums. In determining the upper limit concentration of radioactivity of these wastes, a safety evaluation model was devised to calculate the radioactive concentration. Appropriate selection was made of the parameters used in the model to ensure that the radiological effect is significantly reduced by the end of the institutional control period.

The exposure dose limits used in the safety evaluation are 1 mSv/yr for the institutional control period, which is the same limit as for other nuclear facilities in Japan, an 10 μSv/yr for the post-institutional control period, which is 1/10 of the exemption level for individual dose specified by the ICRP as 100 μSv/yr.

The land disposal facility is constructed in the base rock after excavating the surface soil. The space on the upper and side faces of the land disposal facility are filled with soil mixed with bentonite. The aim in mixing the soil with bentonite is to prevent the ground water from flowing in and dispersing through the land disposal facility. The land disposal facility ($24m \times 24m \times 6m^{H}$) is divided by bulkheads into 16 cells. The waste packages are placed in each cell and then the cells are filled with cement mortar such that no gap is left between waste packages. The spaces between the cell walls and waste packages are also filled with cement mortar.

The space between the cement motar and the outer bulkhead and cover of the drain facility is provided with a porous concentrate layer having appropriate water-collecting functions. Any water that penetrates can be drained out. In addition, inspection routes are provided on the periphery of the land disposal facility in order to monitor and inspect the draining performance.

In placing waste packages, care is exercised to prevent uneven distribution of radioactive concentration and waste types within the disposal facility.

DISPOSAL OF HIGH-LEVEL RADIOACTIVE WASTE

By and large, the basic concept of geological disposal of high-level radioactive waste is very similar to that being taken worldwidely, except that relatively more consideration will be given to the engineered and near-field barriers than to the far-field barriers, which, in Japan, are usually wet and have a chemically reducing condition in most cases. In December, 1989, the Atomic Energy Commission, Japan recommended the following three requirements to assure safety against the possibility of radionuclides in the waste migrating to the biosphere through the ground water: (1) the possibilities of wastes coming into contact with ground water must be kept sufficiently low, (2) in the event of wastes coming into contact with ground water, radionuclides in the waste should not be released into the water, nor should they migrate through the water from their place of embedment, and (3) it must be confirmed that the radionuclides, even in the event of migration from their place of embedment, do not reach the biosphere nor have any significant effect.

Japan is now seeking the possibility to have the disposal method where the safety can be substantially assured only with the requirements (1) and (2). The requirement (3) is regarded as a kind of backup. For this, the multi-barrier system being developed in our country is aimed at resting more upon the man-made barriers. Specifically, the buffer material which has very low water permeability suppresses the permeation of ground water from outside, and movement of water in the buffer material is minimal. The overpack is surrounded by buffer material having low permeability. This serves to prevent corrosion of container materials and enables the radionuclides within the vitrified matrix to be retained in the containers for a long period. Suppression of contact with ground water is also achieved. Even if the contains are deteriorated and the ground water comes into contact with the wastes, the release of radionuclides into ground water is suppressed as the nuclides are fixed within the vitrified matrix. As there is actually little movement of water inside the buffer materials, radionuclides in the water mostly migrate by diffusion. Furthermore, because the buffer materials tend to adsorb the radionuclides, the migration of nuclides is restricted to a great extent.

The research and development programs related to geological disposal are being implemented based on the step-by-step approach: namely, a program proceeds to the next step after achieving a certain result. In the research and development programs so far conducted, surveys on the geological formation of Japan have been carried out with the objective of selecting an "appropriate geological formation". It has been clarified that the "appropriate geological formation" can be found without specifying a particular rock type. That is, the suitability for geological disposal does not depend solely on the geological conditions. The safety of the geological disposal systems can be assured not by specifying certain rock types but by designing an appropriate engineered barrier corresponding to the geological conditions of a proposed site.

For the future advancement of geological disposal research and development programs, it is important to have the general public's better understanding of geological disposal. To demonstrate the technological reliability, the performance of the multi-barrier system will be clarified, and emphasis will be placed on the programs under which a

specific technological method is demonstrated to verify that the long-term safety can be assured by the multi-barrier system. Research and development programs for such demonstration purpose are being conducted under the leadership of the Atomic Energy Commission, Japan. The PNC is the central promoting body with the rid of other ministrations.

CONCLUDING REMARKS

The disposal program of low-level radioactive wastes in Japan has just started with great care for safety and therefore in a very conservative manner. The shallow land burial facility is designed to have exceedingly strong structures and highly effective barrier performance. Furthermore, the conservative evaluation scenario, mathematical model, and parameters, have been used in the licensing reviews conducted by the safety regulatory authorities.

As far as the high-level waste disposal problem is concerned, the situation has not progressed significantly, particularly on siting. Any underground research laboratories, for instance, have not been built yet. To seek technological solutions for such difficulties, a more engineered and more controlled disposal system is now considered.

What is most important for siting is the solidarity with local community. In this respect, Japan now has a good experience. At Tokai-mura, which is a kind of birth-place of Japan's nuclear research development, a couple of quite ambitious nuclear facilities are now under construction and proceeded without difficulties. One is the pilot plant for vitrification of high-level liquid waste, which is called Tokai Vitrification Facility, TVF, owned by the PNC. The other is an experimental facility for nuclear criticality safety, which is called the Nuclear Fuel Cycle Engineering Facility, NUCEF, managed by the Japan Atomic Energy Research Institute;. The construction of those two facilities started after the Chernobyl accident. The two facilities are heavily related to the high-level radioactivity. However, no significant opposition has been aroused. This is because of the bond of trust and favorable relations which have long existed between the nuclear institutions and companies at Tokai-mura and local community.

There is therefore, reason to be optimistic about Japan's radioactive waste management program, especially the implementation of disposal operations. These programs can be advanced on the basis of strong mutual trust, and it is, then, vitally important for all concerned to strive for the continuation and development of this important bond.