*2024 International Nuclear Atlantic Conference – INAC 2024*
*Escola de Guerra Naval, Rio de Janeiro, RJ, May 6 - 10, 2024*

ISBN: 978-65-594-1256-3

# Considerations on Legacy Radioactive Wastes Acceptance Criteria for Final Deposition

P. Cabrera[1], J. C. Dellamano[2] and R. Vicente[3]

[1] *paloma.cabrera@usp.br*
[2] *jcdellam@ipen.br*
[3] *rvicente@ipen.br*

## 1. Introduction

In Brazil, the 1950s were marked by deliberate actions in favor of the country's industrialization and technological development. The National Council for Scientific and Technological Development (Conselho Nacional de Desenvolvimento Científico e Tecnológico, CNPq) was created in 1951 to promote and conduct science, technology and innovation policies. In 1956, with the lemma “fifty years in five”, Juscelino Kubitschek assumed the Presidency and put into practice the Target Plan, a project that defined thirty objectives, grouped into five sectors: energy, transport, industry, education and food. In the same year, the National Nuclear Energy Commission (CNEN) was created [1] and, in 1957 occurred the first criticality of the IEA-R1 research reactor, it was the first nuclear reactor installed in Brazil, located in the city of São Paulo and used for research and radioisotopes production for use in medicine. The second was installed in 1958, in the city of Belo Horizonte, the TRIGA IPR-R1 reactor also plays an important role in research, production of radioisotopes and strong performance in ore prospecting and the analysis of uranium content in ore.

It was in this scenario that the Brazilian nuclear program was born, from the beginning focused on development, the production of national science and technology and improving the population's quality of life. Since then, great advances have occurred in the nuclear area, currently the country has two operational nuclear power plants (NPP) and one under construction, three research reactors, one experimental critical facility and the project to build a 30 MW Multi-Purpose Reactor for research, production of radioisotopes, testing of materials and use of radiation beams. There are also 2,072 facilities that use ionizing radiation, including 11 cyclotrons in operation, 782 medical, 709 industrial and 188 research facilities [2]. Other nuclear activities, such as uranium mining and milling, uranium enrichment, fuel manufacture and petroleum industry, also tend to increase the operations and all these applications produce radioactive waste.

So, in the next few years, the tendency of the radioactive waste inventory is to increase significantly. Moreover, it is necessary to consider that for almost 70 years, several nuclear applications were used in Brazil and generated radioactive waste, which was managed safely and in accordance with the technology, resources and regulations available at the time they were generated. The current inventory counts with thousands of radioactive wastes in initial and intermediary storage waiting for final disposal, since it does not have a national repository yet. The Nuclear and Environmental Technological Center (CENTENA) will be the Brazilian near surface repository for low and intermediate-level radioactive wastes [3]. It is in the site selection phase and consists of an undertaking of great importance for nuclear technology development in Brazil.

In Brazil, the radioactive waste categorization is defined by the document CNEN NN 8.01 [4], based on IAEA recommendations, and it classified the wastes into four categories considering the activity concentration present in the waste, the radioisotope half-life and the radiation nature. Given the radioactive waste categories presented in the legislation, it is established that CENTENA will receives 2.1 category wastes, since the radionuclides expected to be deposited have a half-life greater than 100 days and less than or close to 30 years, with the generation of heat equal to or less than 2 kW/m³ and alpha emitters concentration below 3,700 Bq/g for individual packages and up to 370 Bq/g on average for a package set.

The acceptance of radioactive waste for final disposal, when there is no intention of removal, is subject to the waste acceptance criteria (WAC), a set of guidelines that determine which waste will be accepted for storage in the repository, imposing qualitative and quantitative limits for various characteristics of the waste packages and the waste itself [5]. The WAC should be determined by the repository operator in accordance with legislation and in order to ensure that, in the long term, the disposed waste will not represent any risk to the safety of the installation, including workers, public and environmental, in the operation and post-closure period.

The Brazilian legislation regarding acceptance criteria is described in document CNEN NN 6.09 [6], which defines WAC for low and intermediate level radioactive waste. It is noteworthy that this document came into force in 2002 and, therefore, 45 years after the installation of the first research reactor (IEA-R1) and 18 years after the installation of the first NPP (Angra 1). However, many radioactive wastes were generated prior to the sanction of such legislation, so that a significant part of the national inventory, although stored in safe initial or intermediary storage facilities, may not comply with the current acceptance criteria.

The International Atomic Energy Agency defines as historical wastes those that are generated without a complete traceable characterization programme or quality management system in place [7]. Even if radioactive wastes generated after 2002 comply with the CNEN NN 6.09, until the CENTENA comes into operation and its specific WAC will be defined, all waste that makes up the Brazilian inventory can be considered historical waste.

## 2. Methodology

In this work, we evaluate the Brazilian historical radioactive waste inventory and its main characteristics, in order to point out particularities that must be evaluated before their final storage. It is expected to contribute to the discussion of the subject in the country and to assist in the decision making regarding the management of the wastes.

## 3. Results and Discussion

Most of the low and intermediate level radioactive waste inventory in Brazil is composed of those generated in the NPP and research reactors operation, followed by the wastes generated in other nuclear applications. The country also has wastes from the radiological accident that occurred in Goiânia (1986) that were not included in the disposal facility constructed to store the wastes from the accident, since they had already been transported before the accident response actions and still in the intermediate storage facility (IPEN, São Paulo).

In the case of the radioactive wastes from NPP operation, some efforts have been made in order to align the inventory with the waste acceptance criteria and to improve the confidence in the knowledge on the packages. A project is in progress with the objective to apply the scaling factors method to the current and future wastes to determine the radioisotope inventory for each package. The scaling factor method is based on correlations between the radionuclides that are difficult to measure (DTM) from outside th waste packages using non-intrusive techniques because they are low energy gamma emitters, non-penetrating beta or alpha emitting nuclides and the key nuclides, those that are gamma emitters and can be obtained by external gamma measurements. For the Brazilian NPP, the DTM and key nuclides are already defined, as shown in Table I. These wastes will compose the major part of the wastes in CENTENA.

To survey the first radioactive wastes to be sent to CENTENA, the National Report for the IAEA Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management was consulted [8], in order to define the wastes inventory from NPP. The NPP wastes are stored in an on-site initial storage facility, composed of installations 1, 2A, 2B and 3. The wastes are conditioned in different packages, as shown in Table II, and they are already immobilized in concrete and bitumen matrixes. Table III shows the package number stored in the on-site initial storage facility.

Table II shows the package number stored in the on-site initial storage facility.

**Table I:** Packages used to store wastes from Angra 1 and Angra 2 NPP.

| Waste Type/ Matrix | Angra 1 | Angra 2 |
|---|---|---|
| Evaporator concentrate | Liner | Drum |
| Spent resins | Liner | Drum |
| Spent filter cartridges | Drum | Drum |
| Non-compressible | Metallic box | Metallic box |
| Compressible | Drum | Drum |
| Waste matrix | Cement | Bitumen |

**Packages description:**
Drum: carbon steel, 200 liters
Liner: cylindrical, $1m^3$, internal shielding in concrete
Metallic box: carbon steel, $1.5m^3$ or $2.55m^3$

Table II: Radioactive wastes inventory from the NPP operation.

| Storage Facility | 1 | 2A | 2B | | 3 | | Total (packages) |
|---|---|---|---|---|---|---|---|
| Package Type | Drums[1] | Liners[2] | Drums | Liners | Drums | Metallic box | 8,204 |
| Capacity | 4,064 | 783 | 2,296 | 252 | 5,612 | 300 | |
| Currently Sotoraged | 2,916 | 771 | 2,296 | 85 | 1,868 | 268 | |
| Available Space | 28% | 2% | 0% | 66% | 67% | 11% | |

(1) Currently wastes in Storage Facility 1 corresponds to 1716 drums (200 l), 128 metallic boxes (2.55 $m^3$) and 81 metallic boxes (1.25 $m^3$), but it is reported in equivalent drums.
(2) The Storage Facility 2A is occupied with 743 liners and 19 VBA's, whose sum corresponds to 783 liners.

The wastes from the Nuclear and Energy Research Institute (IPEN/CNEN) make up the second largest group of wastes that will be sent to CENTENA. At IPEN, for example, there are 43 drums (200 liters) and 50 steel boxes (1.6 m³) from the radiological accident that occurred in Goiânia (1,987), composed of paper (cardboard), plastic and metallic objects non immobilized and contaminated with $^{137}Cs$. Even if in smaller volume, other generators also will contribute to the volume of wastes in the CENTENA and it must be evaluated in the future.

## 4. Conclusions

It is important to highlight that all installations that use nuclear technology undergo licensing and they are only authorized to operate if safe practices are adopted. However, a preliminary analysis of Brazilian historical waste allows us to note some characteristics that conflict with the current WAC and that must be considered when defining the national repository final WAC.

According to CNEN NN 6.09, it is the responsibility of operators of facilities that generate radioactive waste to prove, through evidence, that the product generated as a result of treatment and/or packaging carried out in their facilities meets the WAC established in the respective document. However, no quality assurance and compliance verification program is provided for by legislation, that is, no parameters are defined for the accuracy of the knowledge that proves compliance with the WAC. The legislation also does not define methods to investigate and evaluate the compliance withWAC.

It is evident that current knowledge about the waste packages does not meet the WAC defined in CNEN NN 6.09, the studies have been carried out to increase this knowledge. Therefore, when determining the repository final WAC, it is necessary to consider the need for the safety assessment to consider the characteristics of the waste generated before the start of the repository's operation, which, given the large volume of packaging, can be a more economical solution than defining final WACs that are not met and demand destructive methods to study the historical wastes.

Historical waste is currently in different packages, using drums and concrete containers, which, in the first analysis, can satisfy the generic WAC defined in CNEN NN 6.09. It is necessary, however, to evaluate the volume and geometry of such packages, so that the repository safety assessment analysis must consider the characteristics of these packages and the need to add overpackaging. There is also a need to define whether the final WAC will be valid for those waste packaged or for the overpacking, if adopted.

The immobilization matrices used are also points of attention. As shown in Table II, while Angra I uses concrete, Angra II uses bitumen as a matrix for immobilizing the waste generated in the NPP operation. It should be noted that the use of bitumen as an immobilization matrix has fallen into disuse due to its flammability. This characteristic conflicts with CNEN NN 6.09, which states that the combustibility of the product or package must be such that the potential for fire is as low as reasonably achievable, so that the concrete matrix is more suitable.

The characteristics highlighted must be considered in the security analysis of the repository, since the installation aims to solve the issue at a national level, therefore, when defining the final WAC for the repository, it is essential that historical waste is prioritized. It is important that generators are informed about the repository's requirements and that WACs are defined as soon as possible, in order to avoid the continuous generation of historical waste.

**Acknowledgements**

Our acknowledgement to the organization of the International Nuclear Atlantic Conference 2024, the Radioactive Waste Management Service of the Nuclear and Energy Research Institute (IPEN), Nuclear Technology Development Center(CDTN), the National Nuclear Energy Commission and the Eletrobras Eletronuclear.

**References**

[1] T. R. de Medeiros, *Entraves ao Desenvolvimento da Tecnologia Nuclear no Brasil: dos Primórdios da Era Atômica ao Acordo Nuclear Brasil-Alemanha*, dissertação de mestrado, UFMG, Belo Horizonte, Brazil (2005).

[2] “Instalações Autorizadas”, https://appasp2019.cnen.gov.br//seguranca/cons-ent-prof/entidades-aut-cert.asp (2024).

[3] “Centro Tecnológico Nuclear e Ambiental”, https://www.gov.br/cdtn/pt-br/projetos-especiais/centena (2024).

[4] Brazilian National Commission for Nuclear Energy, *CNEN NN 8.01 - Gerência de Rejeitos Radioativos de Baixo e Médio Níveis de Radiação*, CNEN, Rio de Janeiro, Brazil (2014).

[5] International Atomic Energy Agency, *Radioactive Waste Management Glossary*, IAEA, Vienna, Austria (2003).

[6] Brazilian National Commission for Nuclear Energy, *CNEN NN 6.09 - Critérios de Aceitação Para Deposição de Rejeitos Radioativos de Baixo e Médio Nível de Radiação*, CNEN, Rio de Janeiro, Brazil (2002).

[7] International Atomic Energy Commission, *Radioactive Waste Management Glossary*, IAEA, Vienna, Austria (2003).

[8] Brazil, *National Report of Brazil 2020 for the 7th Review Meeting of the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management*, Rio de Janeiro, Brazil (2020).