DECOMMISSIONG ASPECTS IN THE DESIGN PHASE OF THE BRAZILIAN MULTIPURPOSE REACTOR - RMB

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ABSTRACT

Nowadays, there are four research reactors operating in Brazil. The production of radioisotopes occurs mainly in IEA-R1, a research reactor with five megawatts of thermal power, installed in the unit of the CNEN in São Paulo, the Nuclear and Energy Research Institute (IPEN). This reactor, however, does not supply the Brazilian radioisotopes demand for medical applications. This necessity can be supplied by the construction and operation of the Brazilian Multipurpose Reactor – RMB, now in the design phase. Another point that stands out the importance of the RMB is the fact of the IEA-R1, whose first criticality was reached in September 1957, to have a useful life of approximately more ten years. Therefore, it becomes indispensable the construction of a reactor that substitutes it. Beyond the production of radioisotopes, the RMB also could be used for structural materials and fuel irradiation tests as well as for accomplishment of research with neutron beams. Among several tasks, an important point that is already being considered in the design phase of the new reactor is its future decommissioning. The main concern is to take into account the lessons learned and the worldwide accumulated experience in the decommissioning of research reactors avoiding mistakes and reducing the amount of problematic wastes in the future. In spite of the currently lack of specific regulatory legislation with respect of reactors decommissioning, in this paper are presented the approach adopted to face the decommissioning task in the design of the new reactor as well as a summary of the Brazilian regulatory licensing procedures and recommendations.

1. Introduction

The Constitution of 1988 of the Federal Republic of Brazil states that the Union has the exclusive competence for managing and handling all nuclear energy activities, including the *operation of nuclear power plants. The Union holds also the monopoly of the survey, mining,* milling, exploitation and exploration of nuclear minerals, as well as of the activities related to industrialization and commerce of nuclear minerals and materials. The Union is also responsible for the final disposal of radioactive waste. All of these activities shall be solely carried out for peaceful uses and under the approval of the National Congress. The National Nuclear Energy Commission (Comissão Nacional de Energia Nuclear - CNEN) was created in 1956 to be in charge of all nuclear activities in Brazil. CNEN is the Regulatory Body in charge of activities including regulating, licensing and controlling nuclear energy utilization. CNEN is also in charge of research and development and production of radioisotopes. According to Brazilian Legislation, CNEN is also the governmental body responsible for receiving and disposing of radioactive waste from the whole country [1].

Nowadays, Brazil has 4 research reactors operating at CNEN institutes. IEA-R1 is the largest research reactor in Brazil, with a maximum power rating of 5 MWth. IEA-R1 is a pool reactor, with light water as the coolant and moderator, and graphite and beryllium as reflectors. The reactor was commissioned on September 16, 1957, when it achieved its first criticality. Although designed to operate at 5 MW, the reactor operated only at 2 MW between the early 1960's and mid 1980's. The reactor originally used 93% enriched U-Al fuel elements. Currently, it uses 20% enriched uranium (U3O8-Al and U3Si2-Al) fuel that is fabricated at IPEN. The reactor is operated and maintained by the Research Reactor Center (CRPq) at IPEN, Sao Paulo, which is also responsible for irradiation and other services. The IEA-R1 reactor is located in a multidisciplinary facility which has been consistently used for research in nuclear and neutron related sciences and engineering. The reactor has also been used for training, radioisotope production for industrial and nuclear medicine applications, and for general irradiation services.

After 1980, IPEN started producing ^{99m}Tc generator kits from the fission of ^{99}Mo imported from Canada. This production is continuously increasing, with the current rate of about 17000 Ci of ^{99m}TC per year. The ^{99m}Tc generator kits, with activities varying from 250 mCi to 2,000 mCi, are distributed to more than 300 hospitals and clinics in Brazil. Several radiopharmaceutical products based on ^{131}I, ^{32}P, ^{51}Cr and ^{153}Sm are also produced at IPEN. During the last years, a concerted effort has been made in order to upgrade the reactor power to 5 MWth. One of the reasons for this decision was to produce ^{99}Mo at IPEN, thus minimizing the cost and reliance on only one or two international suppliers.

The remainder reactors are the IPR-R1 TRIGA located at the Nuclear Technology Development Center – CDTN, at the campus of Federal University of Minas Gerais in Belo Horizonte. It was the second Brazilian RR. The IPR-R1 is a pool type nuclear research reactor, with an open water surface and the core has a cylindrical configuration. The first criticality was achieved on November 1960. At present, the reactor operates at 100kW and the certification process to operate at 250kW is at the final stage. The IPR-R1 is mainly used for thermohydraulical and neutronics research, neutron activation analysis and applied research, as well as for the production of some radioisotopes, like ^{60}Co that is used in the stainless steel industry, and tracers that are used in the environmental research activities. Additionally it is also employed to train the Brazilian NPP operators. The third Brazilian RR is named Argonauta, and is located at the Institute of Nuclear Engineering (Instituto de Engenharia Nuclear – IEN) on the campus of the Federal University of Rio de Janeiro, in Rio de Janeiro city. The first criticality of the reactor was reached on February of 1965. It is used mainly for training purposes, research and sample irradiation. The most recent Brazilian RR is IPEN/MB-01, also located at IPEN. This research reactor is the result of a national joint program developed by CNEN and the Brazilian Navy. The first criticality of the IPEN/MB-01 reactor was reached on 9 November 1988. The IPEN/MB-01 reactor is a zero power reactor because the maximum power level is 100 watts. The reactor, a water tank type critical facility, has a core that consists of up 680 stainless steel fuel pins with UO_2 pellets inside.

In Brazil, the use of radioisotopes in medicine is growing steadily, with the substitution of external irradiation by internal therapy using new radiopharmaceuticals. However, the IEA-R1 cannot supply (neither the remainder above mentioned reactors) the Brazilian radioisotopes demand for medical applications. With the recent crisis in the worldwide supply of ^{99}Mo, Brazilian nuclear medicine has faced several problems, elapsing mainly from the reactor's shut down in Canada. Nowadays, part of the demand of ^{99}Mo has being supplied by importation of material produced in Argentine and South Africa. Some technetium generators also have being imported from France and Israel. Nevertheless, the necessity of ^{99}Mo can be supplied by the construction and operation of the Brazilian Multipurpose Reactor – RMB, now in the design phase.

2. Brazilian Multipurpose Reactor - RMB

The estimated power for the RMB is between 20 to 50 Mw. Besides the production of several radioisotopes for medical and industrial use, with priority for the production of Molibdenum-99 and iodine-131, the new reactor can be employed for materials testing, physic research mainly in neutron beam applications where higher neutron fluxes are indispensable and personnel training. The estimated cost of the new reactor is about of US$ 400 to US$ 500 million dollars and the time for the design and construction of the reactor is estimated in five years after the releasing of the necessary funds. The new reactor project has like reference the Osíris e Julio Horowitz reactors (France), as well as the OPAL, designed by Argentina and built in Australia.

3. Brazilian regulatory licensing procedures

As mentioned above, CNEN became the Regulatory Body in charge of regulating, licensing and controlling nuclear energy. Since 2000, CNEN has been under the Ministério da Ciência e Tecnologia (Ministry of Science and Technology - MCT). Some of CNEN responsibilities include: the preparation and issuance of regulations on nuclear safety, radiation protection, radioactive waste management, nuclear material control and physical protection; licensing and authorization of siting, construction, operation and decommissioning of nuclear facilities; regulatory inspection; acting as a national authority for the purpose of implementing international agreements and treaties related to nuclear safety, security and safeguards; participating in the national preparedness and response to nuclear emergencies.

Brazil has taken legislative, regulatory and administrative measures to ensure the safety of its nuclear installations, including irradiated fuel and radioactive waste. The Federal Constitution of 1988 specifies the distribution of responsibilities among the Federal Union, the States and the Municipalities with respect to the protection of the public health and the environment, including the control of radioactive products and installations. Furthermore, the constitutional principles regarding protection of the environment require that any installation which may cause significant environmental impact shall be subject to environmental impact studies that shall be made public.

The licensing regulation CNEN-NE-1.04 establishes that no nuclear facility shall operate without a licence. It also establishes the necessary review and assessment process, including the specification of the documentation to be presented to CNEN at each phase of the licensing process. It finally establishes a system of regulatory inspections and the corresponding enforcement mechanisms to ensure that the licensing conditions are being fulfilled. The enforcement mechanisms include the authority of CNEN to modify, suspend or revoke the licence. The licensing process is divided in several steps: Site Approval; Construction Licence; Authorization for Nuclear Material Utilization; Authorization for Initial Operation; Authorization for Permanent Operation; Authorization for Decommissioning Federal Law 9756, approved in 1998, establishes taxes and fees for each individual licensing step, as well as for the routine work of supervision of the installation by CNEN. Other governmental bodies are involved in the licensing process, through appropriate consultations. The most important ones are the Institute for Environmental and Renewable Natural Resources (Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis - IBAMA), which is in charge of environmental licensing [2]. In the table 1 are presented the steps and the required documents for the nuclear licensing procedure [3].

4. Decommissioning regulatory procedures for research reactors in Brazil

The Brazilian legislation defines the operating organization as the prime responsible for the safety of a nuclear or radioactive installation, including the management of spent fuel and radioactive waste. Nevertheless, Brazil does not have yet a national regulation that

establishes rules for the composition of funds for decommissioning spent fuel and waste management facilities and no decommissioning policy has been adopted until now regarding research reactors. Actually, Brazil's regulatory body – CNEN - have to create as soon as possible a specific legal and regulatory framework to cover the Decommissioning issues, specially for the case of research reactors. Besides this, Brazil has not yet defined a policy regarding spent fuel or high-level waste disposal.
Table 1: Steps and required documents for the nuclear licencing procedure in Brazil [3].

Step	Required documents
Localization approval (AL)	• Report about the local • Environmental monitoring program (before operation)
Construction licence (LC)	• Preliminary safety analysis report (RPAS) • Physical protection preliminary plan (PPPF) • Quality assurance program • Personnel training preliminary program
Initial operation authorization (AOI)	• Final safety analysis report (RFAS) • Conditioning answers to the construction licence • Authorization for nuclear material using • Physical protection final plan • Radioprotection plan • Fire protection plan • Commissioning program • Testing procedures • Quality assurance program • Operational procedures handbook • Local emergency plan • Licensed operators team (by CNEN) • Insurance for civil liability in case of damages
Permanent operation authorization (AOP)	• Initial Operations Report • Commissioning Report • Conditioning answers to AOI
During the operation	• Periodic reports • Operational events report • To put CNEN in action in case of emergencies • Stop planning • Request for changes in the technical specifications • Request for technical changes • Operators licencing revalidation • Safety periodical revision (ten years) • Answers to demands CNEN • Submitting to periodical inspections

As Brazil does not yet have a specific regulatory procedure for reactors decommissioning, there are not precise directives about this subject in case of new projects. Nevertheless, it is necessary to supply different considerations about the facility's future decommissioning during the licensing phase. The most important points in the project phase are the origin of funds for decommissioning and place for disposal of the wastes generated in the process.

The legislation involving regulatory bodies in Brazil have been raised. Some CNEN and regulatory relevant documents for licensing and for decommissioning purposes are: Regulations NE 1.04 - Licensing of nuclear installations; NE 1.16 - Quality assurance for safety of nuclear power plants and other installations; NE 1.28 - Qualification and actuation of independent technical supervisory organizations in nuclear power plants and other installations; NN 1.01 - Licensing of nuclear reactor operators; NN 1.06 - Health requirements for nuclear reactor operators; NN 1.12 Qualification of independent technical

supervisory organizations for nuclear installations; NE 2.01 Physical Protection in operational units of the nuclear area; NN 3.01 Radiation protection directives. January 2005; NE 3.02 Radiation protection services. August 1988; NE 3.03 Certification of the qualification of radiation protection supervisors. September 1999; NE 5.01 Transportation of radioactive materials. August 1988; NE 6.02 Licensing of radioactive installations. July 1998; NE 6.05 Radioactive waste management in nuclear installations. December 1985; NE 6.06 Site Selection for radioactive waste deposits.- December 1989; NN 6.09 Acceptance criteria for disposal of radioactive waste of low and intermediate radiation level. September 2002.
CONAMA Regulations: CONAMA – 01/86 Establishes requirements for conducting the environmental study (EIA) and the preparation of the report on environmental impact (RIMA) - (23/01/1986); CONAMA-09/86 Regulates the matters related to public hearings) - 03/12/1987); CONAMA-06/86 Establishes and approves models for licensing application - (24/01/1986); CONAMA-06/87 Regulates environmental licensing of large enterprises, especially in the area of electric energy generation- (16/09/1987); CONAMA-237/97 Establishes procedures for environmental licensing of several types of enterprises - (19/12/1997).

5. Conclusion

Regarding the decommissioning issues involved in the design of the Brazilian Multipurpose Reactor, the main concern is to take into account the lessons learned and the worldwide accumulated experience in the decommissioning of research reactors [4] avoiding mistakes and reducing the amount of problematic wastes in the future.

An important point that is already being considered in the design phase of the new reactor is its future decommissioning. Among the different groups and several tasks, involved in the project of new reactor, there is a group dedicated to decommissioning. In spite of some previous experiences in nuclear fuel cycle facilities decommissioning [5-9], the expertise in this field in Brazil is limited. An important point in our point of view during the reactor's design phase will be the interaction with the Regulatory Body in order to develop national regulations, standards and guidelines for research reactor decommissioning procedures. Another important aspect is the opportunity created by the project of the new reactor to integrate the efforts of the different existent groups involved with decommissioning issues spread out in the CNEN's structure and institutes.

6. References

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