The Status of LILW Complex Disposal Facility Construction in Korea – 17123

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ABSTRACT

In this paper, the experiences and directions of the construction of the LILW disposal facility in Korea are discussed. The LILW disposal facility is being constructed in Gyeongju-si, Korea. The disposal facility is officially called 'Wolsong Low and Intermediate Level Radioactive Waste Disposal Center (WLDC)'. It can dispose of 800,000 drums (hereafter, "drums" means "200 liter drum equivalents" unless specified otherwise) of radioactive waste in a site of 2,060,000 m^2.

The first stage of the LILW facility construction was completed in June 2014, and approved for use by Nuclear Safety and Security Commission (NSSC) in December 2014. The first stage of the LILW facility is a type of underground silo with disposal capacity of 35,200 m^3 (100,000 drums). The first stage of the LILW facility consists of a construction tunnel, an operation tunnel, an access shaft and six silos, etc. Silo for final disposal is located 80~130 m below sea level, 25 m in diameter and 50 m in height. The capacity of each silo is approximately 16,700 drums.

The second stage of the LILW facility is under construction to be completed by December 2019. Site construction is currently underway. The second stage of the LILW facility is a type of near-surface disposal with disposal capacity of 32,875 m^3 (125,000 drums). This stage of the LILW disposal facility consists of an underground gallery, three movable cranes and twenty vaults, etc. Vault for final disposal is located 70 m above sea level, 20 m in width, 20 m length and 10 m in height. The capacity of each vault is approximately 6,250 drums.

These stages of the LILW disposal facilities are together called LILW complex disposal facility. It's the world's first LILW disposal facility with two different types of disposal facilities in one site. For efficient operation, these disposal facilities share a reception and storage building, waste water treatment system, measurement and monitoring system, etc. After construction of the first two stages is completed, LILW disposal facilities will be incrementally expanded, and as the whole LILW disposal facilities are completed, all LILW in Korea will be managed safely in WLDC.

INTRODUCTION

As of December 2015, accumulated amount of LILW in Korea (Korea means ROK, same hereafter) is approximately 131,700 drums.

Among these, commercial nuclear power plants (NPPs) generate 98,800 drums of LILW (75%), research institutes, nuclear fuel manufacturing facilities, and radioisotopes (RI) generate the rest. Also by 2100, accumulated amount of LILW in Korea will be approximately 835,200 drums.

After the amendments to the Atomic Energy Act in 1986, the Korean government has failed nine times to secure a disposal site until 2004. In December 2004, National Policy and Principles was amended to separate the disposal between LILW and HLW by the Atomic Energy Committee.

In 2005, though a revised disposal site selection procedure Gyeongju-city was selected as a candidate site. In January 2007, the Korea Hydro & Nuclear Power Co., Ltd. (KHNP) submitted a permission application for construction and operation of the first stage of the LILW facility (100,000 drum[1]) to the Ministry of Education, Science and Technology (MEST), the national nuclear regulatory authority. As entrusted by MEST, the Korean nuclear safety regulatory body (Korea Institute of Nuclear Safety "KINS"), reviewed the license document and issued the construction and operation approval in July 2008.

In January 2009, Korea Radioactive Waste Agency (KORAD) was established to build a structure of mutual control and balance by differentiating the producers of radioactive waste from their disposal operator, based on the "Radioactive Waste Management Act (2008)". KORAD received the project of first stage of the LILW disposal facility construction from KHNP in 2010, and since completed that in 2014, it is currently operating. Since 2011 KORAD has been constructing the second stage of the LILW facility and it is scheduled to be completed in 2019.

Now, we will provide the process and status on the site selection and constructing first and second stage of the LILW facilities in WLDC.

SITE SELECTION

Korean government has made nine attempts to secure a site of radioactive waste disposal facility for about 20 years since 1986, but none of them have been successful. Major causes of failure are as follows; 1) safety concerns about disposal facility operation by local residents, 2) a policy making by stakeholders with a lack of transparency, and 3) lack of trust toward incentives that was proposed by the government and nuclear industry.

For the above reasons, the Minister of Knowledge Economy (MKE) announced new approaches for site selection. Here are some of details. 1) Separation of LILW and HLW, 2) organization of Site Selection Committee (SSC), 3) decision through local

[1] In case of first stage of the LILW facility, 100,000 drums include more than 200 liter drums.

referendum process, and 4) enactment of a special act for local support.

Accordingly, the MKE organized the SSC in order to guarantee the transparency and fairness of the site selection process. The SSC consists of 17 civilian experts from diverse fields, and managed and supervised the entire process of site selection. In addition, the "Special Act on Supporting the Local County around the Low and Intermediate Level Radioactive Waste Disposal Facility" was legislated and announced on March 31, 2005, to stipulate support for local area with LILW disposal facilities, including special financial support, commission for transporting waste, and relocation of the KHNP headquarters.

The following procedural steps will be used to select the candidate site. As local governors apply to host the disposal facility with consent from local councils, selection for candidate site proceeds. Then according to the results of the site suitability assessment, the MKE requests local governors to conduct the local referendums in appropriate regions strictly in accordance with the Referendum Act. Based on the results of the local referendums, an area with the highest percentage of favorable responses would be selected as the final candidate site.

The local governments that conducted local referendums were in the four areas of Gyeongju, Gunsan, Pohang, and Yeongdeok County. According to the results of the local referendums, Gyeongju was selected as the final candidate site with 89.5% of favorable responses as seen in Table I.

Finally, On January 2, 2006, the MKE designated that the prearranged area for electric power resource development business comprising the entire 49 Bonggil-li, Yangbukmyeon, Gyeongju-si, North Gyeongsang Province (approximately 2,058,000 m²) had been selected as the final candidate site for the 800,000 drums of LILW disposal facility (the MKE Notice No.2005-133).

TABLE I. Results of Referendums

	Gyeongju	Gunsan	Pohang	Yeongdeok
Number of voters	208,607	196,980	374,697	37,536
Number of actual voters	147,636	138,192	178,586	30,107
Percentage of favorable responses	89.5%	84.4%	67.5%	79.3%

THE FIRST STAGE OF THE LILW FACILITY CONSTRUCTION

Overview

In order to implement the approved fundamental principles at the 253rd board of the AEC (December 17, 2004), the Korean government decided to construct a disposal

facility that can dispose of 100,000 drums for the first stage and ultimately expand the capacity up to a total of 800,000 drums in incremental stages.

In April 2006, the KHNP organized Disposal Method Selection Committee (DMSC) to determine disposal methods of first stage of the LILW facility. The DMSC consisting of 16 experts from diverse fields determined the disposal method as an underground silo type for the first stage of the LILW facility at June 2006. Regarding disposal facility after second stage of the LILW facility, the DMSC suggested to select a disposal method with consideration of overall condition, such as condition of site, policy of radioactive waste disposal, etc.

A layout for the initial facility which will dispose of 100,000 drums is depicted in Fig. 1. The first LILW disposal facility consists of surface facilities and underground facilities.

Fig. 1. Layout of the Wolsong LILW Disposal Center

The surface facilities include equipment and maintenance building, a receipt and inspection facility, an interim storage facility, a radioactive waste treatment building, and supporting facilities such as main control center, which are depicted in Fig. 2. The surface facilities were completed in July 2010 and are currently operational.

Fig. 2. Layout of the surface facilities; a) Waste Water Treatment Building, b)Garage, c)Equipment Maintenance Shop & Warehouse, d)Radioactive Waste Receipt & Storage Building, e)Radioactive Waste Treatment Building, f)Service Building I, g)Service Building II, h)Power Supply Building

The waste receipt/storage building inside the site of the disposal facilities is operational for radioactive waste from NPP's which require additional storage capacity. At the end of September 2016, the waste receipt/storage building has been storing and managing about 5,700 drums of LILW.

All nuclear power plants in Korea are located on the coast. So KORAD has constructed and now operates the ship, 'Cheong Jung Nuri', for the transportation of radioactive waste from nuclear power plants to Wolsong LILW disposal center. The Cheong-Jung Nuri is safely designed and constructed in compliance with international standards of International Atomic Energy Agency (IAEA) and International Maritime Organization (IMO) as well as domestic standards such as the Ship Safety Act and the AEA and was approved by the Ministry of Land, Transport and Maritime Affairs (MLTM). The safety of the ship and the appropriateness of the operational procedures were confirmed through inspection by the KINS. Furthermore KORAD prepare 300 containers and five trucks (15ton) for the transport of radioactive waste.

SPECIFICATIONS	
Length	78.6 m
Width	15.8 m
Gross Tonnage	2,600 tons
Speed	12 kn
Engine	3,264 HP
Capacity	Max. 1,520 Drums

Fig. 3. Cheong-Jung Nuri

The underground facilities consist of a construction tunnel for transport of construction equipment and materials, an operation tunnel for transport of radioactive waste, an access shaft for workers, and six silos for final disposal of radioactive waste.

At first, six silos will be constructed approximately 80~130m below sea level (see Fig. 4.), 25 m in diameter and 50 m in height with a disposal capacity of 100,000 drums (approximately 16,700 drums per silo)

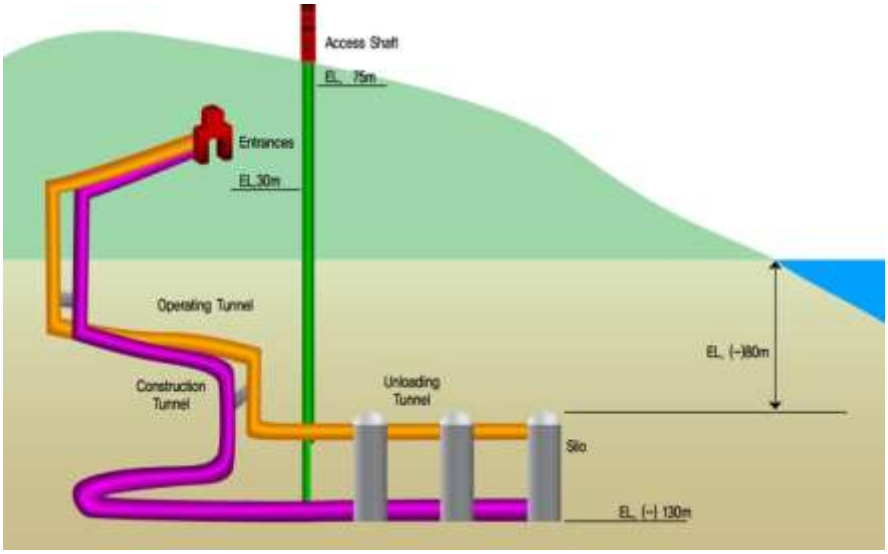

Fig. 4. Cross section view of the underground facilities

Among the underground facilities, excavation for the construction tunnel, operating tunnel and access shaft began in August 2008 and excavation of disposal silos started in February 2011. As of the end of December 2012, the excavation and concrete lining processes were completed for the construction tunnel (1,950 m), operating tunnel (1,415 m), and access shaft (207 m). The excavation of the unloading tunnel

(360 m) was completed in June 2012.

Construction

The construction and operation license for the first LILW disposal facility was issued in July 2008. Construction began in August and pre-service inspection by the KINS began in September 2008. Pre-service inspection for the LILW disposal facility is intended to check the appropriateness of the corresponding construction, performance and overall operation preparation status. Construction was completed in June 2014 and KORAD approved the pre-service inspection from NSSC in December 2014.

Layout

All disposal silos are reinforced with shotcrete and concrete lining. Most waste packages are disposed of in the disposal silos using disposal concrete containers. The engineered barrier system of the disposal silo consists of disposal container, backfills, and a concrete silo. The conceptual drawing of the post-closure phase of disposal silo is shown in Fig. 5.

LILW are disposed of separately in six silos depending on the size and characteristics of the waste in order to maintain integrity of disposal container and minimize the gap between packaging containers. For loading efficiency, 16-Pack (4x4) disposal containers of 200-liter-drums and 9-Pack (3x3) disposal containers of 320-liter-drums are used. The waste drums are placed inside the disposal containers, which are handled with remote equipment such as a crane.

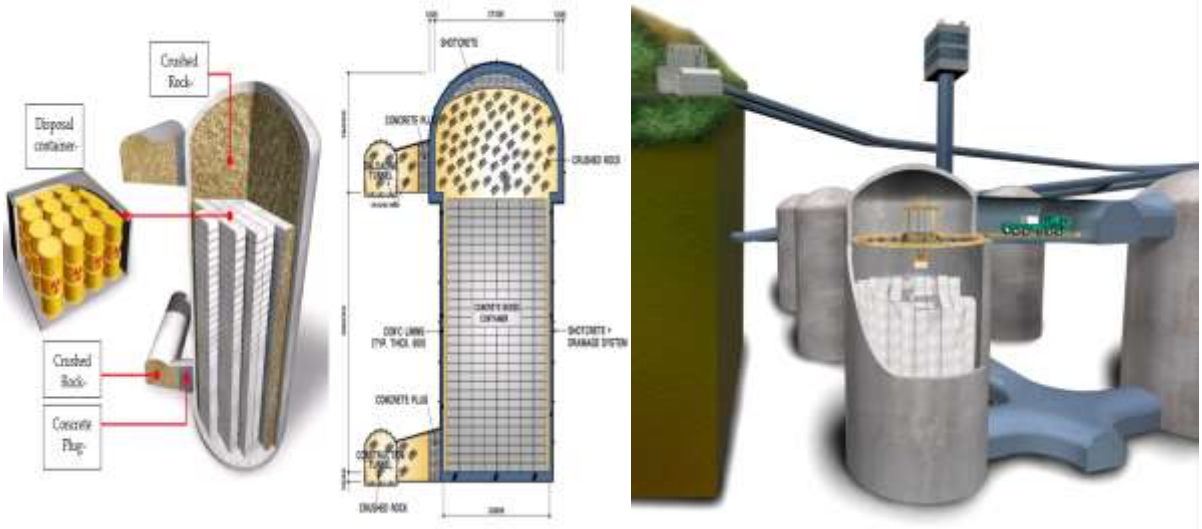

Fig. 5. Concept of disposal silos after closure

Regulatory guidance

To comply with the requirements in permit or license conditions according to the

Nuclear Safety Act, during the construction of the LILW disposal facility, the NSSC carries out the pre-service inspection for the installer of disposal facilities. If violations occur, the chairman of the NSSC immediately orders the installer of the disposal facilities to take corrective actions and complementary measures so as to secure the safety of disposal facilities. The KORAD is in charge of the safety management.

LILW disposal facilities are designed to maintain their structural and functional integrity during normal as well as abnormal operating conditions. Therefore, the design and construction shall be based on proven engineering practices. In addition, installed equipment and components are to be regularly tested and inspected to confirm that they can continue to be used safely.

Safety Assessment results

To show the long term safety, the assessment is carried out in various scenarios. The results of the safety assessment meet the regulatory criteria. At the preliminary phase the expected dose rate which takes the estimated probabilities of different cases into account is 0.004mSv/y less than the regulatory limit (0.1mSv/y): Preliminary phase dose rate: 0.004mSv/y

Therefore, the disposal of the low and intermediate waste in the first stage of the LILW facility can be considered acceptable.

Excavation for silos

The excavation method especially for large underground structure like silos should be determined with consideration for items related to safety of structures such as sizes of excavation sections, degree of self-supporting of rock mass itself and constructability of excavation methods and economic feasibility, etc. For successful excavation of large underground structures and the stability just after excavation (without installation of ground support) should be guaranteed. In case of large excavation section, excavating a whole section in one step can reduce constructability in transportation of excavated materials and installation of ground support. Furthermore may make a collapse of underground structure with weak or unfavorable ground condition.

Furthermore, there may be risk of collapse of underground structure because of weak or unfavorable ground condition. Therefore, a large excavation section needs to be divided into several sections and excavated in consideration of stability and constructability of underground structure.

The site for first stage of the LILW facility has such a complicated ground (rock) condition that causes a lot of difficulty for construction of the silos. This unfavorable condition of rocks was considered to plan and a customized excavation method rather than a consistent method without considering variables was applied to design and construction according to rock condition. For the excavation of silos, the several cases

of domestic and foreign excavation methods were studied and excavation plans have been made especially considering ground conditions of silos. The dome is a critical part for silo construction. Since the shape of dome is different from that of general tunnel and access shafts we had challenges to determine modified excavation methods suitable for conditions of site.

Management of the excavated materials (soil/rock)

During the construction of first stage of the LILW facility, the excavated materials (soil and rock) are brought from the excavation process for underground structures like tunnels and silos and buildings like ground facilities, etc. (see Fig. 6. & 7.)

Fig. 6. The view of Construction ; a)Portal, b)Shaft entrance, c)Operation tunnel, d)Construction tunnel

Fig. 7. Silo construction

The excavated rock is used as embankment materials for roads or side backfill materials for buildings. Especially competent rock from blasting excavation of tunnels is used for concrete production materials or riprap of harbor construction, and the remainder is piled up on the spoil area. The excavated soil is piled up on the spoil bank or given to local citizens as requested. The excavated rock is piled up on spoil area in site because it will be used as backfill materials for tunnels and silos when the first stage of the LILW facility is closed.

Construction activities

All concrete work shall be performed in accordance with ACI, ASTM Codes and Standards to keep the integrity of silo concrete and the function as engineering barrier during the post-closure institutional control period as well as the operation period. The main construction activities are as follows:

1. Concrete production, conveying and placing, consolidation of concrete, and
2. Cold and hot weather concreting, curing, finishes and repair, etc. for concrete lining

Fig. 8. The view of Portal

Fig. 9. The view of unloading tunnel

Environment Friendly Complex (KORADIUM)

At the WLDC, KORAD is building an 'Environment Friendly Complex (KORADIUM)' with a theme of nature and science for restoration of damaged sites and ecological conservation, and it will become a tourist attraction in Gyeongju as an environment-friendly facility where everybody wishes to visit. (See Fig. 10)

Fig. 10. Layout of the Environment Friendly Complex

The environment friendly complex consists of the 'Four Season Flower Garden', Kiosk of Perception', 'Dynamic Deck', 'Light Theme Park' as well as a visitor center, and open air performing theatre. The area of the complex is about 50,000 m².

THE SECOND STAGE OF THE LILW FACILITY CONSTRUCTION

Overview

At the selection of first stage of the LILW facility's disposal method, the DMSC recommended that a disposal facility after the second stage should be selected based on overall condition considering items such as state of site, policy of radioactive waste disposal, etc. So as the method of second stage of the LILW facility, an engineering vault type (at near surface) was selected based on an existence of suitable sedimentary rock region for engineering vault type disposal and considering that most of radioactive waste generated inside Korea is Low-level and Very-Low-level radioactive waste.

The second stage of the LILW facility for 125,000 drums is depicted in Fig. 11.

Fig. 11. Bird's-eye-view of second stage of the LILW disposal facility

The second stage of the LILW facility consists of disposal facility, underground gallery, subsidiary facility, and common facility. The disposal facility consists of 20 vaults and 3 mobile cranes (10 ton). The size of vault is 20 m×20 m×10.9 m (W×L×H) and each vault will dispose about 6,250 drums. Underground gallery located below the vault inspects and tests using collected water within the vault. The subsidiary facility consists of substation building, crane warehouse, control building, and security office.

Vaults are supposed to be constructed at an elevation of approximately 100m above and 70 m above groundwater, which never be effected by tsunami and groundwater intrusion. At second stage of the LILW facility, low-level and very-low-level radioactive waste are supposed to be dispose of, and the safety will be confirmed through institutional management after closure over the next 300 years.

Construction

In July 2016, as authorization of the electric power resource development business' execution plan was obtained from the Ministry of Trade, Industry and Energy (MOTIE), construction began in August 2016 and development work is currently progressing on the site.

It is expected to get approval for construction from NSSC in August 2017 and begin to construct the facility in September 2017.

Layout

The vault is made of a reinforced concrete structure and 20 vaults with the size of 125,000 drums will be constructed. Development site with the size of 250,000 drums will be used for next stage of the LILW facility construction.

About 6,250 LILW drums will be disposed of in each vault and drums will be disposed of separately at regular intervals in order to maintain the integrity of drums and vaults. The waste drums are handled with remote equipment such as a movable crane. After disposal of the drums, grout is poured into the vault. It will be finished by putting a cover on top after closure. The final cover will consist of surface layer, drainage layer, barrier layer and a multi-layer to meet the performance goal by controlling nuclide release to ground water and minimize the likelihood of water penetration into vault.

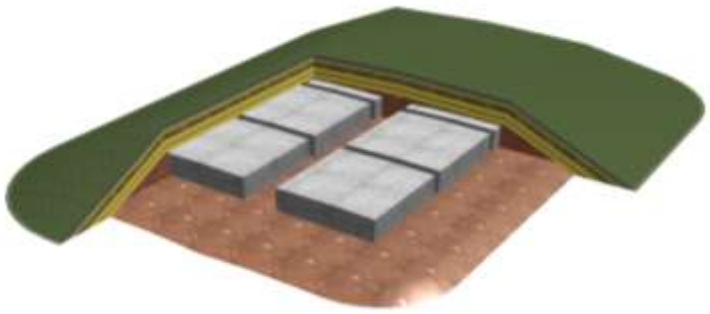

Fig. 12. Concept graphic of final cover

Regulatory Guidance

Same as THE FIRST STAGE OF THE LILW FACILITY CONSTRUCTION's Regulatory Guidance.

Safety Assessment

To show the long term safety, the assessment is carried out in various scenarios like first stage of the LILW facility. Safety assessment is currently underway and is provided in the license to construct and operate the facilities.

Construction Activities

All concrete work shall be performed in accordance with ACI, ASTM Codes and Standards to keep the integrity of silo concrete and the function of engineering barrier during the post-closure institutional control period as well as the operation period like first stage of the LILW facility.

CONCLUSIONS

Despite of nine failures in site selection for nineteen years, the painful experiences were contributed to new approaches for success. Consequently, Gyeongju in Korea was selected as the site of LILW disposal facility, and the first stage of the LILW facility construction was completed by June of 2014, the second stage of the LILW facility is currently under construction.

Once construction of the second stage LILW facility is completed, the WLDC is the world's first complex disposal facility with both underground silo type and engineering vault type together in one site. In consideration of the world's first complex disposal facility, safety verification within WLDC must be accomplished thoroughly.

Considering the site characteristics such as geology, earthquakes, meteorology, and hydrology as well as other manmade disasters, LILW disposal facilities were supplemented and improved. Furthermore they are designed to maintain their structural integrity even with minimal maintenance and repair activities during the institutional control period after the closure.

By applying a multi-barrier concept, the design, installation and operation of the disposal facility shall be complied with the site closure and stabilization; thus, the performance objectives after the closure shall be also met.

Safety is the most important fundamental objective of the national radioactive waste management program in Korea. Much effort has been devoted to construct the first and second stage of the LILW facilities.

The KORAD is continuing the efforts toward the successful implementation of the national radioactive waste management projects, including improvement of the safety and reliability of the LILW disposal center.

The KORAD will play an essential role in the development of the nuclear industry as the main energy resource for green development by building a management system satisfying global standards and enhance the safety, professionalism and transparency as an independent organization of radioactive waste management.

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