Transport concept of new waste management system (inner packaging system)

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Introduction

Kobe Steel, Ltd. (KSL) and Transnuclear Tokyo (TNT) have jointly developed a new waste management system concept (called “Inner packaging system”) for high dose rate wastes generated from nuclear power plants under cooperation with Tokyo Electric Power Company (TEPCO). The inner packaging system is designed as a total management system dedicated to the wastes from nuclear plants in Japan, covering from the wastes conditioning in power plants up to the disposal in final repository. This paper presents the new waste management system concept.

Definition

- Waste packaging: Packaging for disposal
- Waste package: Waste packaging with conditioned waste for disposal
- Transport packaging: Packaging for transport
- Transport package: Transport packaging with contents

Waste classification in Japan

Radioactive wastes are classified into two categories in Japan such as high-level waste and low-level waste. High level waste means a vitrified waste from reprocessing. The other radioactive wastes are categorized as low level waste. Concerning the radioactive waste from nuclear power station, low level wastes are classified into three sub-categories L1, L2 and L3 in Japan.

- L1 is defined as medium level waste whose inventory is higher than acceptance criteria of disposal facility, such as channel box of spent fuel, irradiated burnable poison and core component waste of pressure vessel.
- L2 is defined as so called LLW, which meets the acceptance criteria of the current LLW disposal facility in Rokkasho-mura.
- L3 is defined as a very low level waste.

Background

At present, the commercial electric power-generating reactor of 52 bases is working in Japan

at 16 sites. Radioactive waste such as reactor structure material (control stick, channel box, burnable poison, etc) is stored in the pond of power plant.

The wastes with rather high activity will be disposed to a next disposal facility constructed below the generally used depth. In order to make the optimized disposal system, we studied not only the disposal facility but also the wastes conditioning and the transport in order to optimize total waste management system.

We present a new waste management concept called "inner packaging system", which is achieved total optimization for disposal of rather high activity wastes.

Specification of waste package

When the L1 waste is disposed, the conditioning operation is needed in order to meet the repository acceptance criteria. At this moment the acceptance criteria is under investigation.
However for evaluating the waste management system, we assume the schematic specification of waste package as follows.

- A waste packaging is required for containing the radioactive nuclide.
- Main nuclide of L1 is beta-gamma and the maximum radioactive concentration of the concerned wastes is estimated about 10^{15}Bq/ton of Co-60.
- Total 300 to 350mm thickness of carbon steel is needed for shielding in order to meet the transport regulation.
- The heat power is negligibly small.

Existing conditioning system

For conditioning the low level waste, following two conditioning systems have been operating.

- On site conditioning system
- Centralized facility system

As a general understanding, the “on site conditioning system” will be applied for the L1 waste disposal system in Japan.
Schematic operation of the system is as follows.

- The LLW is conditioned and solidified in 200 litter drums in nuclear power station (on site).
- The waste package is certified to meet the acceptance criteria of disposal facility.
- The certified waste packages are transported using dedicated transport container to the final repository.

On the other hand, the “centralized facility system” is already being operated in several countries such as France (CENTRACO facility) and Belgium (SILVA facility).
Schematic operation of the system is as follows.

- Raw wastes are transported to the centralized conditioning facility.
- The wastes are conditioned to waste package in the facility to meet the acceptance criteria of disposal facility.

- The certified waste packages are transported to the disposal facility.

We evaluated the two systems for applying L1 waste in order to clarify the problems.

On site conditioning system problems

1) Conditioning facility

- For conditioning L1 waste, hot cell is needed because of high dose rate of it. However it may be very difficult to construct the hot cell in the power plant, because of not only the high cost factors but also PA issue in Japan.
- Because of no conditioning facility in disposal facility, each power plant needs to construct the conditioning facility in order to fabricate waste package. Therefore total cost is very high.
- Because the waste packaging is required thick wall, the waste package may be very heavy and the handling equipment may be expensive.

2) Transport

- Total shielding thickness may be required up to 350mm. If waste packaging share main shielding performance, the waste packaging must be met the accidental condition of transport regulation. Therefore the waste packaging must be qualified equivalent to transport packaging and it may be expensive.
- In case of waste packaging sharing the required shielding, as the waste package is fabricated before transport, the content of the transport package is very heavy, and the transport packaging must be light and strong that it may be expensive.
- The limitation of the waste package outer dimensions makes the transport condition restricted, because the dimensions shall be designed following the most restricted power plant limitation.

3) Contamination

In power plants, L1 wastes are basically stored in the pond. The waste packaging shall be soaked in order to load the L1 waste in the pond. Therefore the water shall contaminate the waste packaging surface. The contamination of the waste packaging will be a problem for the operation of disposal facility, because the waste package must be handled in the controlled area just after unloading from transport package. In case of the current LLW disposal system, the waste package is fabricated in dry area and there is no surface contamination.

Centralized facility system problems

1) Repacking

In case of Centralized facility system, accepted wastes shall be repacked when the waste package is fabricated. However L1 waste consist of various wastes with different figures, material, nuclide, activity and so on. Therefore it is easily guessed that the optimized packing operation is very difficult and because of the practical limitation, the wastes will be loaded loosely into the waste packaging and the number of the package will increase, consequently

became high cost.

2) Traceability

It is better to trace the history of the disposed waste. However in case of the system, it is too difficult to follow the wastes history because of the repacking.

Inner Packaging system

In order to solve the problems of the existed waste management systems, we proposed a new management system, called " inner packaging system".

Schematic operation of inner packaging system is as follows.

1) Packaging selection

Depend on the inventory of the subject waste, an applied inner packaging is selected. For example, small inner packaging is selected for high inventory waste, and big one is applied for the low activity wastes.

2) Wastes loading into the inner packaging

- The inner packaging is soaked into the pond.
- The L1 wastes are loaded into inner packaging in the water.

3) Loading into transport packaging

- Transport packaging is transferred into the pond.
- In order to share the same handling equipments, the transport packaging has common outer dimensions.
- The wastes with high activity need high shielding performance; therefore the small inner packaging is selected for high inventory waste.
- The inner packaging with wastes is loaded into the appropriate transport packaging.

4) Transport

- Even if the packages have different weight following the shielding, the outer dimensions of them are common, same transport equipment can handle every package. So the standard handling makes cost reduction.

5) Unloading facility

- In the unloading facility, the inner packaging with wastes is unloaded from the transport packaging and reloaded into the waste packaging.
- When repacking the inner packaging, the contents (wastes) are kept as it loaded. Therefore the traceability of the wastes can be certified, and consequently the optimized packing of the wastes is achieved because the consignor of the wastes will make effort to minimize the number of the package in order to make cost reduction.

6) Waste package fabrication

- In order to make reasonable arrangement in repository, it is better that the waste packaging has same outer dimensions.
- The waste packaging is required the integrity of strength and corrosion in the underground

condition. Therefore the outer structure is made of upper grade steel.

- On the other hand shielding performance is required for protecting the remote control equipments in the repository. However if the thickness of the waste packaging is large, the cost of the packaging will increase. So it is better to use inexpensive materials for the shielding.

The waste packaging of this system has the feature as drawn in Figure 1.

Function dividing

Concerning the packaging design, we introduced “Function dividing” concept, which is design method that a minimum required function in each step of the system is applied to the packaging. Each component of the new system has following functions, for meeting the requirement of each management stage.

1) Inner packaging

- An anticorrosive material such as stainless steel (SUS), which can stand use in the pond, can be selected.
- Because the inner packaging is handled in the pond, the inner packaging isn’t required shielding function. Therefore the inner packaging can be thin in order to reduce the amount of the expensive material.

2) Transport packaging

- Transport packaging is required to meet the transport regulation.
- In order to reduce handling cost, it is better to use common handling equipments.

3) Waste packaging

- Waste packaging is constituted the outer packaging and additional shielding.
- The outer packaging is made of qualified material with required level of structural strength and anticorrosion in underground condition in the repository.
- The additional shielding is made of cheep materials such as cast iron and it is possible to apply reused materials of LLW metals, because gamma shielding is required only the density of the applied material.

By application of the “function dividing”, inner packaging system has advantage comparison to the other systems. In case of site conditioning system, the waste packaging needed to meet all requirement trough the all steps. So the material is needed to select the high-grade material. In case of centralized facility system, the waste packaging is required strength and shielding functions. So the second grade material is selected as shown in Table 1. Concerning the inner packaging system, optimized materials can be arranged for separated part as shown in Table 1.

Conclusion

New waste management concept “Inner Packaging system” has following advantages compared with existing systems such as “on site conditioning system” and “centralized facility system”.

- Packaging selection is easy based on the waste inventory.
- Wastes loading into waste package can be optimized because the competent person for managing the original waste will load it into the packaging.
- Standardized handling equipment can be used because of same outer shape of the transport package with different type of content.
- It is easy to track the traceability of waste because of avoiding the repacking of the wastes.
- Optimum material can be selected by function dividing concept.
- A waste management system which the inner packaging of the L1 wastes is transported with from many nuclear sites to one disposal site and that a waste packaging is manufactured in the low cost and to dispose of can be provided with satisfying the above.

Acknowledgements

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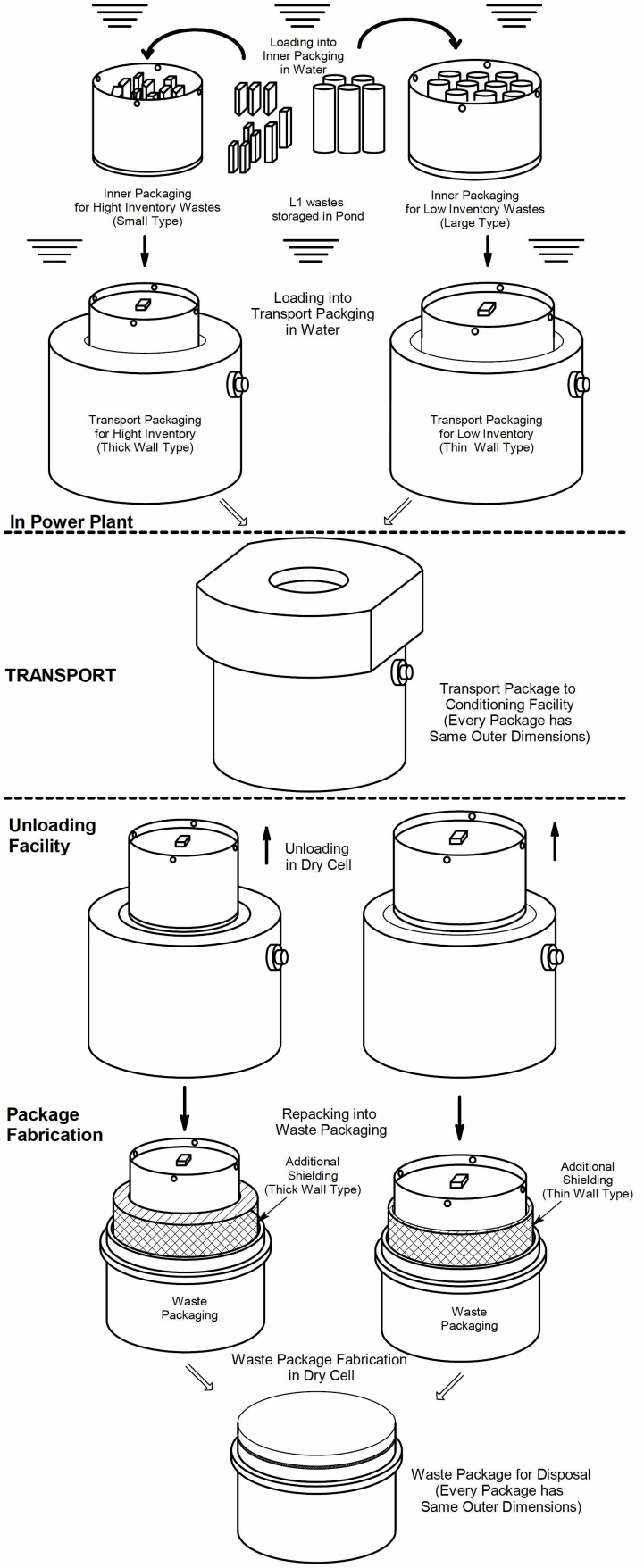
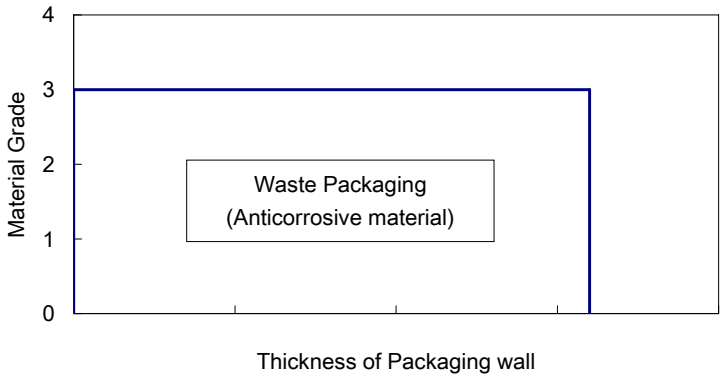
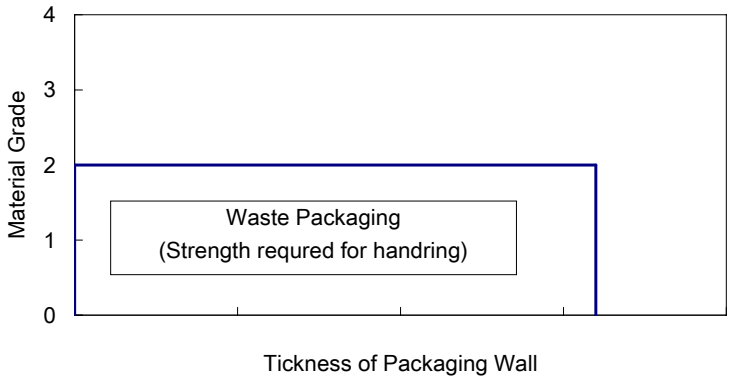
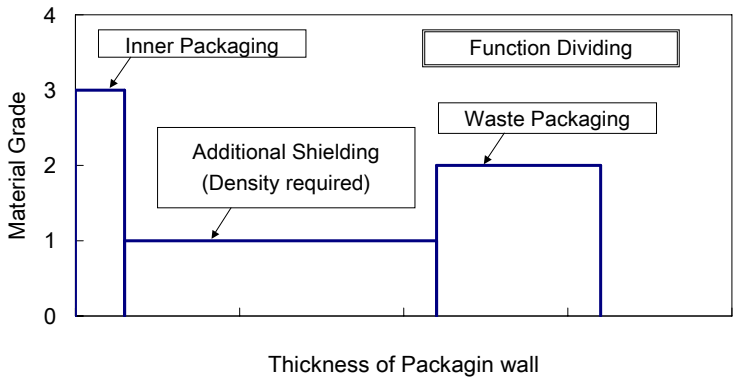


Figure 1 Concept of Inner Packaging system

Table 1 Material optimization of Inner packaging system

	Material Grade for Waste Packaging
On Site Conditioning System	
Centralized Facility System	
Inner Packaging System	

Material Grade	Requirement			Example
	Density	Strength	Anticorrosion	
1	Required	NA	NA	Cast iron
2	Required	Required	NA	Forged iron
3	Required	Required	Required	Stainless steel