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# Deep Borehole Disposal as an Alternative Concept to Deep Geological Disposal

Jongyoul Lee, Minsoo Lee, Heuijoo Choi, and Kyungsu Kim
*Korea Atomic Energy Research Institute, 989-111 Daeduk-daero, Yuseong, Daejeon*
*njylee@kaeri.re.kr*

## 1. Introduction

A mined deep geological disposal system, the disposal depth is about 500 m below ground, is considered as the safest method to isolate the spent fuels or high-level radioactive waste from the human environment with the best available technology at present time. The disposal safety of this system has been demonstrated with underground research laboratory and some advanced countries such as Finland and Sweden are implementing their disposal project on commercial stage. However, if the spent fuels or the high-level radioactive wastes can be disposed of in the depth of 3~5 km and more stable rock formation, it has several advantages. Therefore, as an alternative disposal concept to the mined deep geological disposal concept (DGD), very deep borehole disposal (DBD) technology is under consideration in number of countries in terms of its outstanding safety and cost effectiveness.

In this paper, the general concept and key technologies for deep borehole disposal of spent fuels or HLW, as an alternative method to the mined geological disposal method, were reviewed. After then an analysis on the distance between boreholes for the disposal of HLW was carried out. Based on the results, a disposal area were calculated approximately and compared with that of mined geological disposal. These results will be used as an input for the analyses of applicability for DBD in Korea.

## 2. A Concept of Deep Borehole Disposal

### 2.1 General Concept

Deep borehole disposal of spent fuel from nuclear power plants or solidified high-level radioactive waste from the reprocessing of nuclear fuel is a concept that dates from the 1950s in USA as one of several disposal concepts. This concept was considered again in the 1990s and early 2000s in USA and some countries in Europe such as Sweden, Denmark and the UK [1].

A recent deep borehole disposal concept consists of drilling a borehole (or array of boreholes) into crystalline basement rock to a depth of about 5,000 m, emplacing waste canisters containing spent nuclear fuels or vitrified high-level waste in the lower 2,000 m of the borehole, and sealing the upper 3,000 m of the borehole.

The waste packages would be emplaced individually or as a string of 10-20 packages. A single borehole could contain up to 400 waste packages, each approximately 5 m in length. The sealing material for the borehole can be compacted bentonite, asphalt and concrete (Fig. 1.) [2].

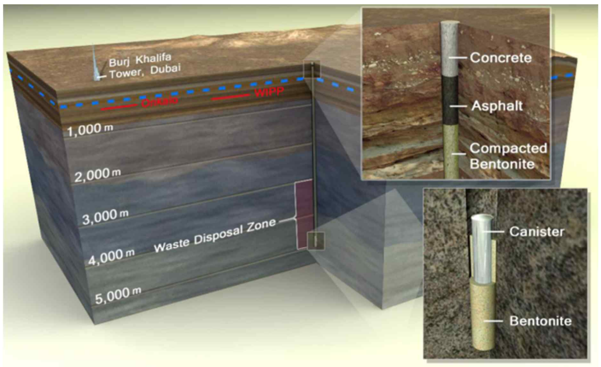


Figure 1. General concept of deep borehole disposal[2].

### 2.2 Potential Advantages

Because the proposed disposal zone in a deep borehole disposal concept is significantly deeper than that of a mined geological disposal, waste isolation from the biosphere and ground water systems could be enhanced by several factors (Figure 2).

- The greater depth of emplacement
- The low permeability of the host rock at depth, as well as longer distances to the surface, which would result in very long travel times
- Deep fluids also resist vertical movement because they are density stratified.
- The reducing conditions (i.e., low concentrations of oxygen), which would result in greater geochemical isolation of the waste due to the lower solubility and mobility of some radionuclides, such as the actinides.
- And also, multiple disposal sites could be located near nuclear power plants with suitable geologies, thus reducing the need to transport spent fuels.

## 3. A Preliminary DBD Concept

Based on fuel types being used in the nuclear power plants and spent fuel arising, a reference spent fuel for a preliminary deep borehole disposal concept, PLUS-7, was determined. With this reference spent fuel type, a concept of the engineered barrier, disposal container and sealing of borehole, were derived[2]. Accordingly, preliminary concept of the deep borehole disposal system was established (Fig. 2).

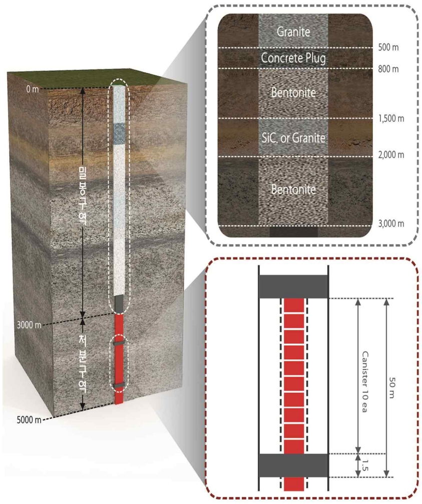


Fig. 2. A preliminary DBD concept

Disposal container for deep borehole disposal has the concept of double layered canister, the material of inner layer is SiC to endure the load in the disposal environment and the material of outer layer is 316L grade stainless steel to facilitate handling of the canister(Fig. 3.). 10 disposal canisters are connected in a row to make a string and 40 strings are emplaced in a deep borehole.

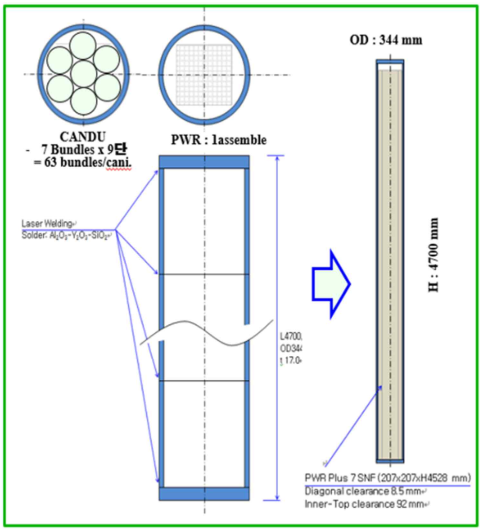


Fig. 3. DBD disposal container concept

The preliminary concept of sealing zone should be based on the performance of not only protection the wastes from groundwater but also delay of leaked radionuclides from disposal canister. And the concept should have the performance of the prevention of human intrusion as well. To do this, the considered materials of borehole sealing were bentonite, SiC, granite, asphalt and concrete plug(Fig. 4). The proposed sealing concept in this report was the very preliminary system, and in order to realize the concept, the test for physical properties, manufacturing and in-situ tests should be performed.

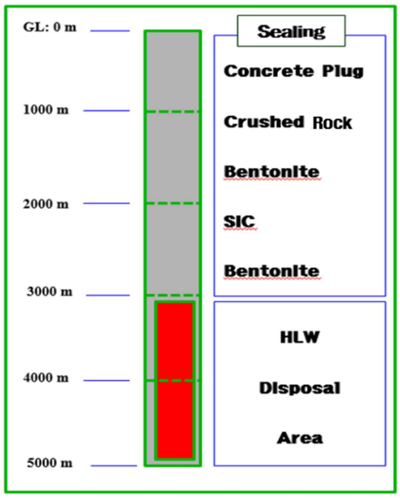


Fig. 4. A preliminary sealing concept

## 4. Concluding Remarks

In this paper, the general concept of deep borehole disposal for spent fuels or high level radioactive wastes was reviewed. And the key technologies, such as drilling technology of large diameter borehole, packaging and emplacement technology, sealing technology and performance/safety analyses technologies, and their challenges in development of deep borehole disposal system were analyzed. Also, very preliminary deep borehole disposal concept including disposal canister concept was developed according to the nuclear environment in Korea. These results will be used as an input for the analyses of applicability for DBD in Korea

## REFERENCES

[1] Bill W. Arnold, Patrick V. Brady, Stephen Pye, Reference Design and Operations for Deep Borehole Disposal of High-Level Radioactive Waste, SAND2011-6749, Sandia National Laboratories, Albuquerque, NM. 2011.

[2] J.Y. Lee, M. S. Lee, K. S. Kim, Preliminary Evaluation of Geoenvironmental Characteristics in Deep Geological Formation, KAERI/TR-5533/2014, Korea Atomic Energy Research Institute, 2014.