

# REGULATORY CRITERIA FOR FINAL DISPOSAL OF RADIOACTIVE WASTES



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## Abstract

This paper describes briefly the legislative and regulatory framework in which the final disposal of radioactive wastes is carried out in Argentina. It also presents the criteria developed by the Nuclear Regulatory Authority (ARN) to assess the long-term safety of final disposal systems for high level radioactive wastes.

## 1. INTRODUCTION

The "National Law of Nuclear Activity" (No. 24804), in force since April 1997 by approval of the National Congress, assigns to ARN the following functions: to regulate and to inspect nuclear activities regarding radiological and nuclear safety, physical protection of nuclear materials, in order to verify that such materials are used exclusively with peaceful purposes and also, to advise the National Executive Power in matters of its competence. For the fulfilment of these functions the Law grants the ARN the necessary legal competence to develop, to establish and to apply a regulatory system to all nuclear activities carried out in Argentina.

Concerning the final disposal of high, medium and low level radioactive wastes, the "National Law of Nuclear Activity" establishes that to define the location of a repository the National Commission of Atomic Energy (CNEA), as Responsible Entity, should propose a location. This place shall have the approval of ARN regarding radiological and nuclear safety and the approval by law of the Provincial State where the localization was intended.

The activity of ARN is carried out in the framework of a regulatory system whose fundamental aspect is the approach adopted to establish the requirements of safety, which is known as "*of performance*". This system has a group of rules known as "AR Standards" (AR: abbreviation of Regulatory Authority) that, among other requirements, establish that the construction, operation and decommissioning of a nuclear installation cannot start without the corresponding construction, operation or decommissioning licence. This system is also applicable to the final disposal of high level radioactive wastes.

## 2. REGULATORY CRITERIA

ARN has developed some basic regulatory criteria applicable to the final disposal of radioactive wastes with the aim to provide assessment targets on radiological and nuclear safety for the demonstration period.

### 2.1. Risk Limits

The radiological protection criteria applied by ARN to the final disposal of radioactive wastes establishes that no individual of the critical group shall be exposed to a risk higher than  $10^{-5} \text{ y}^{-1}$  with optimization of the protection systems, and if the risk is not higher than  $10^{-6} \text{ y}^{-1}$ , the optimization requirement is not considered necessary. Those values are equivalent to a dose constraint of 0,3 mSv  $\text{a}^{-1}$  and a dose reference level of 0,03 mSv  $\text{a}^{-1}$  respectively. These criteria are consistent with the

International Commission on Radiological Protection (ICRP) recommendations [1], [3]. The main aims are to ensure that the individual risks are below the appropriate limits and to keep the radiological impact as low as reasonably achievable (ALARA).

## 2.2. Radiological Protection Criteria Implementation

The multi-barrier concept is considered by ARN an appropriate tool to implement the main objectives mentioned previously. This concept consists of a system of engineered and natural barriers placed between the radioactive wastes and the environment accessible to man, with independent and redundant features, so that the safety of the system relies on the radionuclides containment through the combined operation of the multi-barrier system. In this way, the safety of the system is not compromised by the failure of any particular barrier.

Geological barriers by themselves could implement the radiological criteria described in 2.1., but, ARN requires that a low individual risk to the individuals of the critical group shall be ensured by engineering barriers too, in an independent and redundant manner. The barriers should be selected taking into account the minimum confinement time required to allow the decay of the radionuclides contained in the wastes.

The barriers considered appropriate are the inclusion of the wastes in a stable matrix whose low leaching rate would allow the delay in the radionuclides arrival to the biosphere by 10,000 years; the complete isolation of the wastes during the first 1,000 years to avoid deterministic effects by the use of appropriate containers; backfilling the repository with a material of low hydraulic conductivity and high ionic exchange capacity (to delay the migration of the leached radionuclides) and the use of geological stable barriers, with low hydraulic conductivities, approximately at a depth of 500 meters or more, located in areas without present or future mineral or petroleum interest and with low seismic risk, obtaining by this means a delay in order of magnitude of 100,000 years, and a significant reduction in the occurrence of probabilistic effects.

In **Figure 1**, the considered necessary time to allow the decay of the fission products are indicated (approximately 1,000 years), and also, the same period for the actinides fraction remaining after the reprocessing (approximately  $10^5$ – $10^6$  years).

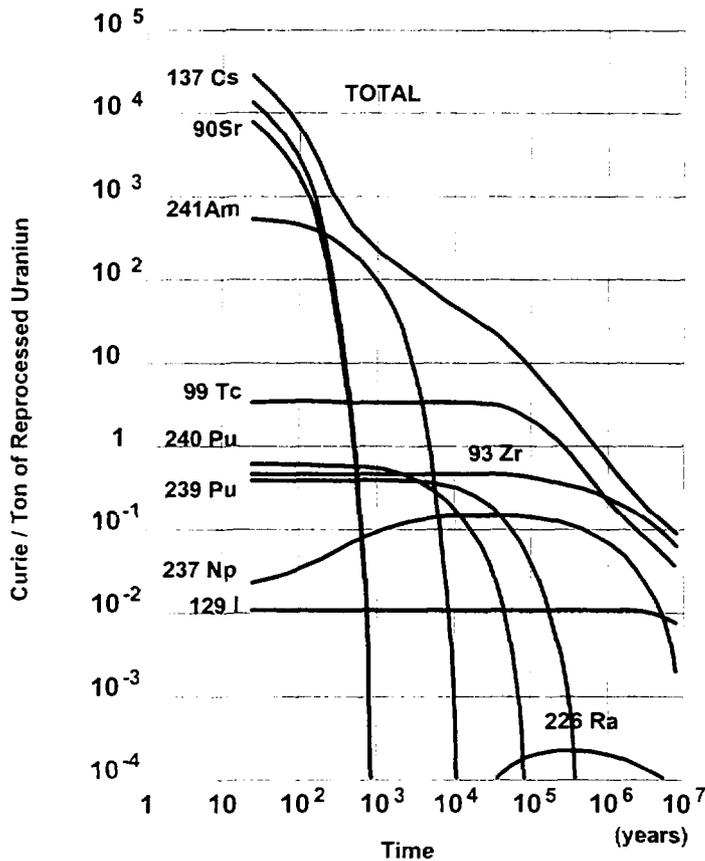
In Argentina, a feasibility analysis for the final disposal of high level radioactive wastes was performed during the eighties. The conclusions drawn are that the final disposal of those wastes in a deep and stable geological formation would be a solution that would not represent higher risks for the present and future generations than those indicated previously [4] - [5].

## 2.3. Considerations for the eventual recuperation of the wastes

The criteria for the prevention of eventual recuperation of the wastes could be derived from the well known radiological protection principle: “the magnitude of individual doses, the number of people exposed, and the likelihood of incurring exposures where these are not certain to be received should all be kept as low as reasonably achievable”.

In the case of disposal of radioactive wastes without the removal of potentially useful material, the presence of this material increases the probability of recovery intention, with the following increase in the probability of exposure of the involved people. Therefore, as the recovery is a potential event whose occurrence probability is near to one in this circumstances, it seems convenient to derive a specific criteria based in the above mentioned principle. Consequently, the associated regulatory requirement could recommend the removal from the waste of the potentially useful material by the society with precedence to its final disposal.

Furthermore, an optimization process could define the optimal time in which the removal should be performed conveniently.



**Figure 1 – Activities in the reprocessed wastes as time function (based on natural uranium fuel)**

ARN considers that the appropriate solution to implement this concept, with the present technological knowledge, is to reprocess the spent fuel elements [2], and to dispose of the high level wastes solidified in a stable matrix, without actinides and fission products of interest, in a deep geological formation, with appropriate characteristics [4]. Additionally, to ensure a convenient structural strength for the waste form, the proposed container would be made from materials resistant to corrosion and mechanical stress, chemically compatible with each other and with the waste matrix, and without residual value that would otherwise give reason to removal intentions [5].

ARN considers that by these means, the probability of removal intention in repositories would be diminished notably. This is mainly because by reprocessing the spent fuel, the plutonium, uranium, fission products and actinides of interest would be removed previously.

The criteria are then based on the final disposal of the reprocessed wastes without any intention of ulterior removal of materials. Otherwise, the radiological impact would be increased without any evident benefit.

#### 2.4 Institutional Control

After the removal of the useful materials, the institutional control of the high level radioactive waste repository is relevant during the safety demonstration phase, in particular, to confirm that the applied barriers perform as they were designed. Due to this reason, the criteria adopted by ARN are to demonstrate the radiological and nuclear safety of the repository in the long term, by analysis that allow to evaluate the performance of each barrier. By this means, an appropriate level of confidence shall be attained about the isolation of the radionuclides from the environment of interest, which

should cover periods longer than  $10^5$  years due to the geological barrier. The assessment should also, take into account, that the safety of the repository site does not require institutional control in the long term.

## **2.5. Human intrusion risks**

The human intrusion probability in a repository that fulfils the characteristics detailed in 2.2. is extremely low due to the site conditions. Furthermore, the human intrusion would be prevented by the previously mentioned reasons, and mainly by the fact that the site has no present mineral or petroleum potential interests, nor have the containers residual value. Additionally, the applied criteria to avoid deterministic risks by engineering barriers implies that in the case of an eventual human intrusion the most exposed individuals would be adequately protected by those barriers.

## **3. ALTERNATIVE REGULATORY CRITERIA**

An alternative waste management strategy to that presented here is to store temporally the spent fuel without reprocessing. The storage period and conditions should be appropriate to maintain the integrity of the spent fuel elements by the required storage period, ensuring their radiological and nuclear safety and also their physical protection. Notwithstanding this, studies shall be performed to make decisions on their final fate. These decisions should be made well in advance before the useful life of the spent fuel structural materials has been reached.

## **4. FINAL REMARKS**

The exposed alternative for the final disposal of high level radioactive wastes would allow meeting the present regulatory criteria of ARN, leaving open the possibility of considering technological developments that would reduce the activity content in the wastes, and consequently, the time required for their isolation. The removal of the material of interest and the further disposal of the produced wastes are then an adequate solution, taking into account that this leaves open the possibility of reuse of these materials as fuel, increasing its energetic exploitation and reducing the radiological impact of the final disposal of nuclear wastes. Besides, by this means not only the economic exploitation is increased, but the probability of eventual human intrusion associated to the intentional recovery of valuable materials contained in the non reprocessed wastes is diminished. Furthermore, the institutional control period required in these cases is reduced considerably and should cover the demonstration period.

## **REFERENCES**

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