Conceptual Study on Disposal Facility for Waste from Decommissioning of NPPs

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Abstract

In Japan, low-level waste (LLW) from the operation of nuclear power plants (NPPs) has been contained in the 200-liter drums with solidification materials and converted into the waste packages. The waste packages have been disposed in the near-surface disposal facilities of Rokkasho LLW Disposal Center.
In the near future, the large-size radioactive waste with higher radiation level will arise from the decommissioning of NPPs and the operation of reprocessing plant. Therefore, we studied a concept of the disposal facility which can reduce radiation exposure to the public, compared to the above-mentioned near-surface disposal facilities.

For the purpose of more efficiently processing and containing of the waste from the decommissioning of NPPs and the operation of reprocessing plant, waste producers have considered the use of a cubic container (1.6 m on a side) for the packaging of the waste, instead of the 200-liter drum. Additionally, the waste packages are expected to have higher surface dose rate. Thus, we concern about the increase in radiation exposure to the public caused by direct or skyshine gamma-rays. From the viewpoint of reducing the radiation exposure to the public, it is effective to adopt not a pit-type facility but a box-culvert-type facility with higher shield effect.

In consideration of the adaptation of the box-culvert-type facility, the waste packages will be emplaced horizontally by forklift truck, not vertically by crane as used in Rokkasho LLW Disposal Center.

There are the following advantages of the box-culvert-type facilities over the pit-type ones:
- Lower radiation exposure to the public;
- All weather operation;
- Expectation of use a candidate area effectively, in the case of multi-layered structure.

1. Introduction

In Japan, radioactive waste is classified roughly into high-level waste (HLW) and low-level waste (LLW). HLW consists of fission products remaining in the spent fuel which uranium and plutonium are separated from in the reprocessing plant. LLW arises from the operation and the decommissioning of nuclear power plants (NPPs). Furthermore, LLW is divided into three according to its radiation level.

LLW from the operation of NPPs has been contained in 200-liter drums with solidification materials and converted into waste packages. The waste packages have been disposed in the near-surface disposal facilities of Rokkasho LLW Disposal Center.

In the near future, large-size radioactive waste with relatively higher radiation level will arise from the decommissioning of NPPs and the operation of reprocessing plant. Therefore, we studied a concept of the disposal facility which can reduce the radiation exposure to the public, compared to the current near-surface disposal facilities.

2. Rokkasho LLW disposal center [1] [2]

In Rokkasho-mura of Aomori Prefecture, we have developed uranium enrichment, reprocessing, MOX fuel fabrication, HLW storage, and LLW disposal.

Regarding the LLW disposal, The No.1 and the No.2 disposal facility are approved in 1990 and 1998 respectively, and have been operating. Each facility has disposed about 150,000 drums, and the total number of disposed drums is about 300,000 as of September 30, 2017.

Each facility was certified to dispose 40,000m^3(equivalent to 200,000 of the 200-liter drums) of LLW.

At present, only LLW from the operation of NPPs is disposed in Rokkasho LLW Disposal Center. Radioactive waste arising from the decommissioning of NPPs and the operation/decommissioning of the nuclear fuel cycle facilities is planned to dispose.

In the future, some 600,000m^3 (equivalent to 3,000,000 of the 200-liter drums) of LLW are expected to be disposed at this site.

3. Low-level radioactive waste [3]

The classification of radioactive waste in Japan is shown in Table.1. Liquid LLW and solid LLW are produced by the operation of NPPs. Radioactive waste with relatively low radiation level of these is disposed in a pit-type facility.

In Rokkasho LLW Disposal Center, liquid LLW and solid LLW are disposed in the No.1 and No.2 disposal facility respectively.

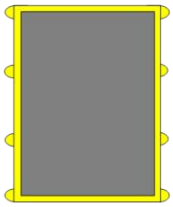
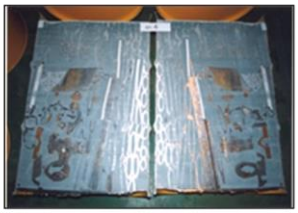
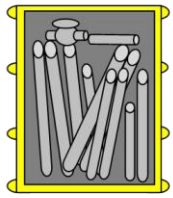
Tab.1 Classification of radioactive waste in Japan

Classification of waste			Example of waste	Source
High-level waste (HLW)			Vitrified waste	Reprocessing plant
Low-level waste (LLW)	NPPs waste	relatively higher-level waste	Control rod, Core internal structure	Nuclear power Plants (NPPs)
		relatively lower-level waste	Liquid waste, Spent resin, Filter	
		extremely low-level waste	Concrete, Metal	
	TRU waste		Parts of fuel rod, Liquid waste, Filter	Reprocessing plant, MOX fuel fabrication plant
	Uranium waste		Consumable material, Slag	Uranium enrichment plant
lower waste than clearance			Decommissioning waste	above all

Liquid LLW includes condensed liquid waste and spent resin, which are mixed with cement, asphalt or plastic. They are then poured into the drums for solidification. Solid LLW includes metals, plastics, insulation and filters. They are classified, and cut/condensed, after which they are stored in the drums and solidified with mortar. The procedures and the cross-section images of each solidification are shown in Tab.2.

The waste shown in Tab.2 arises from the operation of NPPs. The waste from the decommissioning of NPPs and the operation/decommissioning of nuclear fuel cycle facilities is excepted in Tab.2.

Tab.2 Outline of waste packages

	Solidification image	Cross-section
No.1 facility	 Concentrated waste solidified with cement	
No.2 facility	 Metal stored and solidified with mortar	

These excepted wastes are planned to dispose in the future. Particularly, the decommissioning waste will be preferentially disposed because some NPPs are on decommissioning stage.

The specifications of the decommissioning waste packages currently expected differ from the operational waste package currently disposed in the type of package, weight and surface dose. The cubic container is considered as the decommissioning waste package to contain the large size waste (e.g.: dismantled equipment, building) and its size is 1.6m $\times$1.6m$\times$1.6m with a maximum weight of 20 tons. In addition, maximum surface dose of decommissioning waste package is designed to be 20 mSv/h.

In order to dispose the decommissioning waste, we need to take account of these two points: size and surface dose.

4. Concept of new facility for decommissioning wastes

Regarding the surface dose of the decommissioning waste stated in section 3, there would be a concern about the increase in radiation exposure to the public caused by direct or skyshine gamma-rays from the top of disposal facilities during the emplacement work in the current pit-type facility as the No.1 and No.2 disposal facilities. (Fig.1)

Thus, it is necessary to consider about the reduction of exposure from the disposal facility.

Direct or skyshine gamma-rays affect the highest radiation exposure to the public during the operating period of No.1 and No.2 disposal facilities because the radiation exposure increases during the emplacement work of waste packages without a

shield-lid. Therefore, new facility design must be considered to reduce the radiation exposure during the emplacement work.

As shown in Fig.2, for the reduction of the radiation exposure, we considered to make a pit opening on the opposite side from the evaluation point. Radiation from the top of the disposal facility scatters in hemispherical space above the disposal facility, but the scattering of radiation from the side of the disposal facility is predicted to decrease due to the limitation of the scattering space and angle. This will lead to reduction of a skyshine exposure. Consequently, we decided to study on the box-culvert-type facility as a new concept over the current pit-type facility.

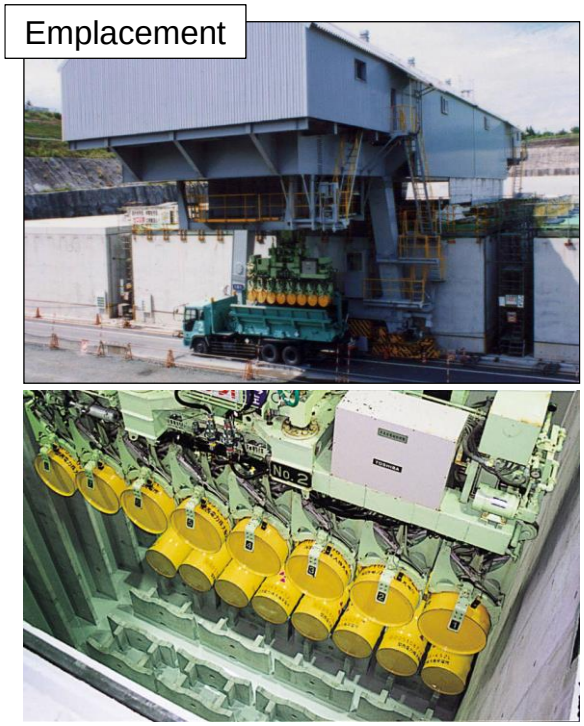


Fig.1 Emplacement process of waste packages

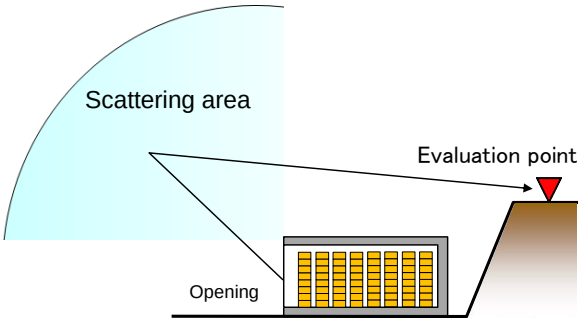


Fig.2 Image of Box-culvert-type facility

The operation process of the box-culvert-type facility is considered to use a forklift to emplace waste packages, because the emplacement machine is needed to enter from the side. The forklift is widely used for the container movement in the general industry, so it is also considered to be suitable for the cubic container for the decommissioning waste. (Fig. 3)

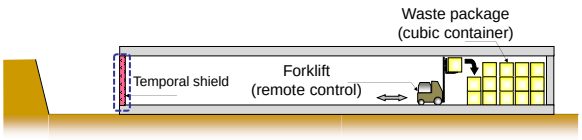


Fig.3 Image of emplacement process

The box-culvert-type facility is regarded as one of the promising design. There are the following advantages of the box-culvert-type facilities.

First, the radiation exposure to the public can be reduced as described above.

Second, it is effective to prevent the entry of rainwater. The waterproof of the disposal facility is required to reduce nuclide migration from the disposal facility. In the current facility, we set the temporary shield-lid of the steel or concrete, and cover the facility by the waterproof sheet. On the other hand, install of roof in the proposed facility is expected that rainwater more hardly enter the facility during the operation.

Third, it is enable to establish the multi-layered facility, because the box-culvert facility has an opening on the side, and waste packages are emplaced by forklift from the side of the facility. When the waste packages are emplaced from the top of the multi-layered facility by crane, it is necessary to consider the influence of the damage of the falling waste packages. However, when the waste packages are emplaced from the side of the facility, the influence of the damage of the falling the waste packages is less. Therefore, it is unnecessary to strengthen the measure to prevent falling the waste packages. In addition, a multi-layered facility will lead to the effective use of site area, because of the increase of the amount of disposal waste per unit area. (Fig.4)

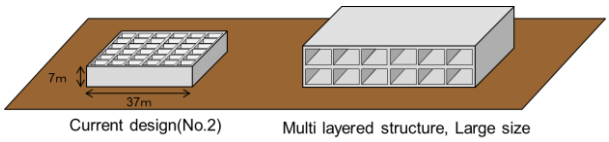


Fig.4 Image of disposal facilities of current design and multi-layered

While there are the above-mentioned merits, there are also the challenges about the box-culvert-type facility.

First challenge is the method of the backfill by mortar after the emplacement of waste packages. Since there is no partition wall, temporary mobile formwork is necessary to gradually fill with mortar in the box-culvert-type facility. Several methods are proposed, but we should study and realize the most rational way considering both of the merits and demerits.

Second challenge is realization of remote-controlled large forklift. There are the real examples of human-operated large forklift and remote-controlled small forklift, but there are no the real examples of remote-controlled large forklift. The remote-controlled large forklift is required the same performance as current equipment from the viewpoints of the efficiency and accuracy.

5. Summary

We studied about the box-culvert-type facility as one of the promising design for the emplacement of the decommissioning waste.

In consideration of the adaptation of the box-culvert-type facility, the waste packages will be emplaced horizontally by forklift truck, not vertically by crane as used in Rokkasho LLW Disposal Center.

There are the following advantages of the box-culvert-type facilities over the pit-type ones;

- Lower radiation exposure to the public;
- All weather operation;
- Expectation of use a candidate area effectively, in case of the multi-layered structure.

6. References

[1] Japan Nuclear Fuel Limited. (2016), CORPORATE PROFILE, Japan Nuclear Fuel Limited.

[2] Japan Nuclear Fuel Limited. (2017), Low-level Radioactive Waste Disposal, http://www.jnfl.co.jp/en/business/llw/ (accessed 2017-10-31)

[3] Japan Nuclear Fuel Limited. (2015), Rokkasho Low-level Radioactive Waste (LLW) Disposal Center, Japan Nuclear Fuel Limited.