Safety Assessment of the New Very Low-Level Waste Disposal Installation at El Cabril, Spain - 9042

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ABSTRACT

The sixth General Radioactive Waste Plan approved by the Spanish government in 2006, foresees important volumes of wastes with a very low content of radioactivity mainly coming from the dismantling of nuclear power plants, along with the occurrence of some radiological industrial incidents in the past. This fact has boosted the construction of a new disposal installation, specifically designed for this category of waste. This new installation is part of the existing low and intermediate level waste (LILW) disposal facility at El Cabril, and includes four cells with a total capacity of around 130,000 m^3. The design of the cells is consistent with the European Directive for the disposal of hazardous waste and fulfils the same basic safety criteria as the present facility for LILW. The safety assessment methodology applied for the very low level waste (VLLW) installation is fully coherent with the approach adopted for the existing disposal facility for low and intermediate level waste (concrete vaults disposal system) and takes into account the potential impact of the new installation during both the operational and long-term periods. The license for the VLLW installation was granted by the Spanish Ministry of Industry, Tourism and Commerce (MITYC) in July 2008, following technical approval by the Nuclear Safety Council (CSN), and the first disposal operation occurred in October 2008.

INTRODUCTION

The El Cabril disposal facility, located in the province of Córdoba, is an essential part of the national management system for LILW. The new very low level waste disposal installation is integrated at El Cabril in all aspects: site, organization, infrastructures, environmental impact, etc. It is located in the south-east area of the current site for LILW (Fig. 1).

With this complementary installation ENRESA will be able to manage the large quantities of waste with a very low content of radioactivity generated especially in the dismantling of the nuclear power plants, as well as those from radiological industrial incidents occurring in the past, thus avoiding the use of the existing capacity of the “high tech” concrete vaults for LILW previously constructed at El Cabril and designed for wastes with a higher level of activity [1,2].

This paper outlines the design principles, objectives and criteria of the disposal installation for VLLW, and describes the facilities. It explains the safety assessment performed to evaluate the radiological impact for the public and the environment and also to assist in estimation of the waste acceptance criteria, as part of the documentation produced to obtain the authorization to operate.

SAFETY OBJECTIVES AND CRITERIA

The disposal of very low level waste is required to fulfil the same basic safety objectives and criteria as accepted for the existing LILW facility at El Cabril [3]. However, the technical design was based on the regulations governing disposal facilities for non-radioactive hazardous waste in Europe, more in keeping

with the type of waste and risk associated with its very low activity content [4]. Two main fundamental objectives are considered in the design:

– Ensure the immediate and deferred protection of the public, the workers and the environment, during operation and after closure.

– Ensure the control and surveillance of the site through exhaustive and traceable means regarding waste, the facility, workers and environment.

The criteria applied that lead to the fulfilment of the objectives are:

– The use of isolation barriers to prevent radionuclide migration

– Limitation activity by waste package and by cell

– The requirement of a surveillance period for a maximum of 60 years

Some other technical options have been adopted in the design, such as:

– A leachate control network system to control the water that may come into contact with the waste

– The exploitation of the cell will be performed under a mobile roof in order to minimize the quantity of potentially contaminated leachates to be treated

– The accumulation of waste will be stable under disposal conditions and will present a load characteristic sufficient to support the final cover.

LILW DISPOSAL FACILITY

VLLW DISPOSAL FACILITY

Fig. 1. El Cabril disposal site location

WASTE CHARACTERISTIC AND INVENTORY

The very low level wastes to be disposed of in the repository are solid or solidified contaminated or activated materials whose chemical behaviour is, for the greater part, inert or previously stabilised. Their radioactive content does not exceed the limit values indicated in the corresponding activity acceptance criteria. A value of 100 Bq/g may be quoted as an average reference value of activity for this kind of waste.

In general, with regard to the nature of the waste, these consist of rubble and scrap. The possible disposal units may be: big bags, drums, metallic containers, packets, large metallic pieces, etc. This morphological variety makes initial classification and treatment recommendable, with the aim of creating “handling units” compatible with the available handling means.

The activity contribution to the overall radioactivity to be disposed of at El Cabril has been estimated at around 1%. It is so small that it does not require any modification of the authorised radiological inventory.

DESCRIPTION OF THE FACILITY

This additional installation at El Cabril includes four cells with a disposal capacity of between 30,000 m^3 and 35,000 m^3 each. These cells are located on the south side of the hill Los Morales and their design focuses on the durability and effectiveness of the isolation barriers for a period longer than 60 years, which is the time required for the radioactivity to decrease to a level sufficiently low for natural disintegration. Since the production of very low level waste is not constant over time, the cells will be constructed as needed. Currently Cell 29 has been constructed and has been operated since October 2008 (Fig. 2).

Each cell includes two waste sections with several protection barriers (Fig. 3). The bottom barriers include the following protection layers: a layer of stone for subdrainage, a one meter thick layer of clay as an impermeable layer, a layer of geobentonite consisting of two layers of polyethylene with a filling of sodium bentonite between the two, a layer of high density watertight polyethylene and a layer of gravel traversed by slotted pipes to collect and drain possible leachates seeping from the waste. Over this is placed another layer of redundant gravel with the same characteristics as the one mentioned, duplicating the safety of the individual system for each zone and thus facilitating the monitoring of system performance. The last layer is a layer of soil on which the waste is placed.

An intermediate protective layer is placed over this first waste section, consisting of a new layer of high density polyethylene and a drainage layer for leachates. Both form the basin for the second section of wastes.

Once the cell is full of waste, it will be sealed with a cover consisting basically of a layer of compacted clay, over which is placed a layer of high density watertight polyethylene and a filling of soil and coarse gravel, finishing in a layer of mantle and the planting of shrubs.

The waste disposed of in the cells must fulfil the waste acceptance criteria. There is no specific waste-containment requirement. Hence, the conditioning of the handling units serves only to facilitate handling and storing operations. The exploitation of the cell is performed under a mobile roof in order to minimize the quantity of potentially contaminated leachates to be treated.

After operations, a post-closure monitoring phase of 60 years is scheduled.

Fig. 2. Disposal cell of very low level waste

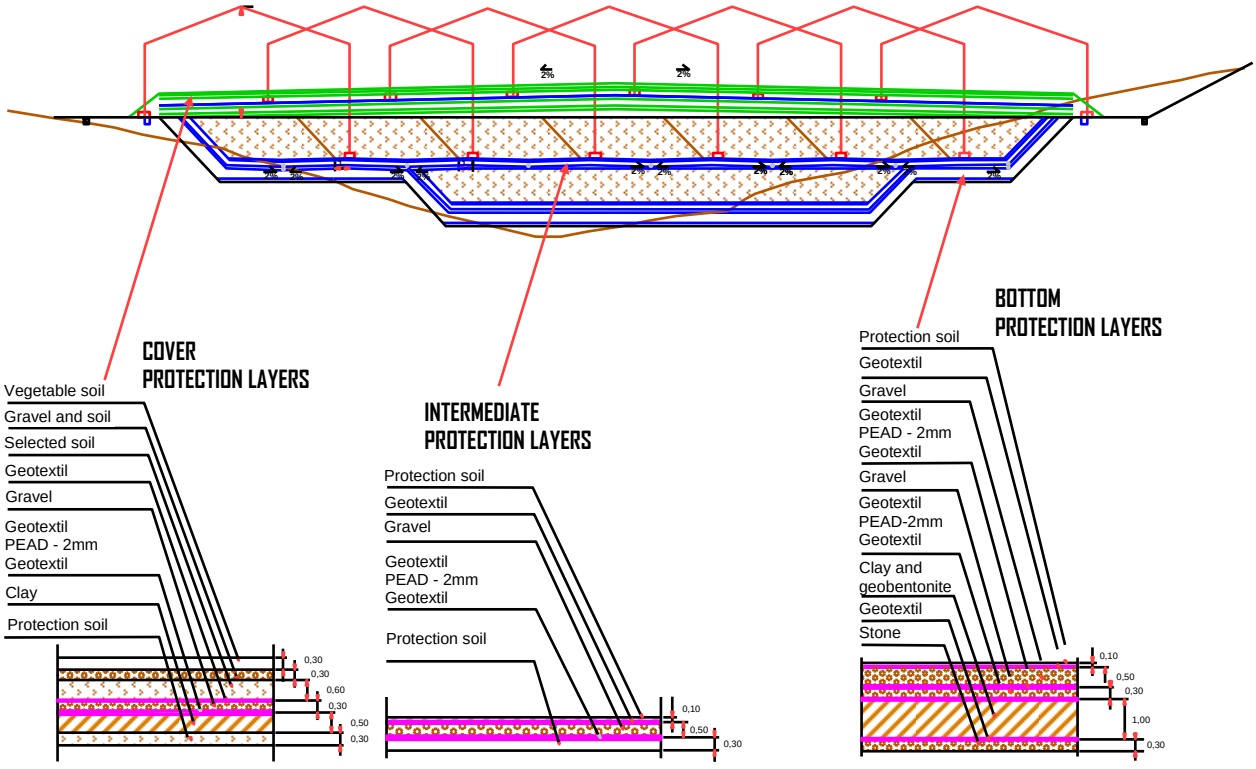

Fig. 3. Waste protection layers.

SAFETY APPROACH

The safety assessment methodology is consistent with the safety approach adopted for the existing disposal area intended for low and intermediate level waste (concrete vaults disposal system). The assessment methodology considers some common aspects and potential interactions between both disposal systems, such as radiological criteria, total activity inventory, surveillance period, site environment or critical group definition. It covers the potential impact of the facility with regard to both the operational and long-term periods.

The safety assessment approach and safety requirements adopted follow the current guides and recommendations of international organizations such as the International Atomic Energy Agency (IAEA), and the International Commission on Radiological Protection (ICRP), along with the national regulatory requirements [5]. The radiological criteria adopted as a maximum value for the exposure of workers under normal conditions is 5 mSv/y, and the dose constraint for the public is 0.1 mSv/y in normal evolution scenarios, according to the national recommendation stated by the Spanish safety authority, Consejo de Seguridad Nuclear (CSN).

The safety analysis examines situations relating to conditions anticipated both now and in the future including events associated with the normal evolution of the disposal facility and less probable accidental and intrusion events.

The safety assessment performed has a dual objective: a) the derivation of waste activity acceptance criteria for disposal; b) the demonstration that an acceptable level of protection of human health and the environment will be achieved both now and in the future.

To generate scenarios for both phases considered, systematic methods purporting to be transparent, justified and documented have been applied.

Scenarios related to the operational phase are developed using a methodology based on the preparation of an operational activities list and on the identification of the possible events associated with each activity during the progress of the radioactive wastes from reception to final disposal, taking into account the design of the facility and its operating methods and instructions.

Scenarios related to the post-institutional phase are developed applying an approach based on the preparation of a list of factors (features, events and process), identifying the relevant factors for disposal performance.

The scenario generation process results in the identification of important scenarios to accomplish the safety assessment objectives. The scenarios are classified in two groups: those relevant to the assessment of specific activity waste limits and those that are relevant to the demonstration an acceptable level of protection of human health and the environment. This does not mean that the scenarios are different for each group; one or more scenarios may be relevant for both groups.

The analysis carried out to support the proposed activity limit is based on calculations for each single radionuclide. The scenario development methodology and subsequent formulation and implementation of model processes ensure that the analysis is coherent.

The long-term safety performance of the disposal facility is evaluated taking into account the analysis of the normal evolution scenario and intrusion events, assuming that the total activity in the disposal cells is a low percentage of the reference inventory established for the vaults in operation for LILW. This

inventory is then additionally limited to be no higher than 1% of the reference inventory of El Cabril, as shown in table I.

Table I. Reference inventory of El Cabril

Radionuclide	Activity (TBq)
H-3	2,00E+02
C-14	2,00E+01
Ni-59	2,00E+02
Ni-63	2,00E+03
Co-60	2,00E+04
Sr-90	2,00E+03
Nb-94	1,00E+01
Tc-99	3,20E+00
I-129	1,50E-01
Cs-137	3,70E+03
Pu-241	1,15E+02
Total alpha (at 300 years)	2,70E-01

Radiological impact

Several scenarios have been studied with regard to the potential migration of radionuclides through water flow. The impact of the disposal was assessed for normal and altered situations, and in both cases according to highly pessimistic assumptions regarding the behaviour of natural and artificial barriers. It is assumed that a group would live close to the facility.

The calculations take into account the migration of radionuclides through the bottom clay layer and the terrain.

The estimated radiological impact for the normal evolution scenario would not exceed the dose criterion of 0.1 mSv/y. Other altered scenarios studied, such as the total cover failure scenario or the flooding (bathtubbing) scenario, due to the loss of basic cover functions such as impermeability, do not lead to unacceptable consequences, the assessment effective dose being below the dose criterion.

Air transfer scenarios include scenarios relating to the operating phase of the facility, accidental fire and disposal unit drop scenarios, and to long-term inadvertent human intrusion scenarios.

In all analysed scenarios the radiological impact is lower than the value limits established in the design.

Also in order to protect the workers, scenarios considering external radiological exposure and the potential impact under accident conditions have been analysed. These types of scenarios are also considered to derive waste activity limits.

Waste acceptance criteria

In order to determine the maximum admissible activity content of a waste disposal unit, scenarios relating to external radiological exposure during normal operational conditions, accidental operational conditions and long-term inadvertent human intrusion situations have been considered.

The specific activity limit for a nuclide is derived from the calculated dose for unit specific activity, thus providing the maximum specific activity which leads to the reference dose limit, applying the direct relationship between dose and activity for each radionuclide.

The activities assessed for each scenario have to be compared to determine the limiting scenario for each radionuclide; i.e., the scenario potentially leading to the most restrictive activity limit. An adequate correspondence between scenarios and elementary volumes of the facility should be taken into account in order to obtain the average specific activity limit of a waste disposal unit and for a waste disposal unit bath.

Table II shows the specific activity limits averaged in a bath of a given specific radionuclide.

Table II. Specific activity limits averaged in a waste bath

Radionuclide	Specific activity averaged in a bath (Bq/g)
H-3	1000
C-14	1000
Co-60	10
Ni-63	1000
Sr-90	1000
Cs-137	30
Pu-241	1000
Pu-239, Pu-240	10
Am-241	10
U-234 to U-238	100

The acceptability for disposal of a disposal unit or a disposal unit bath in the cells depends on the fulfilment of the acceptability index, defined as:

$$IA = \sum \frac{A_{Mi}}{A_{M\max i}}$$

where:

A_{Mi}: is the specific activity of radionuclide i (Bq/g) in the mass waste.

A_{Mmaxi}: is the specific activity limit for radionuclide i (Bq/g) in a waste assuming radionuclide i is the only radionuclide in the waste.

The acceptability index for the disposal unit bath must not exceed 1 and for the disposal unit must not exceed 10.

$$IA_{UA\,bath} \leq 1$$

$$IA_{UA} \leq 10$$

The control of the acceptability index at the time any disposal unit bath is accepted, and the verification of the radiological capacity (assuming a total inventory of 1% authorised radiological inventory at El Cabril), ensures that the radiological impact will remain below the value limits established in the design.

CONCLUSION

The new disposal facility for very low level waste is part of the existing LILW disposal facility at El Cabril. The construction license was applied for in May 2003 and was obtained, following a report from the safety authority and the Environmental Impact Statement procedure, in February 2006. The operating permit was granted in July 2008.

The disposal of very low level waste fulfils the same basic objectives and safety criteria as the present facility at El Cabril. However, the design is based on the regulations governing disposal facilities for non-radioactive hazardous waste.

The safety approach is consistent with the safety approach for the El Cabril facility. The methodology applied has been used to derive waste activity acceptance criteria for disposal and to demonstrate an acceptable level of protection for human health and the environment.

REFERENCES

1. El Cabril LILW operation license of October 5th 2001.

2. El Cabril VLLW design modification authorisation, July 2008.

3. Basic criteria for low level waste disposal facilities approved by the Spanish safety authority, Consejo de Seguridad Nuclear (CSN).

4. Regulations governing disposal facilities for non-radioactive hazardous waste approved by Royal Decree in 2001.

5. Radiation Protection Regulation, approved by Royal Decree in 2001.