WASTE MANAGEMENT IN DECOMMISSIONING PROJECTS AT KAERI

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ABSTRACT

Two decommissioning projects are carried out at the KAERI (Korean Atomic Energy Research Institute), one for the Korea research reactors, KRR-1 and KRR-2, and another for the uranium conversion plant (UCP). The concept of the management of the wastes from the decommissioning sites was reviewed with a relation of the decommissioning strategies, technologies for the treatment and the decontamination, and the characteristics of waste.

All the liquid waste generated from KRR-1 and KRR-2 decommissioning site is evaporated by a solar evaporation facility and all the liquid waste from the UCP is treated together with lagoon sludge waste. The solid wastes from the decommissioning sites are categorized into three groups; not contaminated, restricted releasable and radioactive waste. The not-contaminated waste will be reused and/or disposed at an industrial disposal site, and the releasable waste is stored for the future disposal at the KAERI. The radioactive waste is packed in containers, and will be stored at the decommissioning sites till they are sent to a national repository site.

The reduction of the radioactive solid waste is one of the strategies for the decommissioning projects and could be achieved by the repeated decontamination. By the achievement of the minimization strategy, the amount of radioactive waste was reduced and the disposal cost will be reduced, but the cost for manpower, for direct materials and for administration was increased.

1. CURRENT STATUS OF DECOMMISSIONG AT KAERI

1.1 research reactors

In 1996, it was concluded that the KRR-1 and the KRR-2 would be shut down and dismantled. A project was launched for the decommissioning of the reactors in January 1997 with the goal of a completion by 2008. The total budget of the project is 19.4 million US dollars, including the cost for the waste disposal and for the R&D. The work scopes during the reactor decommissioning project are the dismantling of all the facilities and the removal of all the radioactive materials from the reactor site. After confirming the removal of the entire radioactivity, the site and buildings will be returned to the Korea Electric Power Company (KEPCO).

In 12 hot laboratories which were used for the experiments with isotopes, all the apparatus and furniture were dismantled with hand-in tools such as saws and cutters to the reduced size. After the removal of all the dismantled pieces, the ceiling, wall and floor were decontaminated with papers, movable vacuum cleaners, scabblers, and grinders. For the 10 lead hot cells, used for the production of medical radioisotopes, the pipes and electric wires were disconnected, and then rear doors, lead bricks, glass windows, and finally concrete structures were dismantled and removed. In the concrete cells, the dose rate was very high due to the irradiated samples. Because of the lack of the records and the unclear window glasses by browning, the first work of the dismantling was the identification of the objects in the cells with a gamma camera and a remotely operated camera.

The core structure was also dismantled, cut into the small pieces and packed in the shielded waste cask. The rotary specimens rack (RSR), inserted into the reactor core like a ring, was separated and moved to the pool of the KRR-1 for the future dismantling. Besides the reactor core in the pool, there were many pipes and ducts, for the radiation of the samples and the circulation of water of the pool. The highly radioactive parts of the pipes were separated under water and the less active parts were pulled out of water and cut into small pieces in a temporary shield. The graphite blocks were removed from the thermal columns. The blocks, located near the core, were much activated than expected and could not be handled without any shields. A remotely operated gripping tool was developed and used for pulling out the graphite blocks. The stainless steel tubes of the beam ports and the concrete near the pipes were highly activated by the neutron. A boring machine was used to remove the beam port pipes and the concrete near the pipes at same time.

After removing these highly radioactive parts, the inactive part of the bio-shielding concrete was dismantled by a diamond wire cutter. The size of a dismantled concrete block at a higher position of the shielding was limited to 7 tons because of the capacity of the crane but at the lower position the maximum weight could be increased to 20 tons. After taking down pieces of the concrete, every surface of the pieces was sampled and the radioactivity was evaluated.

1.2 uranium conversion facilities

A separate project for the decommissioning of the uranium conversion plant (UCP) was launched in 2001. The UCP is located at the KAERI and was constructed for the development of the fuel manufacturing technologies and the localization of nuclear fuels in Korea. It was shut downed in 1993 and finally it was concluded in 2000 that the plant would be decommissioned. The project will be completed by 2007 and the total budget is 9.2 million US dollars.

After the decommissioning plan was approved in July 2004 from the Korea Ministry of Science and Technology, several preparative works, such as the preparation of the detailed work procedures, the selection of cutting devices, the installation of a new utility system, and the establishment of an analysis system of the low alpha radioactivity were carried out. And preliminary cleaning was carried out for reducing the air contamination due to the re-floating dust deposited during 10 shut down years. From 2005, all the equipment in the plant, including plant structures, pipes and electric wires were dismantled and removed. The surface of the building was also decontaminated with a steam jet device and a scabbler.

2. WASTE MANAGEMENT IN DECOMMISSIONING

2-1. KAERI's approach for the decommissioning

The following strategies were decided upon at the beginning of the preparation step of the decommissioning project of the research reactors and they were extended to that of the uranium conversion plant.

1) Dismantling time: immediate after the decision
2) Final state of the site: free release of the site and buildings after the removal of all the radioactive materials for unrestricted uses.
3) Waste: minimization of the solid wastes, which will be packed and be sent to the national repository facility, and near zero release of liquid waste.
4) Technologies: development of the technologies directly required for the dismantling of the facilities in the projects, and for any future demands.
5) Participation of commercial companies for a joint development and technology transfer.

As indicated, a minimization of the waste and near zero release were adopted as the strategy and this selection gave big effects to the projects.

2-2. Liquid waste

The liquid waste, generated from the decommissioning of the research reactors, was classified into two groups; operational and dismantling liquid waste. The operational waste consisted of the reactor pool water, and waste water stored in the storage tanks. The laundry/shower waste water and decontamination waste are the examples of the dismantling waste. The radioactivity levels were very low and much of the waste was expected that it could be discarded into the swage. Nevertheless, according to the KAERI's strategy on the liquid waste, all the liquid waste generated from decommissioning site of the research reactors is treated by the solar evaporation system. The liquid waste with a higher total gamma radioactivity than $2.64\text{x}10^4$ Bq/m^3, which was generated during the operation of the KRR-2 and being stored in a tank, was treated with an ion exchange device before the solar evaporation. The laundry and shower waste is treated with a membrane treatment system for removal of the surfactant, which resulted in a lower evaporation rate by generation of a third phase in the solar evaporation system

2-3. Solid waste

The concept for the management of the solid waste is shown in figure 1. All the pieces from the dismantling works were classified into two groups; “to be decontaminated” and “to be finally treated.” The activated metal waste and the bulk radioactive waste such as the decontaminating paper and the soil were classified into the later waste because it was not possible to decontaminate them by the general methods. The examples of the former waste were the concrete blocks, the wood products from the furniture in the laboratories and the metal pieces from the pool internal equipment and their radioactivity was caused by the contamination. This waste was repeatedly decontaminated up to the practically lowest level.

All solid waste, decided to the final treatment, is categorized into three groups as indicated in figure 1. The first group is the radioactive waste, which has a higher activity than 0.4 Bq/g for the beta/gamma activity and 0.2 Bq/g for the uranium contamination. It was packed into drums of 200 liters or containers of 4 m^3 according to the physical properties and will be temporally stored in the reactor building of the KRR-2 and the UCP building after a structural modification. And finally it will be sent to the national LILW disposal site that is now being planned by the KHNP (Korea Hydro and Nuclear Power Company) to start operation from 2008. The second is so-called “restricted releasable,” and the waste with a radioactivity between the minimum detectable activity and 0.4 Bq/g (or 0.2 Bq/g) in average can be classified into this group, and the KAERI will be allowed to treat it according to a pre-decided route. In the future, a study on the local disposal or the long term storage of the waste at the KAERI site as the pre-decided route will be carried out.

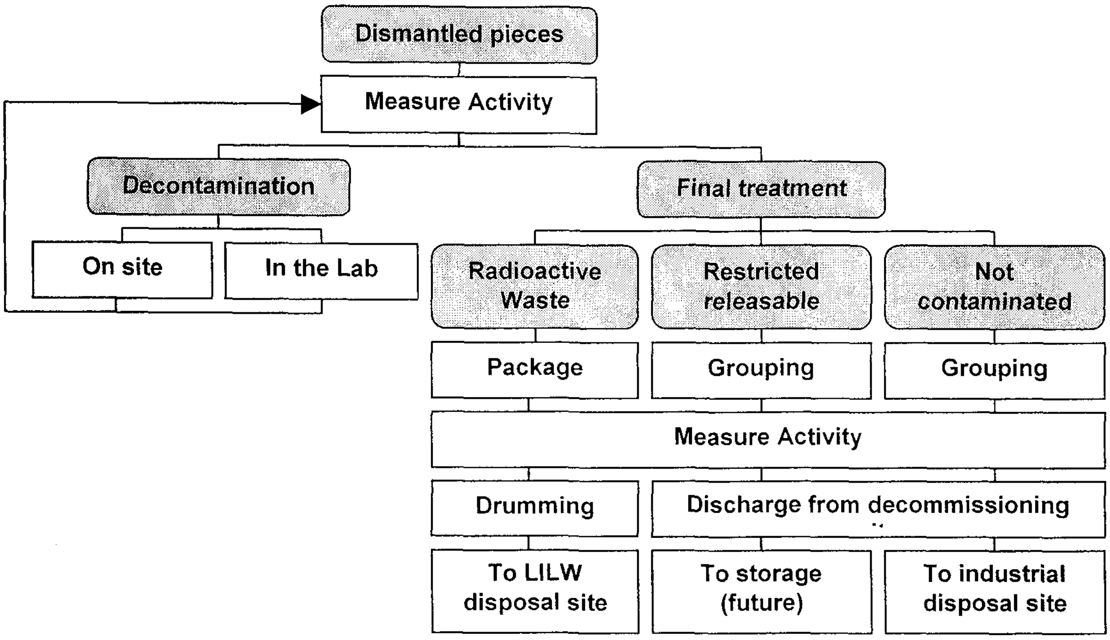

Fig. 1. The concept of solid waste management adopted for the decommissioning at KAERI (for the UCP, not contaminated waste was not considered)

The third group is not-contaminated waste, and it will be sent to a general industrial waste disposal site. The radioactivity criterion of this group is the minimum detectable activity limit by an approved measuring method. For the beta-gamma contaminated waste, the 0.013 Bq/g for Co-60 and 0.007 Bq/g for Cs-137 were selected as the MDA. But for the uranium contaminated waste, the value of the MDA was too low to detect it and therefore, for the waste from the uranium conversion facilities, this third group waste was not considered.

The radioactivity of the not-contaminated waste is lower than the MDA limit, but it should be proven by the law that the MDA would be lower than the clearance level (10 Sv/y for the individual exposure) for the release of the waste and the route to the final destination should be observed. 33 tons of the not-contaminated concrete waste, generated from the dismantling of the hot cells of the KRR-2, tried to be released. Various scenarios, which encompassed realistic situations of the recycling or discarding routes, were evaluated and finally the exposure rate on the recycle of the rubble for a pavement of a road and the landfill disposal of the waste cement turned out to be the most severe case. As shown in table 1, the maximum dose rate was 1.71 Sv/y for the individual public member and 9.87×10^{-3} man.Sv/y for cumulative members. For the evaluation, computer codes of MERCURAD and MCNP-4C were used for the external exposure evaluation, a calculation method defined in NUREC-1640 for an inhalation and ingestion analysis and a computer code of RESRAD for the calculation of the landfill effect.

Table 1. Exposure dose of the public members in case of the pavement recycle and the landfill disposal of 32 tons of concrete waste

No.	Exposure personnel	Exposure Pathway Ext/Inh/Ing[1)]	Individual Exposure Sv/y	Cumulative Exposure Man-Sv/y
1	Workers for processing	*o/o/o*	*1.710*	*3.42E-5*
2	Truck drivers For transportation	*o/x/x*	*0.009*	*4.74E-8*
3	Workers for loading/unlosding	*o/o/o*	*0.025*	*1.27E-7*
4	Workers for pavement of a road	*o/o/o*	*1.66*	*3.32E-5*
5	Drivers on the road	*o/x/x*	*0.001*	*1.84E-4*
6	Workers For lanfill disposal	*o/o/o*	*0.876*	*1.75E-4*
7	Inhabitants on the landfill area	*o/o/o*	*0.837*	*9.87E-3*

Note 1); Ext/Inh/Ing = External/Inhalation/Ingestion

The DECOMIS (DECOMmissioning Information System), shown as figure2, an integrated management system of decommissioning projects of KAERI was developed through the extension of a simple conventional DB system for the report of the data on the waste. The main purposes of this system are the record keeping for future decommissioning projects and the data provision to the staff for the more effective management of the projects. The system includes several information fields, such as project progress management, man power management, waste management, radiation protection, etc. In the waste management part, all information of every step indicated in figure 2, including the waste generation, decontamination, classification, final packaging and storage, were managed for the clearer understanding of the flow of the waste and the evaluation of the waste generation characteristics. This system can also extract the data for the report to a national waste management DB, WACID, and for the more effective management of the radioactive waste, such as minimization.

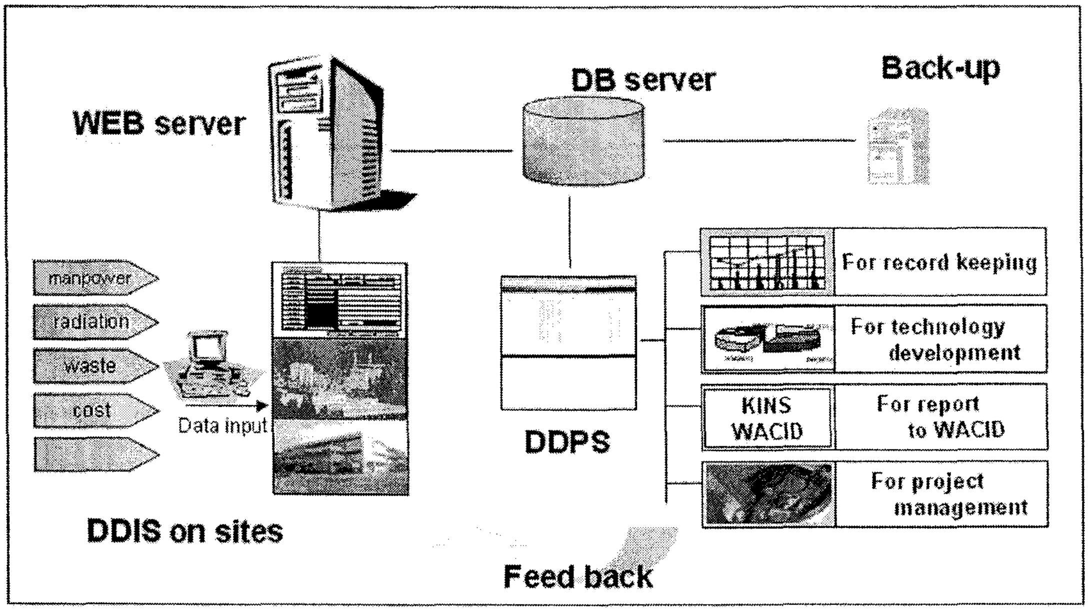

Fig. 2. Concept of an integrated project management system for the decommissioning of nuclear facilities The system consists of data input system(DDIS) and data processing system(DDPS).

Figure 3 shows two examples of the decontamination progress; one for an aluminum duct (A) in the water pool of the KRR-2 and another for a stainless steel storage rack (B) of the beam port plugs in the reactor hall of the KRR-2. For both cases, the objects were cut into small pieces, which were checked and decontaminated in case of remaining the radioactivity and repeated the measurement and the decontamination. The stainless steel pieces were completely decontaminated by two decontamination processes while the contaminants on the aluminum pieces started to be removed after the third process and finished after the 7th process. Finally all pieces could be classified into the releasable or not-contaminated waste and therefore the cost for the final disposal to the national repository could be diminished. But the cost for the decontamination works, including the cost for the man-power, direct materials and the administration, was increased. The change of the total cost according to the repeated decontamination works is shown in figure 8 by the dotted line. For the stainless steel pieces, which were easily decontaminated, about 60 % of the waste management cost could be reduced but for the aluminum case, the total cost was increased by 20 %. For our case, the strategy is the minimization and this increase may be allowed. But under the strategy of the optimization, aluminum pieces would be classified into the radioactive waste without any decontamination works. There were many factors to calculate the change of the total cost, such as the materials, contamination characteristics, decontamination technologies, disposal cost, labor cost and the total period for the project. These factors were much dependent to the site conditions and therefore it would not easy to make a general rule.

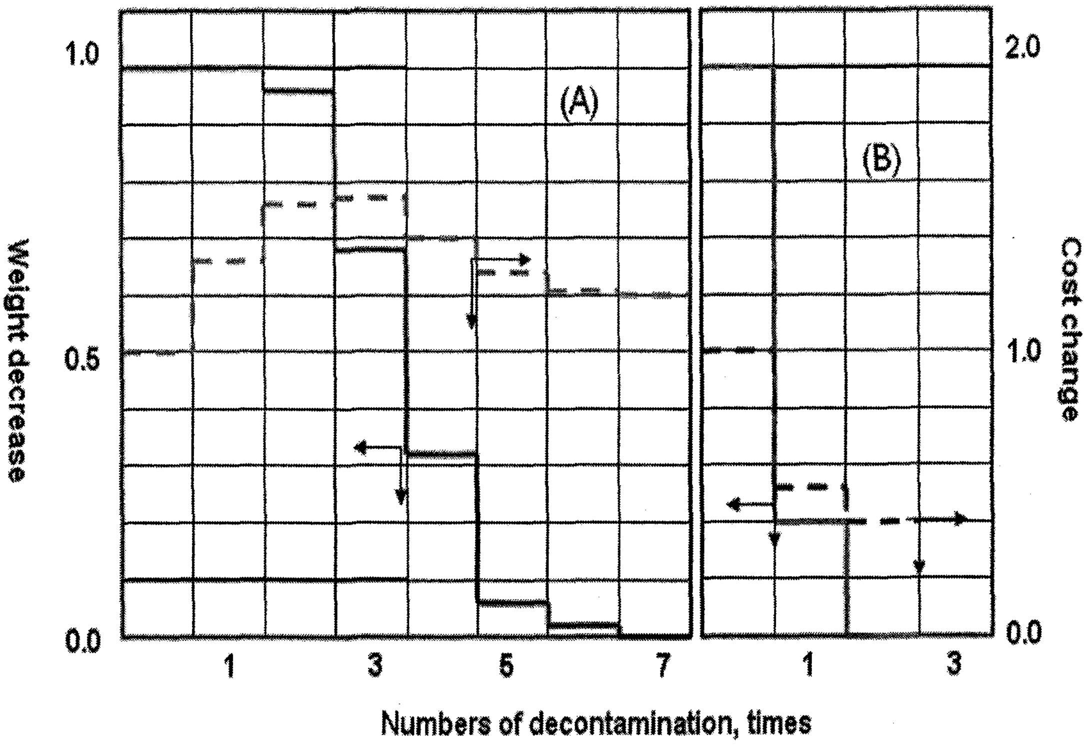

Fig. 3. Weight decrease of the waste to be decontaminated and change of the total cost for the waste management (The base line of the cost change is the disposal cost without any decontamination.)

3. CONCLUSION

The two decommissioning projects have been successfully carried out at the KAERI, one for the Korea research reactors, KRR-1 and KRR-2, and another for the uranium conversion plant (UCP). The laboratories, hot cells and reactor facilities of the KRR-2 were dismantled and the decommissioning of the KRR-1 will be started from next year.

All the liquid waste generated from KRR-1 and KRR-2 dismantling site is evaporated by solar evaporation facility after pre-treatment with the ion exchange or membrane process. All the liquid waste from the UCP is sent to the lagoon and treated together with lagoon sludge waste.

The solid wastes from the decommissioning sites are categorized into three groups; not contaminated, restricted releasable and radioactive waste. 33 tons of the not-contaminated concrete waste was disposed at an industrial disposal site as a sample case, and all other of the not-contaminated waste will also be re-used or discarded as general industrial waste. The restricted releasable waste is stored for the future disposal at the KAERI. The radioactive waste is packed in drums or containers, stored in the decontaminated facility building at the decommissioning sites till they are sent to the national repository site.

The minimization of the radioactive solid waste is one of the strategies for the decommissioning projects and could be achieved by the repeated decontamination. The amount of radioactive waste could be reduced and the disposal cost could be reduced, but the cost for manpower, for direct materials and for administration was increased. The total cost was increased for the repeated decontamination. The minimized radioactive waste or the optimized cost for the waste management would be dependent to the strategy of the project and the site conditions.