J. of the Korean Radioactive Waste Society
Vol.9(2), PP. 87-92, June 2011.

[Technical Paper]

Very Low Level Radioactive Solid Waste Management in CHINA

중국에서의 극저준위 방사성 고체 폐기물 관리

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(Received March 18, 2011 / Revised May 03, 2011 / Approved May 24, 2011)

Abstract

This paper introduces the policy and regulations on very low level waste (VLLW) management in China. Given the important decommissioning and site restoration program of the old facility, it is considered necessary to create a new disposal facility dedicated to VLLW. Many general design principles are in common with to the disposal facility for low and intermediate level waste (LILW), namely the isolation of the waste by means of a multibarrier system, but using bentonite and/or high density polyethylene membranes instead of the generalized use of concrete barriers. The design of the facility is consistent with the design of disposal facilities for hazardous waste. The engineering design of two VLLW disposal facilities is introduced.

Key words : VLLW, landfill Disposal, Multibarrier, disposal cell, Decommissioning

요 약

본 논문은 극저준위폐기물 관리에 관한 중국의 정책과 규정들을 소개하고 있다. 오래된 시설의 중요한 해체 및 부지복구 프로그램에 주어진 바와 같이, 극저준위폐기물의 처분을 위한 새로운 시설의 필요성이 대두되고 있다. 여러가지 일반적인 설계원리들은 다중방벽에 의해 폐기물을 격리시키는 중저준위폐기물 처분시설과 같다. 콘크리트 방벽을 사용하는 것 대신에 벤토나이트 또는 고밀도 폴리에틸렌 멤브레인을 사용하는 것 외에 통상적으로 처분시설의 설계는 위해폐기물 처분시설의 설계와 같다. 극저준위폐기물 처분시설 2개소의 공학적 설계가 소개되었다.

중심단어 : 극저준위 폐기물, 매립 처분, 다중방벽, 처분셀, 해체

Ⅰ. Introduction

Chinese nuclear industry dates back to the 1950s. Some nuclear facilities were shut down and the others are entering the decommissioning stage. Large amount of very low level radioactive waste will be generated from the decommissioning

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program and cleanup or site restoration program. How to manage these kinds of waste is a new challenge confronting us.

In 2004, IAEA developed guidance on the application of the concepts of exclusion, exemption and clearance (No. RS-G-1.7). This guidance refers to the application of a graded approach for making the provision for safety and radiological protection. In order to ensure that all radioactive waste be managed in an acceptably safe manner, a common framework has been established to provide an approach for ensuring such safe management, particularly disposal, of all radioactive wastes types consistent with the IAEA waste management principles. For VLLW disposal, landfill is a generally acceptable option.[1]

In some countries, such as France, Spain and the United States, facilities for VLLW disposal already exit and are under operation. Their successful experiences of management of VLLW can be used for reference. Under these circumstances, Chinese regulatory body decides to build on-site landfill disposal facilities for VLLW in the northwest and southwest regions.

II. Regulations on VLLW Disposal

Issued in 1995, the Chinese national standard, "GB9133 Classification of Radioactive Waste," introduced a classification system based on the radionuclide concentration levels. The following categories were defined: exempt waste (EW), low level waste (LLW), intermediate level waste (ILW) and high level waste (HLW). At that time, there was not the concept of VLLW, which can be a part of low level waste. LILW is disposed at near surface vault type facility. In order to be consistent with new international waste management trend and optimization principle, this standard is being revised and VLLW will be included .

Issued in 2002, the national standard, "GB14500 Regulations for radioactive waste management," first put forward that large amount of VLLW from decommissioning and environment restoration do not need to be disposed at LILW disposal facility, they can be disposed according to the activity limit and scheme approved by the regulatory body.

A new national standard, "Landfill Disposal for Very Low Level Radioactive Solid Waste," is being drawn up and will be issued in the near future. One challenge we face is how to deal with relative small amount of VLLW because in China solid waste is mechanically divided into two kinds: radioactive solid waste and non-radioactive solid waste (municipal solid waste, industrial solid waste and hazardous waste). They belong to different management systems and comply with different acts, regulations and standards. Normally the owner of landfill site for municipal solid waste (MSW) refuses to accept radioactive solid waste. There is still a long way to go to reach consensus agreement on this.

III. Design Criteria

Currently there is no technical code or standard for VLLW landfill disposal in China. When locating and designing a facility, we follow technical codes for LILW, MSW or hazardous waste. Many general design principles are in common with those for the LILW disposal facility, namely the isolation of the waste by means of a multi barrier system. But they need to be adapted to the characteristics and activity of this specific type of waste by using sodium bentonite geosynthetic clay liner (GCL) and high density polyethylene (HDPE) membranes instead of the generalized use of concrete barrier.

Some technical requirements of "Landfill Disposal for Very Low Level Radioactive Solid Waste" are as follows :

VLLW should be landfill disposed in the nearby facility. For large amount of VLLW, an on-site facility is recommended. HDPE membrane, GCL, and geotextile can be used as liner system engineering material. The highest water table should be controlled at 2 meters below the liner foundation. Institutional control period is 30 years.

IV. Description of Northwestvllw Disposal Site[2]

Northwest VLLW disposal site is located in Gansu province, Gebi desert (Fig.1). It is an on-site facility serving for the decommissioning and environment restoration of a nuclear base. The total capacity is 200,000m^3 and occupied area is 134198.19m^2. It is under construction now. The natural condition of the site is:

Average precipitation: 66.4mm/y.

Average evaporation: 2471.1mm/y.

The water table: 25.0-27.7 m below surface.

Permeability coefficient: $2.30 \times 10^{-5} \sim 5.30 \times 10^{-5}$m/s

1. Characteristics of the VLLW

A majority of the VLLW will come from decommissioning and environment restoration of the Northwest Nuclear Base. In most cases, the VLLW is wall scrap or floor scrap, demolished concrete, contaminated soil, sand or sludge. The proposed maximum specific activity for some radio nuclides in waste packages is shown in Table I. The maximum total activity of a batch is given by equation (1).

$$\sum \frac{a_i}{A_{i\max}} \leq 1 \quad \cdots\cdots (1)$$

Where a_i is the average specific activity of waste batch for radionuclide i and A_{imax} is maximum specific activity of radionuclide i.

2. Disposal cell

The disposal cell is an underground type. The bottom of the cell is at about -8m. Given that the groundwater is relatively deep and there are several clay layers beneath the cell, the structure of the liner system is simple as it consists of one GCL layer. The region where the site is situated is arid and windy. The highest wind speed is 28m/s. To prevent wind erosion, the level of the top of the cell cover is the same as the ground level (Fig.2)

The dimensionof the disposal cells is 125m long by 55m wide by 8m deep.The depth of the VLLW in one cell is about 5.4m. One single cell can accept approximately 20000m^3 of VLLW .

From bottom to top, each disposal cell is formed by (Fig.3):

(a) Liner foundation, 300mm, sand and gravel content <10%, does not contain granulates bigger than 30mm in diameter, rammed layer by layer

Table 1. Maximum Specific Activity

Nuclide	A_{imax}(Bq/g)	Nuclide	A_{imax}(Bq/g)
Co-60	10	Ni-63	10000
Sr-90	100	Am-241	10
Cs-137	10	Eu-152	10
U-238	100	Eu-154	10
Pu-239	10	Np-237	10

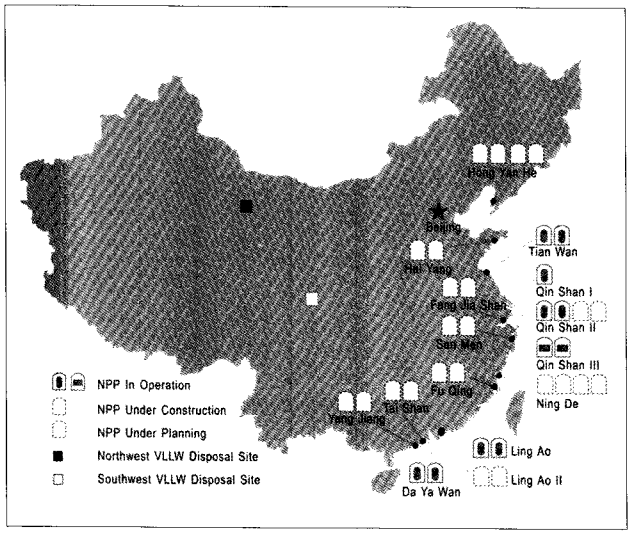

Fig. 1. Site Location

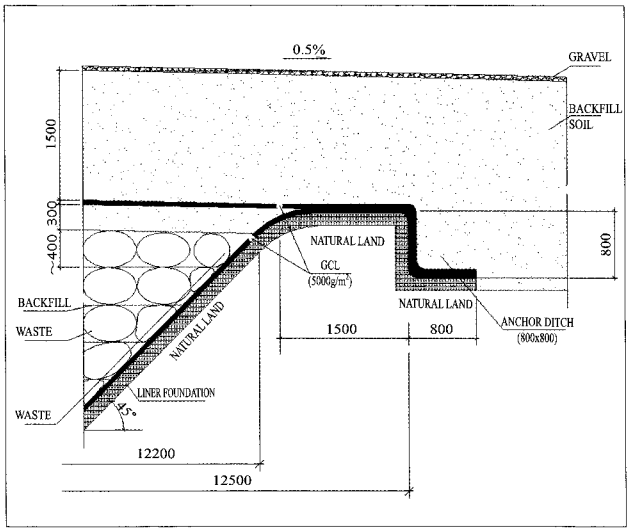

Fig. 2. Cross-Section of the Disposal Cell (part)

(150mm), compacting factor. ≥ 0.94

(b) GCL, 5000g/m², permeability coefficient ≤5.0×10^{-11}m/s

(c) Protection layer, tamped backfill, rammed layer by layer (150mm), does not contain granulates bigger than 5mm in diameter.

From bottom to top, the cover of the cell composes four layers:

(a) Backfill, 300mm, the same as the protection layer at the cell bottom.

(b) GCL, 5000g/m².

(c) Backfill, 1500mm.

(d) Anti-erosion layer, crushed rock, diam 30~60mm

3. Auxiliary Facility

There are three auxiliary facilities: truck scale, reception station and garage. The functions associated are reception and weighing, sampling and monitoring, changing and showering for the workers, storage for the operational vehicles.

The range for environmental monitoring covers 3~5 km around the site. Samples of aerosol, groundwater, soil, plant and animal are taken for radiological analysis. There are two groundwater monitoring wells upstream of the groundwater flow, two others downstream. Comparing water sample from upstream with sample from downstream can find in time leakage of radio nuclides from the disposal cell. The monitoring frequency is once a month for aerosol and groundwater and once every half a year for soil and during harvest season for plant and animal.

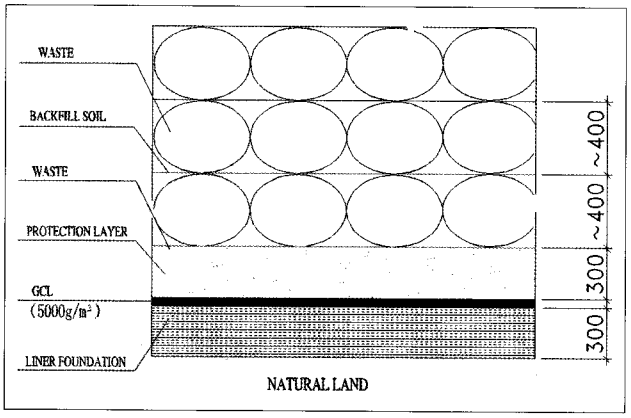

Fig. 3. Liner System of Disposal Cell

V. Descripion of Southwest VLLW Disposal Site[3]

Southwest VLLW disposal site is located in Sichuan province. It is also an on-site facility serving for the decommissioning and environment restoration of a nuclear base. The total capacity is 60,000m³ and occupied area is 47953.4m². It is under construction now. The natural condition of the site is:

Average precipitation: 897.7mm/y.

Maximum precipitation: 1282.7mm (1998)

Average relative humidity: 66-68%.

Average evaporation: 892.4mm/y.

The water table: 5.56-23.61m below surface.

Permeability coefficient:: $2.9 \times 10^{-8} \sim 7.5 \times 10^{-8}$m/s

1. Characteristics of the VLLW

The majority of the VLLW will come from decommissioning and environment restoration of the Southwest Nuclear Base. In most cases, the VLLW is wall scrap or floor scrap, demolished concrete, insulation material, contaminated soil, and residues of incineration of combustible waste. The proposed maximum specific activity for some radio nuclides in waste packages is shown in Table II. The maximum total activity of a batch is given by equation (1).

2. Disposal cell

The region where the site is situated is humid and rainy. The liner system of the disposal cell consists of several layers. GCL and HDPE together act as infiltration proof layer. The cell is completely covered by a

Table 2. Maximum Specific Activity

Nuclide	A_{imax}(Bq/g)	Nuclide	A_{imax}(Bq/g)
Co-60	10	Ni-63	10000
Sr-90	100	Am-241	10
Cs-137	10	Eu-152	10
U-238	10	Eu-154	10
Pu-239	1		

removable rain protection structure during landfill operation (Fig.4). The dimension of the disposal cells is 101m long by 31.9m wide by 6.2m deep. One single cell can accept approximately 10000m^3 of VLLW.

From bottom to top, each disposal cell is formed by (Fig.5):

(a) Liner foundation, 300mm, sand and gravel content <10%, does not contain granulates bigger than 30mm in diameter, rammed layer by layer (150mm), compacting factor ≥0.94

(b) GCL, 5000g/m^2, permeability coefficient ≤5.0 × 10^{-11}m/s.

(c) HDPE, 2.0mm

(d) Geotextile, 600g/m^2.

(e) Protection layer, tamped backfill, rammed layer by layer (150mm), does not contain granulates bigger than 5mm in diameter.

From bottom to top, the cover of the cell composes seven layers:

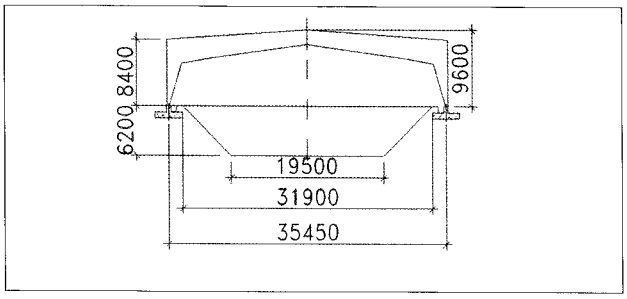

Fig. 4. Cross-Section of disposal cell

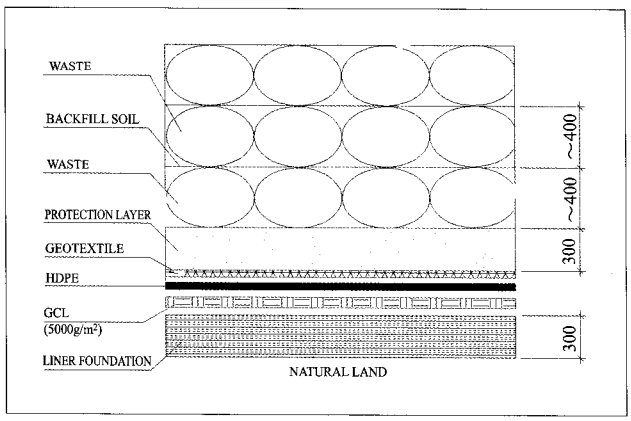

Fig. 5. Liner System of Disposal Cell

(a) Backfill, 300mm, the same as the protection layer at the cell bottom.

(b) HDPE, 2.0mm.

(c) Geotextile, 600g/m^2.

(d) Drainage grid, 7.0mm.

(e) Geotextile, 400g/m^2.

(f) Backfill, 1000mm.

(g) Vegetation layer, local plant.

3. Auxiliary facility

There are also three auxiliary facilities: truck scale, reception station and garage. The functions associated are reception and weighing, sampling and monitoring, changing and showering for the workers, and storage for the operation vehicles. The function of environmental monitoring system is identical to that of the Northwest VLLW Disposal Site.

VI. SUMMARY

Landfill disposal of VLLW in China is still newly emerging things. Regulations, standards and operation experiences are being improved day by day. The Northwest and Southwest VLLW disposal sites are being planned to receive waste package at the beginning of next year. After period of operation, the multibarrier system for VLLW disposal could be upgraded based on accumulated experiences.

How to manage relatively small amount of VLLW is a great challenge we meet. Can it be disposed in MSW landfill? There is still a long way to go to reach an agreement.

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[2] CNPE, Detail Design of Northwest VLLW Disposal

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[3] CNPE, Detail Design of Southwest VLLW Disposal Site, 2010.