DESIGN AND LICENSING OF THE EL CABRIL L/ILW DISPOSAL FACILITY

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ABSTRACT

The site of El Cabril is located in the province of Córdoba, SW of Spain. For a number of years there has been a small LLW storage facility composed of three buildings, with capacity for 15,000 drums of 0.22 m^3. In 1986 the facility was transferred to the Spanish National Company of Radioactive Waste (ENRESA).

In accordance with the Spanish waste management strategy, and with the existing regulations in the nuclear field, in 1988 ENRESA applied for the construction permit of a new facility in the site of El Cabril. After the safety evaluation carried out by the Nuclear Safety Council (CSN), the construction permit was granted by the Ministry of Industry in October 1989. Construction started in January 1990 and has been developed following the safety requirements imposed by the CSN, and contained in the permit. In May 1991 ENRESA submitted the operating license application and in October 1992 a Ministerial Order was issued granting the provisional operating permit, which incorporates the requirements established by the above mentioned regulatory body.

The facility, conceived as a "near-surface disposal in engineered structures", allows the eventual retrieval of the waste and has capacity for some 50,000 m^3 of raw waste or 35,000 m^3 of conditioned waste. In addition, the center includes a conditioning building, with compaction and incinerator systems, a waste characterization laboratory, as well as the necessary auxiliary buildings. The present paper describes the design of the installation, the licensing process, the project development and the safety requirements.

INTRODUCTION

In October 1992 the Spanish National Company of Radioactive Wastes (ENRESA) obtained the provisional operating license for the low and intermediate level radioactive waste disposal facility of El Cabril, which started its operation effectively on 19th November, with the reception of the first radioactive waste shipment.

The facility, with capacity for 35,000 m^3 of conditioned waste, is located on a hill in the Sierra Albarrana, a very sparse populated area in the municipality of Hornachuelos, in the North-West of Córdoba. The site is on a geological formation of gneisses and mica schists, known as El Cabril formation, and covers about 20 hectares of a ENRESA property of about 1,100 hectares.

El Cabril was previously a mining site belonging to the old Spanish Nuclear Energy Board (JEN, now CIEMAT) and has been used for the storage of low radioactive wastes since 1961. In 1986, the property and the storage facility, composed of three buildings, with a total capacity for 15,000 drums of 0.22 m^3, was transferred to ENRESA by an Order of the Ministry of Industry.

The construction of the new facility at El Cabril is based on the national radioactive waste strategy defined in the "First General Radioactive Waste Plan" (approved by the Government in October 1987) and developed in the "Second General Radioactive Waste Plan" (approved by the Government in January 1989). The policy set up by these plans considers the disposal of all low radioactive waste (already produced, as well as the waste to be produced up to the end of the year 2010) in the site of El Cabril, indicating that the selected technical option corresponds to the concept of "near-surface disposal in engineered barriers". The system is based on the French model, with the necessary differences to permit the easy retrieval of the waste, as was required by the Nuclear Safety Council (CSN). The adopted solution to facilitate the waste recuperation consists of the use of concrete containers or boxes for storage.

The conditioning of low and intermediate level waste produced by the operation of the ten Spanish nuclear power plants, the nuclear fuel factory of Juzbado and the CIEMAT installations is the responsibility of the waste generators, excepting compactable waste. The conditioning of the wastes generated by medical, research and industrial activities (minor producers) was carried out up to now by CIEMAT and will be done in the El Cabril facility from now on.

Consequently, the El Cabril Center provides capacity to treat waste from minor producers, reduce the volume of compactable waste, condition waste generated in the facility itself and recondition the waste packages inside the concrete containers, prior to disposal.

DESIGN OBJECTIVES AND CRITERIA

The new facility at El Cabril has been planned to provide a long-term storage for low and intermediate-level radioactive waste. Consequently the disposal system must satisfy two basic objectives:

- Ensure the immediate and deferred protection of the public and the environment.

Immediate protection does not pose any particular problems and in this regard it is similar to other nuclear installations. Long term protection implies the use of a system of multiple barriers.

- Allow the free use of the site after a maximum period of 300 years, without radiological limitation.

  This maximum period of 300 years was taken from the French standard (1), which has been used as a reference, and corresponds to a period during which it is reasonable to assume that construction may be prevented on the site, and at the end of which, it is supposed that all artificial constructions will have totally degraded.

  This objective involves the limitation of total activity of radionuclides to be disposed in the facility, as well as the concentration of radionuclides in the waste.

Besides, a third objective has been adopted in the El Cabril project: to facilitate the recoverability of the waste if circumstances were to make it advisable. The original design was modified in order to incorporate this concept, based, as has been indicated, on the use of concrete cubic containers for the emplacement of the waste package inside the disposal *cells*.

The three barriers constituting the multi-barrier system have been defined as follows:

- The first barrier consists of the waste immobilization matrix and the concrete storage container.
- The second, made up by the bottom slabs of the cells, the cover and the infiltration control network, limits the ingress of water and allows whatever water which might have come into contact with the waste packages to be controlled and possibly treated, if necessary.
- The third is the geological barrier, or the surrounding terrain which would limit the impact any potential leaching in the eventuality of the degradation of the two first barriers, which are assumed to be completely degraded in the free use phase.

Activity limitations are derived from the radiological impact assessment of the facility in the post-operational phases (institutional control period and free use phase) using long-term radiological acceptance criteria. The procedure involves the consideration of ground water migration scenarios and human intrusion scenarios. The first are highly site-specific and are used in determining the total activity limits of a facility. Intrusion scenarios, which may occur once the surveillance period is over, are practically independent of the site and provide the limits of radionuclide concentration in the waste, which are generally more restrictive than those obtained from ground water scenarios.

GENERAL DESCRIPTION OF THE FACILITY

The facility is divided into two zones: the disposal zone, and the conditioning and auxiliary buildings zone. The distribution of the different buildings and structures is shown in Fig. 1.

Disposal Zone

In the disposal zone there are 28 storage cells grouped in two platforms: the north platform, with 16 cells, and the south platform, with 12. The platforms are horizontal surfaces some 90 m. wide, excavated in trenches in the hillside, and side banks have been left to rest on the final cover. In each of these platforms, the cells are half-buried with regard to the operating level and are laid out in two rows, each of which is served

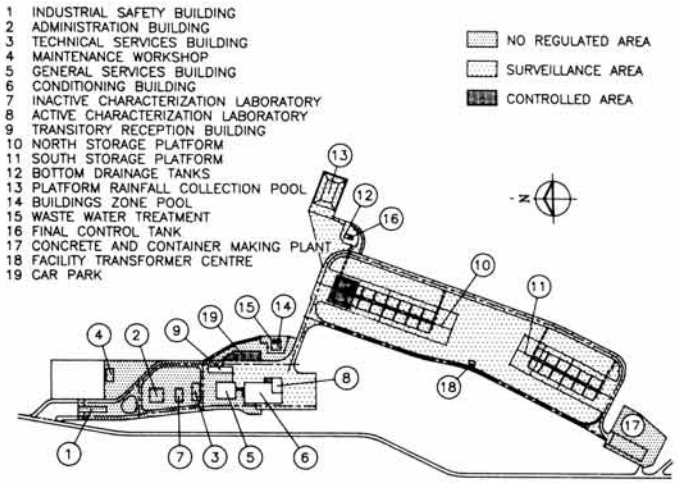

Fig. 1. General layout.

by a sliding roof which moves along rails. These roofs carry travelling cranes of 25 tons for handling the containers. The travelling cranes are operated by remote control from the Control Room, located in the Conditioning Building.

The storage cells have approximate external dimensions of 24 x 19 x 10 m. The main element is the bottom slab, which is 0.6 m thick at the edges and 0.5 m thick in the center, and is coated with a waterproof layer of polyurethane and a 10-20 cm layer of porous concrete. This forms a horizontal surface on which the containers are placed.

The bottom slab of each storage cell is linked to a network of pipes, installed in inspection drifts located below the storage structures, via a transparent holding tank. This network, called "the infiltration control network", discharges into a final control tank and makes the monitoring of the disposal system behavior possible.

The waste packages, to be disposed in the storage cells, most of them 0.22 m^3 drums, are immobilized previously inside concrete containers, with external dimensions of 2.25 x 2.25 x 2.20 m. weighing some 24 tons, each of which may accommodate 18 drums. This operation is carried out in the Conditioning Building from which the containers are transported by lorries to the disposal zone. The transport lorries are placed in a side corridor located between the storage structures and the roof wall.

The concrete containers are stored in piles of four levels in the storage cells, with a capacity for 320 containers each. They are placed in contact with each other, a central gap being left to allow for container manufacturing or positioning tolerances.

Once each storage cell has been fully loaded, the central gap is filled with gravel to stiffen the assembly, and an upper closing slab is built. The *structure is then* waterproofed with a synthetic coating.

When the waste emplacement operations are finished, the project foresees the burial of the disposal cells under a low permeability cover, made up of alternate layers of impermeable and drainage materials.

Figure 2 shows the general scheme of the disposal facility through the subsequent operating phases.

The building for the manufacturing of the concrete containers is located close to this zone, but in a separate area.

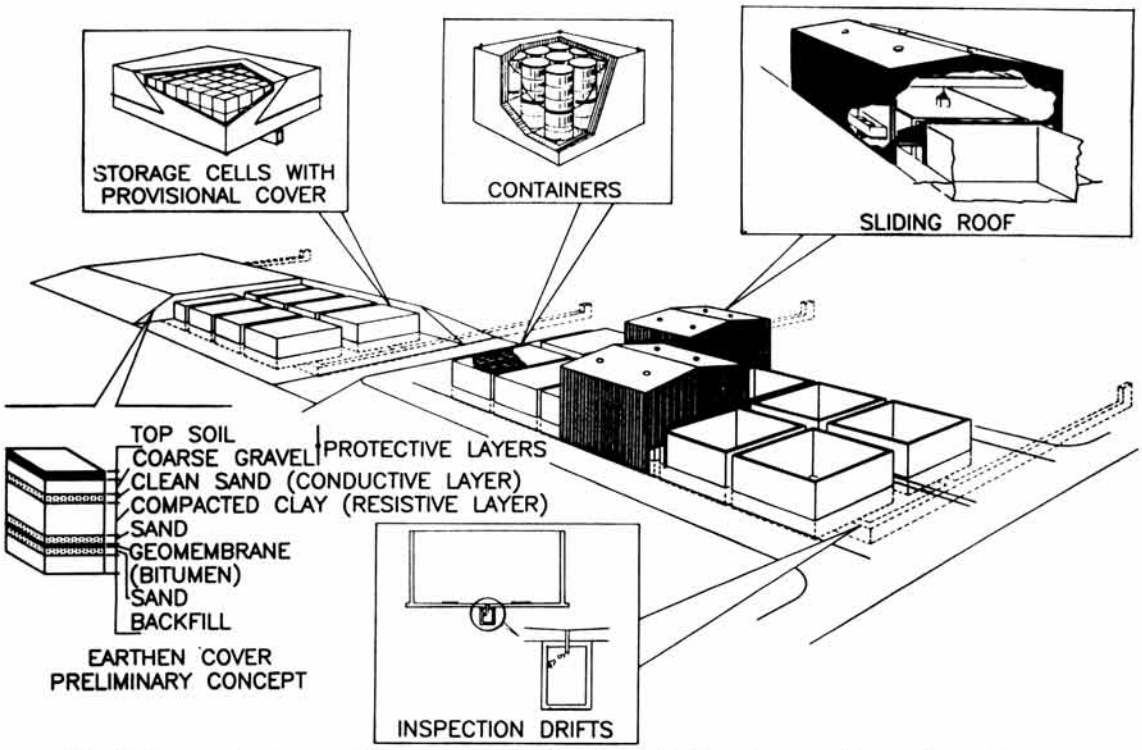

Fig. 2. General scheme of the disposal facility through the subsequent operating phases.

Building Zone

The building zone houses the installations for waste treatment and conditioning and their control, as well as the auxiliary services needed for the operation and maintenance of El Cabril Center. The buildings directly involved in the waste management are the following:

- Transitory Reception Building. This building contains the vehicle radiological control post and the vehicle decontamination post, as well as transitory waste packages storage. From the radiological protection viewpoint, and together with the General Services Building, it separates the non-regulated zone from the monitored zone.
- Conditioning Building. All the treatment and conditioning operations are performed in this building and all waste passes through it. It also houses the Control Room, from which most of this building's systems, as well as the storage zone support equipment are operated. In this building is centralized all the information on the operation of the whole facility, as well as the electrical distribution of this building and the adjoining Characterization Laboratory, the uninterrupted power supply, the controlled ventilation and the radiation monitoring systems. It houses the incinerator, the drum compactor and the mortar injection system.

  The incinerator is of the excess air type, with a double combustion chamber. A temperature of 800°C is reached in the first, and 1,000°C in the post-combustion chamber. At the chamber outlet there is a silicon carbide high-temperature filter. The fumes are cooled down by dilution in air cooled down to 140°C. The gases then pass through very high efficiency filters and once filtered are discharged through the stack.

  The drum compactor with a force of 1,200 tons provides an average volume reduction factor of over 3. It is kept below atmospheric pressure by the controlled ventilation system. The pellets are inserted by a distributor which places them in order inside a storage container, which is then sent to the mortar injection line.

  The mortar injection system for immobilization of the waste packages into the concrete containers, consists of a horizontal mixer, peristaltic pumps and a telescopic injector, as well as the necessary dosification control equipments.
- Active characterization Laboratory.- This building is used for performing tests to verify the characteristics of the different types of active waste samples and packages. The laboratory contains a hot cell made of concrete with an stainless steel inner lining, and controlled ventilation. This cell is equipped with lead glass windows, two remote-controlled manipulators, a travelling crane, equipment for cutting and removing the metal casing of the drums, drum cutting, dry core extraction equipment, mechanical test equipment and liquidation system for samples and drums.

LICENSING PROCESS AND PROJECT DEVELOPMENT

Regulatory Framework

In Spain there is no specific legislation for the development of radioactive waste disposal facilities. The licensing procedure of el Cabril is based on the Spanish regulatory framework existing in the field of nuclear and radioactive installations (2), that basically consists of the following regulations:

- Act 25/1964 on Nuclear Energy, which sets up the general principles for the peaceful use of nuclear energy.

- Regulation on Nuclear and Radioactive Installations,, approved by Decree in 1972, which governs the procedure for administrative authorizations.
- Act 15/1980 creating the Nuclear Safety Council (CSN), which modifies considerably the responsibilities involved in the licensing system.

The development of nuclear and radioactive installations requires different authorizations (site, construction and operations permits) depending upon the category, defined by 1972 Decree. The licensing process is conducted by the Ministry of Industry and the CSN. The authorization is granted by the Ministry and incorporates the perceptive and legally binding report of CSN in matters related to radiological protection and nuclear safety.

El Cabril facility, according to the two first mentioned regulations, was classified as a nuclear installation. Taking into account the previous use of the site for radioactive waste storage, and the policy defined by the General Radioactive Waste Plans, the facility has been subject to the construction permit, and the operation permit which were preceded by a technical stage of site characterization.

During the licensing process of El Cabril facility other regulations have been considered which are as follows:

- Radiation Protection Regulations, approved by Royal Decree in 1982 and reviewed in 1992.
- Regulations on Environmental Impact (Royal Decree Legislative 1302/1986 and Royal Decree 1131/1988). They subject the construction of disposal facilities to the prior issuance of an Environmental Impact Declaration on non-radiological impacts. The process involves a public information period about the project.

In addition, Article 37 of the Euratom Treaty, which requires the Commission of European Communities judgement prior to the start-up of a radioactive waste disposal facility, has been taking into account.

Project Development

At the beginning of 1986 ENRESA initiated the program of site characterization, on the basis of studies carried out up to that date by CIEMAT. This program includes geological, geotechnical, seismological, hydrogeological, meteorological and erosion studies, which provided a good knowledge of the site features.

In May 1988, ENRESA submitted to the Ministry of Industry and to the CSN the license application for the construction of the El Cabril facility, together with the Preliminary Safety Analysis Report, as well as the Environmental Impact Study. After a prime examination of the safety report by the CSN, a general revision of the facility design was carried out by ENRESA in order to comply with the requirement of the CSN and to introduce the necessary provisions for eventual retrieval of the waste.

The construction permit was issued via a Governmental Order dated the 31st of October 1989, published in the Official State Gazette on the 2nd of November. It contains two parts: the Radiological and Safety Limits and Conditions, elaborated by the CSN, and the Environmental Declaration on Non-Radiological Impacts elaborated by the General Secretary of the Environment and the CSN.

The construction work started in January 1991 and was finished in the Summer of 1992. The construction has been performed according to the approved Quality Assurance Program. The concrete containers and the storage cells are designed and built to withstand extreme loads, including a ground horizontal seismic acceleration of 0.24 g. Moreover, complementary site studies were carried out during the construction period, as well as an Environmental Monitoring Program.

In May 1991 ENRESA applied for the operating license and presented the Final Safety Analysis Report, together with the Operating Management Plan, the Operating Specifications, the Emergency Plan and the Program of Nuclear Tests. In addition, during the safety assessment process other documents were presented: the Radiological Health Physics Manual, the Environmental Monitoring Program, the Physical Security Plan and the Operating Quality Assurance Program.

In order to comply with the provisions of the Article 37 of the Euratom Treaty, in November 1991 the Spanish Foreign Ministry submitted the required document on general data of the facility to the Commission of the European Communities. The Commission issued its positive judgement on El Cabril facility in June 1992.

Finally, the provisional operating license of El Cabril facility was granted by Order of the Ministry of Industry on the 9th of October 1992, and was published in the Official State Gazette of the 21st of October. The same Order contains the authorization to manufacture the concrete containers in the facility. The operation license must be reviewed and renewed in a period of four years.

In addition, it has been established that facility closure, including the completion of the waste isolation with the final cover, shall be subject to a specific authorization, considering the results of requested complementary studies.

SAFETY AND RADIOLOGICAL REQUIREMENTS

The safety and radiological requirements contained in the operating permit have been derived from the safety evaluation performed by the CSN. This assessment is divided in two different parts: the first one is related to the facility active systems during the operational phase (including organization, management, control and surveillance programs) and the second one related to the long-term performance of the disposal system.

The first part has been developed by the application of the usual regulations and standards on nuclear facilities, considering the specific characteristics of this facility.

The development of the second part has been based on the radiological impact assessment contained in the Final Safety Analysis Report presented by ENRESA, taking into account the recommendations and methodologies of international organizations (3-5), the requirements promulgated in other countries (1, 6) and the long-term radiological acceptance criterion defined by the CSN, as a risk of 10^{-6}/year or the equivalent dose associated with this risk level (0.1 mSv/year) (2).

The radiological consequences of the analyzed exposure scenarios (normal migration scenario and hypothetical intrusion scenarios) are much lower than 0.1 mSv/year. Therefore the limitations of total activity and radionuclide concentrations to be stored in the disposal facility have been established on a conservative basis.

The last objectives of the safety evaluation have been: the identification of uncertainties linked to the long-term disposal system performance and the definition of studies and

investigations in order to increase the confidence of the evaluations prior to the closure.

The more relevant radiological and safety conditions are stated here:

- Waste acceptance criteria.- Solid and solidified wastes to be disposed of in the facility are defined as those whose activity comes mainly from short-lived radionuclides ($T_{1/2}$ 30 years) with very limited content of long-lived alpha emitters, according to the limits of the following classification:

Level 1

Total alpha activity $< 1.85\ 10^2$ Bq/g

Beta-gamma emitters activity, with $T_{1/2} < 5$ years, (tritium excepted): $< 1.85\ 10^4$ Bq/g by isotope

Total Beta-gamma activity for isotopes with $T_{1/2} >$ 5 years:

$< 7.4\ 10^4$ Bq/g

Tritium $< 7.4\ 10^3$ Bq/g

Level 2

Total alpha activity $< 3.7\ 10^3$ Bq/g

Co-60 " $< 3.7\ 10^5$ Bq/g

Sr-90 " $< 3.7\ 10^5$ Bq/g

Cs-137" $< 3.7\ 10^5$ Bq/g

Concentrations of radionuclides that are not specified in the permit, may be deduced by the use of scale factors defined for the operating wastes arising from light water reactors.

Qualitative and quantitative acceptance criteria on physical and chemical characteristics of the waste form for each defined level have been developed by ENRESA and approved by CSN. Any change in the origin, type or conditioning process of the waste considered up to now will be subject to the elaboration of specific acceptance criteria and their approval.

All radioactive waste packages must be immobilized inside concrete cubic containers prior to their disposal. The use of these containers will have to be approved of by the regulatory body after passing the structural tests, as well as the transport reclamation tests for type A packages.

- Capacity of the disposal facility - The volumetric capacity, already defined in the construction permit, is of 35,000 m^3 of conditioned waste. The total activity to be disposed of in the facility will be lower than the reference inventory shown in Table I.

  The average concentration of alpha emitters in the facility will be $\leq$370 Bq/g.

- Waste emplacement - The distribution of the waste packages inside the container and of those in the storage cells must be carried out in order to obtain a good homogeneous activity distribution. With this objective, additional limits of activity for container and storage cells have been approved.

  In application of the ALARA criteria, the peripheral places inside each storage cell will be occupied by waste containers with dose rates in surface lower than 200 mR/h.

  Additionally, it has been required that only containers with level 1 wastes can be located on the upper layer of each storage cell. This provision ensures, according to the evaluation of human intrusion scenarios (7), the compatibility with the long-term radiological protection objectives and criteria.

- Record and archives systems - Duplicate archives in two different places will be maintained during the operation phase in order to keep all the necessary information at the moment of the closure assessment. Such information shall include at least: a) the data related to the waste containers (including manufacture identification, location in the storage cells, waste origin, type and conditioning process, as well as radionuclide content), b) the information related to each storage cell (including design and manufacturing data, chronological and technical data of the cell occupation, results of the infiltration control network surveillance and potential anomalies) and c) the results of the site and environmental surveillance programs.

  Moreover, it has been required that the computerized system shall have capacity to provide information, on the wastes received, treated, conditioned and disposed, as well as the total activity disposed at any time (7).

- Control of Effluents - Two criteria have been established limiting the radioactive gaseous and liquid discharges.

  The channels for radioactive gaseous releases are the outlet of the controlled ventilation system and the incinerator stack. Both systems have been designed and will be operated in such a way that the doses to a hypothetical member of the public at the limit of the restricted area, due to all gaseous discharges to the atmosphere and considering all exposure

TABLE I
Reference Inventory

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+00
Tc-99	3,20E+00
I-129	1,50E-01
Cs-137	3,70E+03
Pu-241	1,15E+02
Total alfa	2,70E+01

pathways, be as low as reasonably achievable and lower than 10^{-2} mSv/y.

The collection, treatment and conditioning systems of *liquid* radioactive waste are designed to meet the objective of "zero discharge". In order to implement this requirement, the radioactive waste collected in the tank of the radioactive liquid effluent system and of the infiltration control network will be utilized to produce the filling mortar of the storage containers.

- Studies and investigation programs - The following experimental studies have been required to know the long term actual performance of the disposal system: a) a radioactive waste characterization program, including the necessary tests to verify the lixiviation rate, b) an investigation plan on the durability of engineered barriers, c) an experimental erosion study to provide the necessary information for the final design of the cover, d) the update of the flux and transport hydrologic modeling, with the obtained experimental data.

Finally, the organization structure for operation includes a quality assurance group and a radiological protection group. The staff has the required qualifications and a training program has been established. All activities involved in the operation of the facility will be carried out according to the approved Quality Assurance Program and the Radiological Health Physics Manual. Besides, Emergency and Physical Security Plans are arranged, and the Environmental Monitoring Program to be performed during the operation phase will be submitted for approval every year.

SUMMARY AND CONCLUSIONS

The El Cabril facility, owned by ENRESA, in operation since November 1992, resolves the storage of low and intermediate-level radioactive wastes in Spain up to 2010. The design of the near-surface disposal allows for the recoverability of the waste if necessary. It has been constructed according to safety criteria imposed by the regulatory body (CSN). The safety and radiological conditions contained in the operation permit define the studies in order to provide enough information on the actual performance of the disposal system at the moment of its closure.

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