RADIOACTIVE WASTE MANGEMENT IN SPAIN

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General view

INTRODUCTION

Radioactive waste generation began in Spain during the 1950's, in association with the first applications of radioactive isotopes in industry, medicine and research. Spain's first nuclear power plant started up in 1968. At present, there are in operation some one thousand installations licensed to use radioisotopes (small producers), nine nuclear Power Reactors and a tenth is now entering the dismantling phase. There are also activities and installations pertaining to the front end of the nuclear fuel cycle (mining, milling and the manufacturing of fuel elements).

Up to 1985, the research centre Junta de Energía Nuclear (now CIEMAT) collected conditioned and stored radioactive waste from the small producers. Since the beginning of their operations, the nuclear power plants and fuel cycle facilities have had the capacity to condition and store their own radioactive wastes.

ENRESA (Empresa Nacional de Residuos Radiactivos, S.A.) began its operations in the second half of 1985. It is a state-owned company founded by the Government in compliance with a parliamentary resolution and commissioned to establish a system for management of all radioactive wastes throughout Spain, it is also in charge also of decommissioning of nuclear and radioactive facilities, as well.

We will first focus on the management of low and intermediate radwaste, a task which ENRESA carries out in all its phases, will then describe of the solutions available for the interim storage of spent fuel in Spain and will finally give a perspective of the first dismantling experience in Spain: that of the Vandellós I NPP.

LOW & INTERMEDIATE WASTE (L& ILW)

The aim of L&ILW management is final safe disposal. The disposal option adopted is the bases for the guidelines used in all other tasks involved in the management process: Both the typology of the wastes and their conditioning will be defined by the acceptance criteria to be met by the conditioned waste packages in order for them to satisfy the safety requirements applicable to final disposal.

Following evaluation of the different alternatives available, near-surface disposal with engineered barriers was chosen as the method best covering Spanish needs. The way in which producers are to prepare their wastes, and the acceptance criteria these must satisfy in order to be collected, are specified in the contract drawn up between each producer and ENRESA. In the case of small producers who do not possess conditioning facilities, the criteria refer mainly to the way in which the wastes are segregated and presented to ENRESA, while for the nuclear power plants having the capacity to treat and condition their wastes, the requirements cover the characteristics to be met by each type of conditioned waste and due compliance by the plant with the waste treatment and conditioning procedure agreed on with ENRESA and its quality assurance system. The process of waste acceptance and quality verification is completed by a testing system based on audits and destructive and non-destructive controls carried out in laboratory. The fundation of the entire low and intermediate level waste management system is the disposal facility of El Cabril. After four years of operation some aspects have been reviewed, in particular those related to operational practices, and a new aim has been defined, which is optimization of existing disposal capacity.

EL CABRIL FACILITY

General Aspects

On October 9th, 1992, a Ministerial Order granted the Operating Licence for the solid radioactive waste disposal facility of El Cabril, construction of which started in January 1990. Recently, on October 1996, a new operating licence was granted for the next five years.

El Cabril is in the province of Cordoba, some 400 Km South of Madrid and 100 Km North of Seville, and has been designed as a low and intermediate level waste near surface disposal facility. Consequently, it must meet two basic objectives: a) ensure the immediate and deferred protection of the public and the environment, b) allow free use of the site after a maximum of 300 years, without any radiological limitations.

The solution adopted provides enough disposal capacity for all L&ILW generated in Spain up to the year 2014.

The aforementioned objectives require the following: isolation of the waste packages from water and limitation of radioactivity levels. Together with Man, water is a potential vehicle of dispersion of stored radioactivity. The facility must therefore be isolated from ground water (placing the waste packages above the water table) and from surface water (avoiding flooding areas and watercourses, and protecting it from rainfall). Moreover, by adopting pessimistic hypotheses of human intrusion at the end of the surveillance period of a maximum of 300 years, the total activity and maximum mass activity must be limited so that the impact involved is negligible.

The Disposal System

The waste packages, mainly steel drums, are placed inside concrete containers. The drums (or pellets from supercompaction process) are than immobilized inside the container, forming a concrete block weighing some 25 tons and with external dimensions of 2.25 x 2.25 x 2.20 metres. These containers are placed in disposal cells, each of which has a capacity for 320 containers and approximate external dimensions of 24 x 19 x 10 metres. The containers are stacked in contact with each other, a central strip being left to allow for container manufacturing or placement allowances.

Both the containers and the disposal cells are designed to withstand extreme loads, including the Site Safety Earthquake (SSE) with a ground acceleration of 0.24 g.

The concrete used in the cells and containers was defined after a research programme studied how to optimize the durability of the concrete barriers.

Once each disposal cell has been fully loaded, the central strip is backfilled with gravel to stiffen the assembly and fill in gaps, and an upper closing slab is built. The structure is then waterproofed with a synthetic covering. The bottom slab directs any potentially infiltered water to the drain age system. Each cell is linked to this system via a holding tank, so that if exceptionally water collects in the drain age network, allowing to sample water, and to stablish the individual cell involved and so to repair its cover.

This passively operating network of pipes discharges into a final control tank with a year's collection capacity. This makes it possible to monitor the performance of the disposal system, detecting and determining the origin of abnormal amounts of seepage water, as well as possible contamination.

During the operating phase, in order to protect the waste containers from the weather, minimize the amount of water collecting in the drain age network and support the container handling system, each row of disposal cells is served by a rail mounted sliding shelter. This auxiliary roof is placed above the disposal cell currently in operation. After the cell has been waterproofed, the roof is moved to the adjoining cell.

When El Cabril is closed down, the facility will be topped with a low permeability cap, formed by alternating layers of waterproofing and draining material.

General Description of the Facility

The facility is divided into two main zones: the disposal zone, and the conditioning and auxiliary building zone. 28 disposal cells have been built in the disposal zone, divided into two areas or platforms; the north platform with 16 structures, and the south platform with 12. The platforms are horizontal surfaces some 90 metres wide, excavated in trenches in on hilltop, and side banks have been left on which to support the final cap.

In each of these areas, the cells are half buried below the operating level and are laid out in two rows, each of which is served by a sliding shelter that moves along rails. These roofs carry a 32 ton travelling crane for handling the containers. The travelling cranes are operated by remote control from the Control Room located in the Conditioning Building, thus minimizing operational doses.

Of all the possible options, ENRESA chose to construct and operate the container production plant at El Cabril, above all to be able to control the quality of fabrication.

The building zone houses the auxiliary facilities for Waste Treatment and Conditioning and control, as well as the auxiliary services needed for operation and maintenance and the Waste Verification Laboratories. Theses auxiliary buildings are: Industrial Safety Building Maintenance Workshop; Inactive Waste Quality Verification Laboratory; Technical Services Building; General Services Building; Reception and Storage Building; Active Waste Quality Verification Laboratory.

Waste Treatment and Conditioning at the Facility

Five main groups of operations are performed in the Conditioning Building:

Small Producer Wastes (Institutional Wastes)

This facility includes the systems and equipment necessary for conditioning small producer waste (hospitals, research, industry).

Compactable Wastes

A drum compactor with a force of 1200 tons has been installed, with which average volume reduction factors of over 3 were attained (actual volume reduction is 2, due to precompaction in Nuclear Power Plants).

Conditioned Wastes
Any wastes arriving already conditioned in a solid matrix, normally of cement, are transferred to the disposal containers with a remote-controlled travelling crane.
In both cases, once the container is full, it is transferred to the container handling warehouse by means of a carriage. From here, and once the lid is on, the container is transported by the travelling crane to the mortar injection post.

Liquid Wastes
Liquid wastes from small producers and drains from the facility, very low-level aqueousœsolutions, are collected in tanks in the building basement.
The treatment system has been selected with two objectives: not to increase the volume of wastes to be disposed of and to meet the design objective of zero release of radioactive wastes.

Testing of Waste Forms and Packages

Waste Acceptance Criteria
ENRESA has issued a set of specifications to be met by the producers in accordance with the limits stated in the license of El Cabril Facility.
The activity in the waste package is derived from the activity in the overpack abovementioned levels. General and Safety Related Acceptance Criteria are common for all waste packages to be received. In addition different Quality Requirements are specified depending on the activity in the waste packages.
Each producer presents an acceptance application including a complete description of the conditioning process and quality assurance system. ENRESA carries out a characterization process, including activity, strength and leaching resistance measurement and issues a waste type agreement.
In addition ENRESA is able to randomly check on the quality of the actual packages being delivered. This includes non destructive (spectrometry) and destructive (mechanical, leaching, radiochemistry) tests performed at El Cabril laboratory.

Waste Quality Verification Laboratory
This laboratory has two different areas in two buildings, the active one located in the controlled area and the inactive one in the conventional part of the facility.

Active Laboratory
The layout has been designed taking into account the tests to be carried out:
a) Reception and control area.
b) Manipulation cell: for preparation of packages for leaching tests and for extraction of test probes to determine their mechanical and radiological properties. The cell has all the necessary equipment (crane, specimen conditioning, drum skin cutting equipment, mechanical test bench, sample extraction, etc.). All the operations areœremote controlled.
c) Aliquot preparation cell.
d) Leaching area: for the introduction of full size packages without their metal casing or test probes in demineralised water at constant temperature.
e) Chemical and radiochemical laboratory.
f) Chemical and radiochemical measurement laboratory.

Tests to be Carried Out in the Active Laboratory

For characterization of the matrices of real packages, a total of 50 tests are to be carriedœout in the Active Laboratory. These can be divided into 3 main groups:
a) *Non destructive testing*. These include spectrometry.
b) *Destructive testing*. These include tests on preparation and handling of real packages, physical mechanical tests and homogeneity tests. They involve destructive treatment of the packages and therefore generate secondary waste which must later be conditioned.
c) *Tests for microstructural characterization of the matrix*. These include leaching tests on real packages or specimens for which it is necessary to first carry out non destructive, destructive and complementary chemical and radiochemical testing.

Inactive Laboratory

This building is located in a non regulated area. It includes a laboratory for characterization tests on samples and inactive test pieces simulating the matrix.

Radiological Control

The design of the facility complies with the Spanish regulations on radiological protection with special emphasis on application of the ALARA criteria.
Thes criteria are enforced by implementation of the following design bases:
- Remote control of the main activities involving radioactive materials. Virtually all the handling operations of waste packages, as well as supercompaction, are controlled from the control room with the assistance of CCTV.
- Zonification of operating areas with appropriate separation of the different operation to provide biological shields sized in accordance with the associated risk and for required ventilation.

Safety Assessment

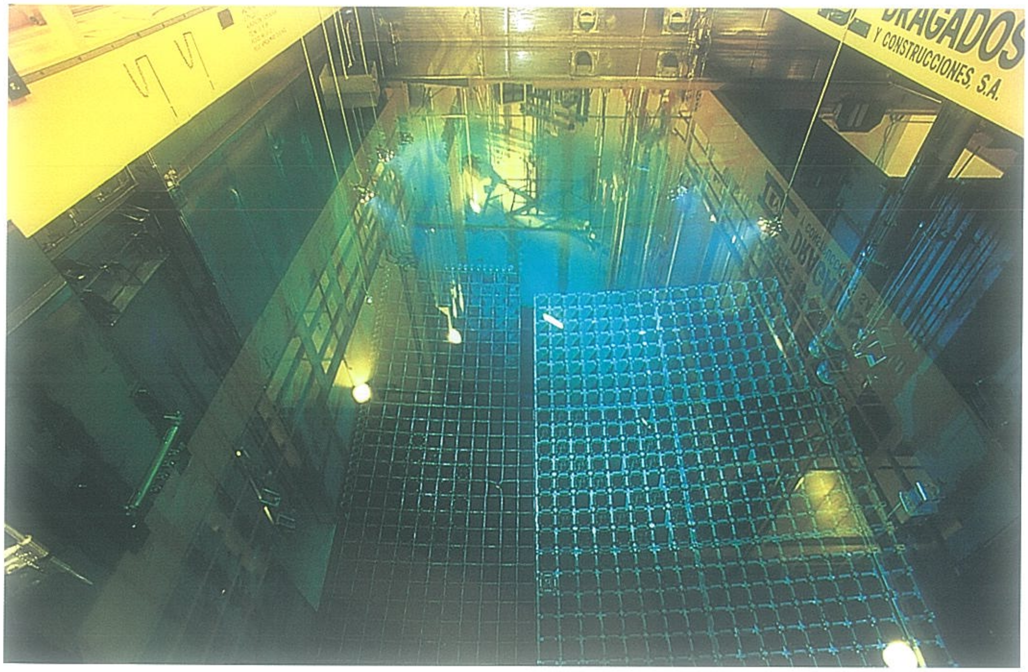
The main items considered in the radiological impact assessment of the facility are intrusion scenarios and ground water path to the biosphere.

Evaluation of Human Intrusion Scenarios
Two different studies of human intrusion scenarios have been performed.
The results obtained in the evaluation of both scenarios are below the limits set in the national regulations on radiological protection, but do not provide an objective indication of the risk associated to the deposit as the scenarios are defined in a very arbitrary way. On the other hand, the dose figures may be considered high enough to merit further evaluation.
For these reasons a second study was undertaken where a residential scenario was defined in a more realistic and comprehensive way. To define of the scenario as well as the evaluation methodology, the recommendations from the Expert Group of the Nuclear Energy Agency of the OECD have been adopted; the evaluations performed in the USA for the environmental impact statement of 10 CFR 61 were also considered. In this scenario it is assumed that no human intrusion progresses enough to produce significant doses within the 500 years following closure.

Groundwater Path
Safety assessment includes a model of water percolation and radionuclide migration through the disposal system, geosphere and biosphere. The assessment is made in a deterministic way conservatively estimating the dose to a hypothetical critical individual.
Calculations are based on two codes linked in a specific development American DUSTM accepted by the NRC, and French (ANDRA) AQUABIOS for the biosphere.
Behaviour in time corresponds to two different phases: surveillance (first 300 years after closure) and post surveillance. In the first period water flow is controlled by the design conditions of the engineered barriers (infiltration rates of the cap, permeability of the concrete barriers). In the post surveillance period, complete degradation of the engineered barriers is assumed. Radionuclide release rates are controlled by the equilibrium between percolated water and degradated waste and barrier materials.

Inspection, Collection and Transport of Waste

Once a waste type is agreed, waste packages are delivered to ENRESA. Responsibility is transferred at the producers site and ENRESA transport the waste.
ENRESA carries out inspections and audits at the producers' site to check performance of the quality system and the documentation and data of the packages to be transferred.
Transportation is organized through yearly and monthly schedules agreed on with the producers. These schedules are sent to the authorities.



Except in the case of institutional wastes which are retrieved by ENRESA teams, transport of wastes is subcontracted to a specialized company. Nevertheless the shielded and casks are owned by ENRESA to have more flexibility in the contracting process.
The total number of transports is about 350 a year. Packages over 10 mSv/h in contact are transported in shielding casks. Packages below 10 mSv/h in contact are transported in single load expeditions using shielded trailers of different lengths, with a compromise between shielding requirements and maximum load, thus optimizing the number of packages per expedition.

INTERIM STORAGE OF SPENT FUEL

The interim storage of spent fuel has been technically resolved and demonstrated at the industrial level. This type of storage is based on two main techniques: dry storage (casks and chambers) and storage in pools, both at reactor site (ATS) and away from reactor (AFR); the former is currently the norm. The casks provide a modular capacity which is used as the need arises, while the capacity provided by the chambers and pools is massive from the moment they start operating.
The Spanish strategy is as follows:

- Increased storage capacity of the reactor pools by reracking, with a view to optimizing their final occupation.
- Increased storage capacity by means of metallic containers.

Reracking

At present, reracking of Almaraz, Asco and Trillo NPP's has been performed and is under way for the rest of the pools in Plants needing an additional short term storage capacity.

Spent Fuel Storage and Transport Casks

Towards the end of 1988, ENRESA carried out a comparative study of all the existing technologies. This led to the choice of metallic casks as the initial strategy for supplementing the ARS capacity, for those cases where reracking was unfeasible or resulted in insufficient capacity. One year later, in 1989, the contract was awarded to the U.S. company Nuclear Assurance Corporation (NAC) for the design of a dual purpose cask (storage and transport), through an agreement in which the Electric Power Research Institute (EPRI) and the U.S. utility Virginia Power (VEPCO) took part along with ENRESA. At that time, VEPCO was already running ARS Interium Storage in Casks at the Surry Nuclear Power Plant, and was the pioneer of this technology in the U.S.A. From the beginning, the Spanish companies Equipos Nucleares (ENSA) and Empresarios Agrupados also took part in this project.
One of the reasons that determined the choice of these containers as the technology for storage was that their use does not require any other installations. This means that once they are loaded in the Nuclear Power Plants, they can be stored in the plant itself until it is decided to transport them to another location (whether to another plant, to the AFR Interim Storage or to the Final Repository (FR)), without having to send them back to the fuel pool and thereby disrupt normal operation of the Plant. Another important determining aspect is flexibility. Because of their modular nature, it is possible to adjust manufacture and supply to the needs of the different Plants. Furthermore, it is not as investment intensive as pools and vaults. Finally, the possibility of incorporating this technology into the national industry was also a determining factor and, in that sense, the project was organized in such a way that technological transfer was maximized. It would thus be possible to go ahead with design and manufacture of this equipment in the future and on a national scale.
The licensing process for this container was carried out in the U.S.A., and thus it is a development that originated in that country and has potential clients there. With a view to its use in Spain, the regulatory authority started the licensing procedure for waste storage. Once it has been approved as Package B(U), all that is required for use in spent fuel transportation is inscription in the licenced container records for this purpose. The detailed monitoring that took place during the licensing process, was also part of the technology transfer, as it has permitted ENRESA and its contractors to gain an in-depth knowledge of the process followed by the NRC, and has thus enabled the company to prepare for the licensing process in Spain, both for this particular container, and for successive ones that will be required on the based on the needs of the Spanish Nuclear Power Plants.
The first fruit of the experience gained by the Spanish companies that took part in the above-mentioned project was development of another dual purpose container, designed specifically for the fuel at the Trillo Nuclear Power Plant and known as ENSA-DPT [Dual Purpose Trillo]. It was designed by ENSA with the collaboration of NAC, and it has made slight improvements to the original NAC-STC design. In December 1996, the CSN gave its approval to the design for the transport of this container. Authorization had already been given for storage. Therefore, it will be possible to start manufacturing the first units in 1997.
From the technical point of view availability of a AFR Interium Storage would greatly simplify the logistics of spent fuel handling and surveillance, since the fuel would be located at a single site, a fact which would also reduce operating costs. In addition, availability of such a facility would allow the decision to dismantle the plants to be made independently of removal of the wastes.
Thus, we would be looking at the year 2.010-2.014 as the likely implementation year of such facility.

FINAL DISPOSAL OF HIGH LEVEL WASTES

As it is well known, the final solution for the disposal of high level radioactive waste has not yet been implemented by any country in the world. Therefore, as far as final management of high level radioactive waste is concerned, ENRESA is currently investigating various lines of research. Given the current state-of-the-art of this technique, the line of research that was has most been taken into account so far on an international level, is Geological Repository. This system is based on confining the spent fuel at a great depth, between 600 and 1,000 metres.

Since 1986, and with a view to this, ENRESA has conducted systematic geological studies throughout the Spanish territory, basically taking into account three rock formation types: granite, salt and clay. In these years the geology of the country has been characterised, just in case our society makes a future decision in which geological storage is considered to be the best system for confining high level wastes.

Just like other international agencies, and on seeing that the AFR Interium Storage permitted the decision to get repository under way to be postponed, ENRESA thought it fit to give an opportunity to the new emerging technologies that might offer a solution to the question of high level wastes, that was supplementary to a repository.

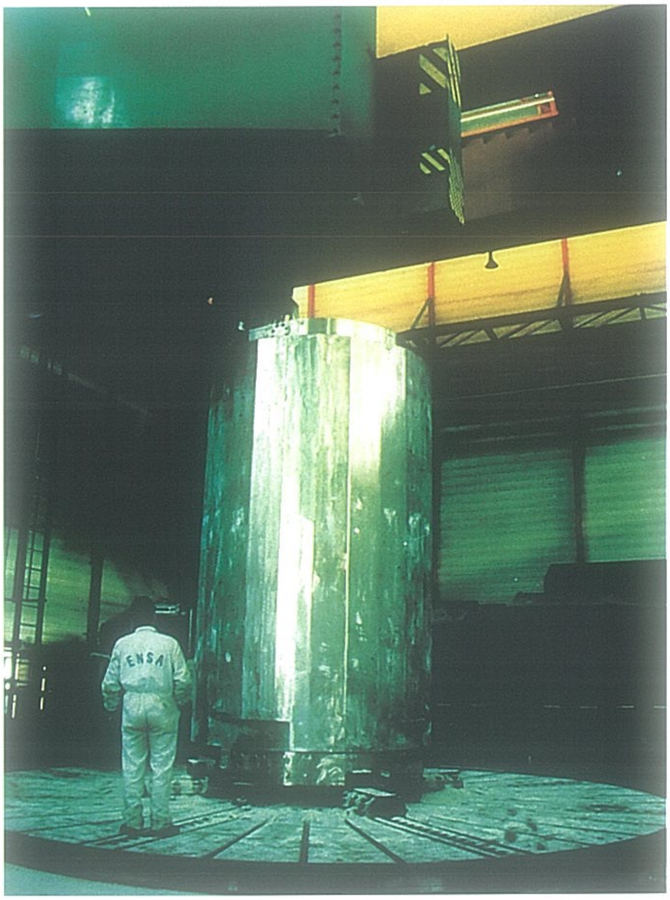
In spite of the fact that it is still young, nuclear technology is evolving very quickly and, thus, it is possible to consider concepts such as partitioning and transmutation. These technologies still have a long way to go from a development perspective, probably from 25 to 30 years. However, with the dry storage techniques, such a period will be available, or even longer.

Partitioning is a chemical treatment, designed to separate the radioactive materials that are present in the spent fuel. Transmutation is a nuclear process, by means of which the long-lived radioisotopes are converted into short-lived radioisotopes, and even into non radioactive isotopes, through neutronic bombardment.

Partitioning and transmutation activities have been the focus of international attention for many years, basically in the U.S.A. in the early 70's, and interest has continued to a greater or lesser extent in several countries. The European Union explicitly envisaged partitioning and transmutation activities in the programme framework of 1994.

In any case, the problem of pool saturation has been solved, whether this be through dry storage in metallic containers or through reracking and the AFR is a clear option that does not involve any problems, so there is no rush to get a final solution under way. This will give technological development time to provide improvements to solutions that are currently being considered. With a view to this, ENRESA has a strong R+D programme to be carried out in coordination with the projects of the OCDE, the International Atomic Energy Agency (IAEA) and the Framework Programme of the European Union. The 3rd R+D Plan is currently in progress, and this is to be carried out between 1995 and 1999, and has a budget of 8,000 million pesetas. Over 93% of the budget is devoted to lines of research for the management of high level wastes.

DECOMMISSIONING OF THE NUCLEAR POWER PLANTS



ENRESA is also the company in charge of decommissioning the Spanish Nuclear Power Plants, when their period of activity has culminated. The only plant which is currently in this situation in Spain, is Vandellós I. A decision made at ministerial level, commissioned ENRESA to draw up the decommissioning Plan, which was subject to government approval.

When the aforementioned plan be approved, ENRESA will start the decommissioning works in accordance with the Spanish nuclear legislation.

ENRESA submitted a document to the Ministry of Industry in June 1991, which contained an analysis of the various options for dismantling with a view to the closure of the above-mentioned nuclear power plant, together with a proposal for the most feasible option.

The option accepted by the Ministry of Industry, involved the dismantling of almost all the structures and components which were external to the reactor building, once the spent fuel was removed and the radioactive waste from the operations had been treated, but the reactor building itself would not be dismantled, leaving the reactor without nuclear fuel, until a period of time had elapsed (latency).

The reactor building, as well as the reactor and its internals, would be suitably isolated, and the different connections with the exterior have to be sealed. The activity contained will remain isolated, and will decay with time. The site has to be subject to surveillance, during the dismantling process as well as in the latency phase. This surveillance would be restricted to the controlled zone, leaving the rest of the site (approximately 80%) in full use without any restrictions.

Once the latency period had elapsed, for which 25 to 30 years was considered appropriate, all the remaining installations will be dismantled up to a green field.

The Environmental Impact Statement has been submitted to the Ministry of the Environment, and is currently at the public information stage.

Before the work can be undertaken, the license declaring that operations are to be carried out under the auspices of ENRESA, has to be granted to the company, so it is a prerequisite that ENRESA receives Decommissioning Plan approval from the regulatory authority."

Antonio COLINO is the President of ENRESA