A Preliminary Deep Borehole Disposal Concept for Cs-Wastes From Pyro-Processing

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1. Introduction

The purpose of disposal for radioactive wastes is not only to isolate them from humans, but also to inhibit leakage of any radioactive materials into the accessible environment.

Among the eight kinds of radioactive wastes generated from the pyro-processing that KAERI is developing to reuse the fissile nuclides and reduce the footprint of final repository, there are two highly-heat generating wastes, and they are called Cs-spent filter waste and Sr-spent filter waste. Generally, these two wastes are considered to be stored for some time to get rid of the decay heat at a storage facility of the above ground or the underground. And then they are to be disposed of as low and intermediate level radioactive waste.

In this study, the characteristics of the Cs-waste from pyro-processing such as waste form, decay heat and weight etc., were reviewed. Based on the review results, the concepts of Cs-waste disposal container and disposal at the depth of more than 2 - 3 km were designed preliminarily. And with this concept, thermal analyses were carried out and disposal area for the total Cs-waste amount based on the recent national energy basic plan was estimated.

2. Characteristics of Cs-waste

2.1 Decay heat of Cs-waste

Cs-spent fuel filters will be generated from the preprocessing of spent nuclear fuel. The decay heat from one Cs-spent filter waste form after discharge from a reactor was calculated and listed in Table 1.

Table 1. Decay heat of Cs waste with time

time		decay heat	
after discharge [yr]	after disposal [yr]	basis [W/10tonSF]	1 Cs-Waste [W/1 block]
40	0	3,293	548
60	20	2,068	344
80	40	1,299	216
100	60	**816**	136
110	**70**	**647**	**107**
120	80	513	85
140	100	323	53
160	120	204	34
180	140	129	21
200	160	**82**	13
250	210	28	4
300	260	**11**	1

Table 1 shows that most of decay heat disappears about 200 years after discharge.

2.2 Amount of Cs-waste

According to the current version of material balance, the amount of the waste from 30 tHM of PWR spent fuels is given in Table 2. With the consideration of 23,618 tHM of PWR spent fuels from 24 reactors, around 14,171 waste forms are expected.

Table 2. Amount of Cs waste from pyro-processing of 30 tHM of PWR SNF

Total weight of waste, kg	2,750
Size of waste form, mm	300 (D) ×900 (H)
Weight of waste form, kg	160
Number of waste forms	18

3. DBD Concept for Cs-waste

3.1 Disposal container concept

A double layered disposal container concept was proposed for the deep borehole disposal of Cs-waste. Inner part material of the disposal container was SiC to endure the pressure of disposal depth with high density brine water. And outer part of that was stainless steel to protect the inner SiC vessel and to make it easy to handle the containers strings in the deep boreholes. A container can hold 4 waste storage cans and 10 containers make one string to be emplaced in the borehole. This disposal container concept is shown in Fig. 1.

3.2 Disposal concept

A recent deep borehole disposal concept consists of drilling a borehole (or array of boreholes) into crystalline basement rock to a depth of about 5 km, emplacing disposal containers containing radioactive wastes in the lower 2~3 km of the borehole, and sealing the upper part of the borehole. The waste disposal containers could be emplaced individually or as a string of 10~20 containers. In the waste emplacement procedure of deep borehole disposal system, bridge plugs will be constructed to support the weight of container strings. A single borehole could emplace up to 400~600 containers (1,600~2,400 waste blocks), each approximately 5 m in length. The sealing material for the borehole can be compacted bentonite, asphalt and concrete (Fig. 2).

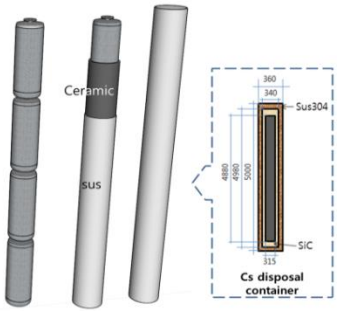


Fig. 1. A Concept of DBD container.

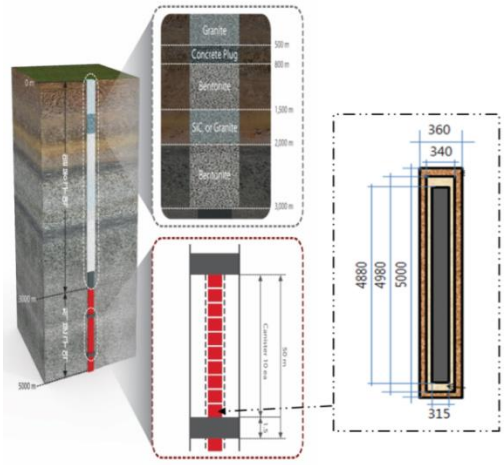


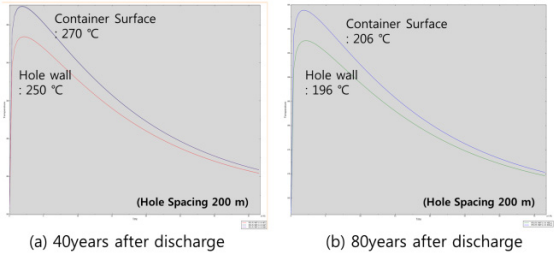
Fig. 2. A Concept of DBD for Cs waste.

4. Some Analyses for Cs-waste DBD System

4.1 Thermal Analyses

With the preliminary Cs-waste deep borehole disposal concept, some thermal analyses carried out and Fig. 3 shows the results. As shown in Fig. 3, the maximum temperature of canister surface and hole wall will be 270°C, 250°C respectively for the Cs-waste at the 40 years after discharge from reactors. For the Cs-waste at the 80 years after discharge, those will be decreased to 206°C, 196°C respectively.

For the integrity of the borehole or the bridge plugs in the disposal area, thermal condition at the disposal depth should be considered and a requirement related to this condition need to be established.



(a) 40years after discharge (b) 80years after discharge

Fig. 3. Conceptual drawing of buffer.

4.2 Disposal Area for Cs-waste

With the total amount of Cs-waste from pyro-processing, DBD area for Cs-waste was estimated. Two cases of disposal depth, depth from 3 km to 5 km and that from 2 km to 5 km, were considered and the disposal area were 0.36 km^2, 0.24 km^2 respectively, as shown in Table 3.

Table 3. Disposal area for Cs-waste

No. of Deep Borehole (No. of total waste form : 14,170 ea)		Disposal area	
		Array	Area km^2
Disposal depth 3 ~ 5 km	9	3 x 3	0.36
Disposal depth 2 ~ 5 km	6	3 x 2	0.24
* Borehole spacing : 200 m			

5. Conclusion

In this study, a preliminary deep borehole disposal concept for Cs spent filter waste which was one of highly decay heat generating waste from pyro-processing of PWR spent nuclear fuels was proposed. To do this, characteristics of the waste were reviewed and a concept of disposal container was drawn. Then, based on the DBD concept, some analyses such as thermal analyses and disposal area was carried out.

These kind of analyses need to be carried out in detail with the real site data later. And the result of this study can be used as an input data for the establishment of the disposal policy.

Acknowledgement

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