# OVERVIEW IN ARGENTINA ON RADIOACTIVE WASTE MANAGEMENT

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## ABSTRACT

The National Atomic Energy Commission (CNEA) of the Argentina Republic was established in 1950. It has in operation two nuclear power plants; a third one is under construction (70% completed) and a fourth one is under study. In order to supply the fuel elements to the nuclear power plants mentioned before, CNEA has implemented the front part of the Fuel Cycle. Regarding the back-end, the actual policy concerning to the spent fuel elements, is to storage them waiting for further decision. Together with these activities, the CNEA has developed, in practice, all the peaceful applications of nuclear energy. Mentioned activities, generate important volumes of radioactive wastes of different characteristics and the overall strategy of the Argentine Program is to plan, develop and implement the technology and provide the facilities for the permanent isolation of the generated wastes, with the aim that not compromise the health and safety of general public. To implement and coordinate all these activities CNEA has established a Radioactive Waste Management Program. In this paper an outline is given concerning the policy, treatment, conditioning, characterization, storage, transport and final disposal of radioactive wastes in our country.

## INTRODUCTION

Argentina has in operation, by means of Comision Nacional de Energia Atomica (CNEA), two nuclear power plants, the 380 MW(e) pressure vessel (PHWR) Atucha I and the 640 MW(e) pressure tube- type, Embalse. Both, of natural uranium and heavy water, represent 8% of the installed electric power and frequently more than 17% of the total generated. There are a third pressure vessel type nuclear power plant under construction (70% completed) Atucha II of 720 MW(e) and a fourth one is under study.

In order to supply the fuel elements to the nuclear power plants mentioned before, CNEA has implemented the front part of the Fuel Cycle, which include prospection, exploration, mining and milling ores, refining of the standard concentrates; conversion into uranium dioxide; sintering of UO2 pellets; production of Zircaloy tubes; fuel elements fabrication and a high pressure testing loop.

Complementing the nuclear plants requirements, the construction of an industrial plant for heavy water production with a capacity of 250 Mg/year is nearing completion.

Regarding the back-end of the fuel cycle, the actual policy of our country concerning to the spent fuel elements, is to storage them in pools or in concrete silos waiting for further decision. Nevertheless, an experimental reprocessing plant is under construction (95% complete) which will allow to engage a plutonium recycling demonstration program in our nuclear power plants (as U-Pu mixed oxides) and to get enough know-how in this field.

Together with these activities, the CNEA has developed, in practice, all the peaceful applications of nuclear energy; it has designed and constructed several research and radioisotopes production reactors; it produces over 90% of the radionuclides consumed in the country (it is one of the main Cobalt-60 producers), and an uranium enrichment plant was developed and commissioned in order to supply the fuel to be used in experimental and research reactors (mainly taking into account that Argentina have exported experimental reactors to several countries as Peru, Argelia, etc. and therefore the fuel elements supply must be made sure) and to attain light enrichment in the fuels to be used in our nuclear power plants to improve the "burn up".

The operation of nuclear power plants, the different stages of nuclear fuel cycle, the activities in the atomic research centers, universities, hospitals, industries, etc, generate important volumes of radioactive wastes of different characteristics.

For that purpose, the CNEA has established since 1986 the "Radioactive Waste Management Program".

The objectives are:

- To deal with the treatment, conditioning, intermediate storage, transport and final disposal of low, medium and high level radioactive wastes.
- To perform the conceptual, basic and detail engineering of required installations, as well as to supervise their construction, erection and commissioning, and direct their operation.
- To implement systems for the collection, transfer, and transport of radioactive wastes.
- To supervise the operation for decommissioning of nuclear and radioactive installations, including those belonging to uranium mining, carrying out waste management.
- To perform the quality assurance procedure on the waste forms and on the existing installations and equipment.
- To perform the required technical and economical financial studies taking into account the cost of the management processes and the differed costs derived from those processes and from the decommissioning operations, so as to establish an adequate economic policy.
- To make all the necessary information available to the technical and to the public information media, and to give advice on the subjects of its competence.
- To collect the available information, to carry out the necessary studies and to advise to the Parliament members in order to establish an adequate

legislation, with the aim to provide the basis for the safe management of all types of radioactive wastes.

To discharge these duties, the Program's organization includes the following five departments: Technology of processes, Installation and services, Projects evaluation, Information and control and Budget administration.

The wide range of these activities requires personnel from different specialties, including radiochemists, chemists, physicists, geologists, engineers (chemical, mechanical, civil and computer science), architects, management and administrative personnel, etc. These requirements involve not only a constant selection of adequate personnel to the different tasks but the training of new professionals and technicals agreed with the program expansion.

## RADIATION SAFETY CRITERIA

In order to consider the treatment and final disposition of all waste produced in the country it is necessary to establish previously safety criteria.

Radiation safety criteria adopted for normal situations are consistent with ICRP recommendations.

The main objectives are to keep individual exposures below recommended limits and to reduce the radiological impact as far as it is reasonably achievable. The Authority considered as upper bound resulting for an ideal critical group, from the disposal of waste in the repository under consideration, 0.1 mSv in one year.

Concerning potential disruptive events in a repository, the maximum individual risk for a member of the public must not exceed the risk due to normal radioactive releases.

The order of magnitude of the upper bound established by Argentine Authorities (0.1 mSv in a year) corresponds to a risk of lethality of the order of $10^{-6}$ in a year.

$$R_{max} = 10^{-6} y^{-1} \quad \text{(Eq. 1)}$$

where Rmax is the maximum value of the probability of lethality committed for one year.

## METHODOLOGY

The principal safety goal is to keep waste isolated from the biosphere to such an extent and over time scales that any possible return of radionuclides to man, also far in the future, will only result in negligible exposures for the public. The degree of isolation of waste depends on performance of the various barriers and the waste disposal system as a whole.

This concept considers independent and redundant geological and engineering barriers such that failure of one does not jeopardize the safety of the system as a whole.

The first barrier is the immobilized waste where sophisticated technologies and special knowledges are required.

The different barriers are selected taking in account a "minimum isolation time" required before the wastes achieve the biosphere. To determine this "minimum isolation time" each case has to be studied: amount and type of waste, foreseen disposal site efficiency of the alternative barriers and costs involved in each alternative.

Though the "wait and see" policy to the spent fuel was adopted as have been mentioned before, immobilization of high level liquid wastes by vitrification is being studied. Two methods are being tested employing borosilicate glass as encapsulation matrix: fusion and sintering (hot pressing).

Cementicious matrices are used in order to immobilize medium an low level wastes and formulation development studies to produce acceptable waste/matrix composition are carried out with each waste stream. A polymeric matrix (Alkatene) has been used, in certain cases, in the past.

The waste management procedures must ensure the safety of operating personnel and public by avoiding unacceptable radiation exposure due to direct handling or by dispersion of the contained radioactive isotopes.

Relevant properties have to be assessed for each management step. Quality of the waste packages to ensure compliance with the waste acceptance criteria must be checked in the final disposal.

Procedures, quality control, and quality assurance systems applied to the process, waste-form and its container are being established.

With the aim to guarantee the behavior of the waste-form product, that is the first barrier, in the short and in the long term, modelling and experimental studies were adopted in each case.

The second type of barrier would be a repository, wherein a series of complex engineering and geological elements must be considered so as to assure pre-established isolation.

The strategy is based on a near surface disposal of medium and low level wastes. As it will be described further on, trenches system is being used for low level wastes and a monolithic type concrete repository for medium level wastes was decided.

Concerning high level wastes a deep geological repository is being studied.

## RADIOACTIVE WASTES

At its has been said the operation of nuclear power plants, the different stages of nuclear fuel cycle, the activities in the atomic research centers, universities, hospitals, industries, etc., generate important volumes of radioactive wastes of different characteristics. Wastes produced since beginning of the nuclear activity in our country, forty years ago, are in brief:

### Low level Radioactive Wastes

There are 832 $m^3$ of low level wastes treated and conditioned into 4160 drums of 0.200 $m^3$ according to specifications and procedures defined in each case. From these drums, 3500 has been disposed in the Trench No 1 for low level solid wastes. At present this trench is completed and closured; the remainder 660 drums are disposed in the Trench No 2. This trench can accommodate up to 5600 drums.

There are 100 $m^3$ of biological wastes treated and cemented in a concrete pit "ad hoc".

From Atucha I, 15 $m^3$ of evaporator concentrate are being immobilized by cementation, that means about others 750 drums.

### Medium Level Radioactive Wastes

About 50 $m^3$ of medium level wastes, mainly sealed sources and structural materials from the redesign of an experimental reactor, are immobilized by a cement grout in a concrete pit.

Both nuclear power plants under operation, have generated 103 $m^3$ of spent ion exchange resins that once they are treated and conditioned according to specifications and procedures, they will produce 3260 drums of 0.200 $m^3$. These drums will be in an intermediate storage until a final disposal has been constructed.

Medium level wastes also involved the filters from operation of nuclear power plants. They are stored in concrete pits waiting for a further decision. In Atucha I N.P.P. there are about 400 filters in 4 concrete pits. In Embalse N.P.P. there are 135 filters of 0.50 m of diameter by 1.50 m long. The principal responsible of the activity is in both cases Co-60 and in less degree Cs-137.

Moreover, the yearly yield of twenty drums containing scraps arising of Co-60 production must be considered.

**Alpha Contaminated Wastes**

As the time being, 1.2 $m^3$ of a contaminated wastes treated and conditioned are in an intermediate storage waiting for the final disposal. These wastes are arising from an experimental mixed oxide facility.

**High Level Wastes**

High level wastes are composed basically of spent fuel elements.

a. Atucha I nuclear power plant:

An amount of 5654 spent fuel elements equivalent to 859 Mg/U are stored in pools at reactor. Pool building No 1 has a capacity for 3500 elements, the remainder elements are in the pool building No. 2 which has at present 4730 free positions, that is enough capacity for the life of the plant.

Inside this second pool, 14 coolant channels of the reactor core which were replaced, are deposited waiting for its treatment and conditioning.

b. Embalse nuclear power plant:

Spent fuel elements amount at present 31 727, which are equivalent to 1070 Mg/U.

The fuel elements storage pool has a total capacity of 56900 elements. It is expected that this installation will be completely full about February 1993. Therefore, in order to implement this situation, the interim dry storage concept into modular concrete silos has been decided to adopt.

c. Spent fuel elements from experimental and production reactors:

There are up to now 232 elements with 14 188 g/U (U235 - 20%) and 207 elements with 29 988 g/U (U235 - 90%). These elements are in a temporary wet storage in a concrete building "ad hoc".

**Wastes Arising from the Uranium Mining and Milling**

a. Uranium tailing.

It is considered about 4 986 000 Mg of wastes generated from all the uranium mines.

b. Liquid wastes.

Liquid wastes are collected in ponds: 41 400 $m^3$ are acid effluent and 59 200 $m^3$ are neutralized effluents.

All the radioactive wastes produced in our country, are managed by the Waste Management Program or below its supervision and control.

## INSTALLATIONS

In addition to the installations available in nuclear power plants, concerning to the treatment and conditioning of medium and low level wastes, the following facilities for managing wastes exist in our country.

**Radiochemical Facility**

This facility involves several installations: three hot cells to deal with high level wastes; radiochemical laboratories to deal with medium and low level wastes; a laboratory with high integrity glove boxes and a laboratory for high complexity radioactivity measurements.

Different methods of treatment and conditioning of radioactive wastes as well as characterization of matrices and waste-forms and controls related to the acceptance are performed in this facility.

**Low Activity Solid Waste Treatment Plant**

Wastes from CNEA atomic centers, as well as from medical centers and industrial activities are processed in this plant. In a classification room wastes are divided into incinerable and non incinerable, and the later into compactable and non compactable.

For incinerable wastes an incinerator is available with 1 $m^3$ capacity, incineration rate 34 $m^3$/h, and working temperature 970- 1070 K. The ashes are transferred to an equipment where they are incorporated into bitumen by mechanical agitation in the proportion of 1:2 in weight, at 453 K. The mixture is loaded into drums, that are carried out to the LLSW trench. The incinerator's ventilation system, passes through a heat exchanger and then goes to a filter room located in the plant's upper section. Compactable wastes are compacted with an hydraulic press into drums (3 to 6 Mg). The press operates under forced draft and the gasses are conveyed to the filter room. The drums loaded with classified and pressed wastes , are carried to the trenches for final disposal.

Non compactable wastes are put directly into drums and then disposed of as a previously described.

To immobilize medium and low level wastes by cementation a remotized mixer equipment is used.

**Trenches for Low Level Radioactive Wastes**

There are two trenches. At present, the Trench No 1 is completely full with 3500 drums and closured. The Trench No 2 is 120 m long 20 m wide, and 1.20 m deep. It is enclosed by perimetral batter supported by walls of concrete. Its base is a 0.60 m thick bed of compacted caliche, plus a 0.10 m thick layer of soil concrete and upper layer of granitic stone (0.07 mm thick). The slope is from 2 to 5%.

This trench can accommodate up to 5600 drums of 0.200 $m^3$ each. It is provided with a movable shed covering the area corresponding to a bunch of 560 drums. When this amount of drums is accumulated under the shed, they are covered with the local clayish earth. Over the compacted soil an asphaltic layer to 2 kg per $m^2$ with EM 1 material of road type is applied while hot, attaining 2 mm thickness pores free. Over the asphaltic layer dry and fine sand was placed; afterward a black film of polyethylene (250 $\mu$m) (Agrotylene produced in our country) is placed on transversal direction respect to the trench is and the edge were brought together by welding.

Finally a tosca layer is placed over the polyethylene, free of lumps and without compactation; followed by a black layer soil of 0.15 m thickness and grass over it. As soon as one bunch is covered, the shed is displaced to provide shelter to a new bunch of drums.

The drums entering the trench contain radionuclides with half-lives less than 5 years, although too limited amounts of nuclides of longer half-lives are also accepted. Drums with contact exposures higher than 10 mSv/h are not admitted. A sampling station for monitoring the aquifer is under construction. Each trench has a data base in which the characteristics and the history of each drum are recorded.

**Low Activity Liquid Wastes Decay and Evacuation Plant**

The installation is designed to receive the active effluents from the radioisotope production plant, store them for decay and later, after monitoring, either discharge them to the trench for liquids, or to the environment through the Arroyo Aguirre.

The installation is an underground construction, 17 m long, 4 m wide, divided into three main cubicles, two of which contain one 15 $m^3$ tank each, while the third cubicle contains the pump and their valves.

**Semi-Containment Trenches System for Low Activity Liquid Wastes**

This installation was designed for the disposal in selected ground sections of radioactive liquid waste containing radionuclides with half-lives shorter than 30 years and activities not higher than medium.

The trenches were constructed according to classic schema, after studying the retention capacity of the soil by ion exchange at Ezeiza Atomic Center. The soil is of loessian slimes with a high contents of clay. Trenches are 10 m wide, 20 m long and 3 m deep.

Each trench has sampling station for monitoring the aquifer and a data base where the characteristics and origin of the pumped liquid are recorded.

**Cubicles of Concrete**

Two concrete pits are available. They are 4 m in diameter 10 m deep and their wall thickness is 0.30 m. They are intended for final disposal of difficult to handle structural parts, such as contaminated experimental reactor components, graphite, irradiation boxes, high activity Ir and Co sources, etc. These pits are cemented periodically, so as to maintain an adequate dose at their mouth.

**Temporary Storage of Spent Fuel Elements (MTR Type) and Control Rods**

This a concrete building 85 m long, 12 m wide and a 4 m high with access gates at each end . It consists of 6 longitudinal batteries of pits; each battery being raised 0.20 m above floor level, are 0.80 m wide, while the separation between batteries is 0.50 m. The deposit has a total capacity of 198 pits, each of them having an inner lining of stainless steel tubes, 0.15 m diameter and 2.10 m long, capable of receiving a maximum of two fuel elements or one control rod. The pits in each battery are intercommunicated each other both through top and bottom by means of stainless tubes provided with manual spheric valves to regulate the flow of demineralized water.

The equipment also includes a closed circuit for water recirculation and demineralization, a reserve tank and shielded transport.

**Installations Under Construction**

Among the installations being built are

a. an intermediate storage for aconditionated MLW.

b. construction of 1500 $m^2$ of laboratories.

c. construction and commissioning of two pilots plants, one for cementation and other for vitrification.

d. a facility for the decontamination of large components

e. another temporary storage of spent fuel elements (MTR type) and control rods.

f. three trenches more for aconditionated LLW (one at Ezeiza Atomic Center, one at Atucha N.P.P. and another one at Embalse N.P.P.).

g. An intermediate dry storage for spent fuel elements of N.P.P.

**Repositories**

Studies are being carried out regarding a monolithic type concrete repository buried at little depth, for final disposal of immobilized medium level wastes. Total waste volume of MLW until year 2022 was considered taking into account the simultaneous operation of four nuclear power plants. At that time, the number of 0.200 $m^3$ drums containing conditioned radioactive wastes will be about 40 000.

These drums will be inserted into a concrete container. Its outer dimensions are 2.70m x 2.10m x 1m with a 0.10m wall thickness. After drums are inserted (12 drums per container), the residual volumen will be filled with cement grout and closed with a concrete cap. The containers containing the drums will be placed in a special concrete facility. It will be a parallellepiped shape construction partly buried and its dimension will be about 23m x 22m x 7m (total volume 3500 $m^3$). This construction will perform 18.4 $Mg/m^2$ total load over the bottom. The facility will have a capacity for 400 concrete containers, that is 4800 drums. Therefore, it is foreseen at least eight modules between nowadays and the year 2020 under at present conditions. Control measurements will be performed at each module. During the operation a movil structure including the necessary components will cover the module and when it will be completed and closured it will be displaced to the following module.

The mechanism of site selection becomes a very important issue. The requirements to establish a disposal site are that it should satisfy all relevant performance criteria, taking into consideration all technical, environmental, social and economic considerations.

From geological point of view the following requirements are involved:

- Waste packages placed in the selected site will ensure that no radiological risks will not occur before 300 years.
- The engineering design involves the possibility to construct on the first 10 m depth.
- Candidate sites will be located mainly inside the circle drawn over the line that joints Atucha N.P.P. with Embalse N.P.P. "Low use" soil will only be considered. Therefore, future possibilities related to agriculture, cattle ranch, industry and trade, tourism, mineral resources, cultural and educational activities, must be taken in consideration.

- Candidate sites would have an area not less than 500 000 $m^2$.
- Density of population must be less than one inhabitant per $km^2$.
- Neither permanent nor temporary water courses must be in the selected area.
- Underground water table would be below 30 m.
- Annual rainfall regime would be less the 700 mm per year.

Also on an advanced stage are the studies for siting a geologic repository for high level waste immobilized in a vitreous matrix. After analyzing known granitic rocks, as to their petrographic and structural features, dimensions and depth of rocky formations, seismic and hydrogeological conditions, mining and oil potential, as well as population and human activities, Sierra del Medio near Gastre, Province of Chubut, was chosen.

Further studies included: photointerpretation, alignment, statistical analysis, geological and geophysical recognition of the rocky formation, drillings down to 200 m, geomorphological and hydrogeological analysis of the area, and deep drilling down to 800 m.

The repository should be capable of accommodating wastes originated in the operation of 6 nuclear power plants.

Aconditionated wastes (borosilicate glasses or spent fuel elements encapsulated, will be placed in holes 1 m in diameter and 9 m in depth bored in gallery, in turn sealed with a mixture of sand and bentonite with high ion retention capacity.

Each vitreous matrix containing 10% in weight of oxides from fission products and transuranic elements, will generate a thermal power of 500 W after decaying during 20 years. In order not exceed the adopted maximum temperature of 333 K in the rock, the minimum distance between containers will be 5 m with a thermal power of 5 $W/m^2$ on a horizontal plane.

The distance between galleries will be 20 m.

All the facts here exposed show that the Argentina has decided, within certain limitations, to face with emphasis all about radioactive waste management.

We always remark, without fear of mistake, that the success or failure of a nuclear power plan will depend on how to resolve the nuclear waste issue.