DECOMMISSIONING OF NUCLEAR FUEL CYCLE FACILITIES IN THE IPEN-CNEN/SP

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ABSTRACT

IPEN has been facing the problem of the dismantling and decommissioning of their Nuclear Fuel Cycle old facilities. Those facilities already played their roles of technological development and personnel's training, with transfer of the technology for institutions entrusted of the “scale up" of the units. Most of the pilot plants interrupted the activities more than ten years ago, due to the lack of resources for the continuity of the researches. The appropriate facilities maintenance has been also harmed by the lack of resources, with evident signs of deterioration in structures and equipments. The existence of these facilities also implicates in the need of constant surveillance, representing additional obligations, costs and problems. The decommissioning strategy for the old facilities dedicated to the technological domain of the Nuclear Fuel Cycle follows an approach of advancing gradually in dismantling, since the resources and technical conditions are available. The reasons of such approach are the need of political decisions related to the destiny of the facilities, lack of financial resources and of specialized personnel in the decommissioning issue. As some facilities had the activities suspended for about twelve to fifteen years, also constitute relevant problems the equipment deterioration and personnel's loss, due retirements and transfers for other activities and difficulties related to the availability of operational reports, drawings and descriptive memorials. It should be emphasized that one of the most concerning aspects, with relationship to the future of the facilities and the postponement of the dismantling, is the loss of the experience accumulated by the personnel that set up and operated the referred units. A fundamental aspect of the dismantling process of a disabled nuclear facility is the removal of the retained material of the process and the final disposition of the radioactive wastes generated during the operations. The reduction of the amount/volume of radioactive waste is of vital importance. Some facilities demand special attention, requiring preliminary operations of treatment of retained materials and/or wastes. Besides the technological development activities related to the subject accomplished in the IPEN, this document also presents a brief report about the D & D activities performed in IPEN since 2002. The knowledge obtained thanks to the research project BRA-12800 supported by the IAEA was extremely useful in the decisions and activities regarding the D & D activities.

1. Introduction

The Brazilian National Nuclear Energy Commission (CNEN) is a federal autarchy, reporting to the Ministry of Science and Technology. Accordance to the 1988 Constitution it is for the monopoly of the mining of radioactive products, the production and commerce of nuclear materials as well for the orientation, planning, supervision and control of Brazil’s nuclear programs. CNEN, as a superior agency of planning, orientation, supervision and inspection, is the body entitled to establish standards and regulations on radiological protection, to issue licenses (permissions) and to survey and control the nuclear activities in Brazil. CNEN also develops research and development related to the use of nuclear techniques in benefit of the society. The CNEN is divided into three directorates: Directorate of Radiation Protection and Nuclear Safety - DRS, Directorate of Logistic Support – DAL and Directorate of Research and Development – DPD. The DPD is further subdivided into five scientific and technological institutes. The Center for Development of Nuclear Technology - CDTN, which was created in 1952 in Belo Horizonte city of Minas Gerais State, as Brazil's first nuclear research institute. The Nuclear Engineering Institute - IEN and the Radiation Protection and Dosimetry Institute - IRD, both in the Rio de Janeiro city of Rio de Janeiro State. The Regional Center of Nuclear Sciences – CRCN in Recife city of Pernambuco State, the newest of all centers The Institute for Energy and Nuclear Research – IPEN, the biggest of the CNEN's research institutes, located in São Paulo city.

1.1 Brazilian nuclear activities

To understand better the facilities dismantling & decommissioning problem at IPEN it is important to describe the scenery of the nuclear energy in Brazil. Brazil has modest fossil energy resource and one of the largest hydroelectric potential in the world. Nowadays, Brazil only has two nuclear power plants in operation: Angra-I with 657 Mwe (gross electric power) and in commercial operation since January 1985; and Angra-II with 1345 Mwe (gross electric power) in commercial operation since January 2001 (1). Both are located in the Angra dos Reis County – Rio de Janeiro State, near the cities of Sao Paulo, Rio de Janeiro and Belo Horizonte. Still in the early steps of its construction, Angra-III depends on governmental decision for its conclusion (it is suspended by now). This represents only about 2% of the total Brazilian electric installed generation capacity of about 94.7 GWe (2003).
Besides the nuclear power plants, Brazil has established a nuclear power utility / engineering company – Eletrobras Termonuclear S.A. (Eletronuclear); a heavy components manufacturer – Nuclebras Heavy Equipment (NUCLEP); a nuclear fuel manufacturing plant (FCN) and a yellow-cake production plant belonging to Nuclear Industries of Brazil (INB). Brazil ranks in sixth in world uranium ores reserves – 310,000 t U_3O_8 recoverable at low costs. The main uranium mining activities are in the Caitité County – Bahia State and fuel elements manufacturing plant is located at Resende County – Rio de Janeiro State. Brazil has also the basic technology for uranium conversion and enrichment, as well as private engineering companies and research and development (R&D) institutes belonging to CNEN.
In comparison with some developed countries, Brazil has a relatively modest and recent nuclear power program. Due to the reduced dimensions of the nuclear market in Brazil and to the lack of great projects of nuclear facilities shutdown in the near future, there still are not companies specialized in dismantling and decommissioning.
Until the 2000 year, the only decommissioning experience in Brazil was the closure of the Santo Amaro's Mill – USAM. This facility was property of the Brazilian Nuclear Industry, INB, and during fifty years it was dedicated to the processing and production of thorium and rare earths from monazite sands, originated of the southeast beaches of Brazil, between the Bahia and Rio de Janeiro states. The plant was installed in a residential area and in a densely populated region of the S. Paulo, the largest city in South America. The operations were ended in 1992. The decommissioning activities occurred between 1993 and 1999. The Public Ministry of São Paulo State, together with INB, had established a deadline for the plant decommissioning, with daily penalties for lack of fulfilment, and the requirement of reports about the status of the decommissioning (2).

1.2 IPEN's profile and its nuclear fuel cycle pilot plants

The IPEN is an institution owned by the Government of Sao Paulo State, supported and operated technical and administratively by the CNEN. IPEN is located at the west of Sao Paulo city, inside the Campus of the University of Sao Paulo – USP. IPEN occupies an area of nearly 500.000 m^2 (20 % buildings) and is associated to the University of Sao Paulo for teaching purposes. Through a partnership with USP, IPEN conducts a post-graduation program. The IPEN staff is currently composed of about 1,100 persons of which 30 % own post-graduate degree (PhD and MSc).
Since its foundation in 1956, IPEN has played a decisive role in the development of the nuclear science and technology in Brazil. It was created with the main purpose of performing research and development of nuclear energy peaceful applications. The IPEN research centres are engaged in multidisciplinary areas such as nuclear radiation applications, radioisotope production, nuclear reactors, nuclear fuel cycle, radiological safety, dosimetry, laser applications, biotechnology, materials science, chemical processes and environment. An example of a large national impact IPEN activity has

been the production and supply of radiopharmaceuticals. About 2 million diagnostic and therapeutic nuclear medicine procedures per year have been performed in 2004 with products supplied by IPEN.
The main IPEN's facilities include: the nuclear research reactor IEA-R1m that reached criticality in 1957 (built with United States support under the Atoms for Peace Program) and has been upgraded recently to operate at 5 MWth; a Zero Power Reactor IPEN/MB-01 (critical assembly); two Cyclotrons (CV-28 and Cyclone 30 MeV – for radioisotope production); two electron beam accelerators of 1.5 MeV for irradiation applications in the industry and engineering; two Cobalt-60 Irradiators (11,000 and 5,000 Ci); dispersed fuel fabrication facilities (for research reactors); laboratories for chemical and isotope characterization, micro structural and mechanical tests.
The Institute recent history has shown a major participation in the technological development of all steps of the nuclear fuel cycle. One example of the important engagement of IPEN in the technological development in the nuclear fuel cycle area is the isotopic enrichment of uranium by ultra centrifugation, nowadays in process of industrial implantation. This significant achievement was performed in cooperation with the Brazilian Navy.
Nuclear fuel cycle activities at IPEN, from uranium purification to hexafluoride conversion and fuel fabrication for research reactors, besides thorium and zirconium purification, were accomplished in pilot plant scale and most facilities were built in the 70-80 years. The facilities were used to promote human resources, scientific research and better understanding of fuel cycle technologies. The IPEN´s pilot plants were distributed in groups located in different centres:

- CQMA: ADU Dissolution (Impure Yellow Cake); Uranyl Nitrate Purification; ADU Precipitation; Calcination of ADU to UO_3; Denitration by Fluidized Bed (NUH to UO_3); UF_4 Production - Aqueous route; UF_4 Production - Moving Bed Units I and II –Dry route; Thorium Sulfate Dissolution; Thorium Nitrate Purification; Reprocessing laboratory.
- PROCON: Fluorine Production; Uranium Hexafluoride Production; UF_6 Transfer.
- CCTM: UO_2 Fuel Pellets Production.

2. Factors Affecting the Decision and the strategy of D & D in the IPEN

Radical changes of the Brazilian nuclear policy, in the beginning of 90's, determined the interruption of most R&D fuel cycle activities and the facilities shutdown in the IPEN. Most Nuclear Fuel Cycle Facilities had the activities interrupted until 1992-1993. Since then, IPEN has faced the problem of the pilot plants dismantling and/or decommissioning. Immediately after the nuclear R&D program interruption, the uncertainties related to an eventual retaking of the Program created some political hesitation about the dismantling decision. Due to total lack of resources for operation and maintenance, the units had the production interrupted and they meet in precarious conservation situation. As an additional problem could be mentioned the great increase in the population verified in the neighbourhoods of IPEN and USP in the last twenty years.
However, the approach has changed in the last years. Of course, the retaking of the R&D Nuclear Program is now discarded. On one hand, it has been considered the problem of the costs related to facilities maintenance/surveillance and, on the other hand, the problem of the gradual loss of experience and knowledge accumulated because of retirement or dispersion in different activities of the personnel former involved with the different nuclear fuel cycle processes. As the activities were interrupted in most facilities, IPEN has promoted a professional recycling of the remaining personnel with emphasis in environmental applications of the existent experience (chemical processes) and other Institutional different priorities, such as radioisotope production or research reactor operation and fuel production. Another problem that should be mentioned is the exhausted capacity of radioactive waste storage at IPEN. Besides this, Brazil has yet not defined a place for a radioactive waste national repository.
The reasons to promote the dismantling of the IPEN´s Nuclear Fuel Cycle Pilot Plants as soon as possible elapse of the follow main aspects:

- The IPEN is located in the Sao Paulo City, inside the Campus of Sao Paulo University, in an area of nearly 500,000 square meters;

- The localization is an important aspect determining the reuse of the space and buildings of the fuel cycle facilities, since this is a very valuable area and the surroundings are a very populated area;
- Need of physical space for new activities as, for example, the Fuel Cells Program, since the activities of R & D in the area of the nuclear fuel cycle were interrupted, not having perspectives of retaking of the Program;
- Need to take advantage, as soon as possible, of the knowledge of researchers that were indeed involved with the project, assembly and operation of the different facilities, since it comes happening a gradual loss of personnel for retirements and transfers;
- The long period since the interruption of the R & D activities has increased the difficulty of tracking documents and reliable information, besides to evident deterioration of equipments and structures, increasing the concerns with relationship to the risk of liberation of radioactive compounds or that present risks for their chemical toxicities.

Besides the above mentioned aspects, in the last ten or fifteen years, IPEN has changed its “nuclear profile” to a “comprehensive and multidisciplinary profile”. Nowadays, some Brazilian governmental and strategic programs are: Fuel Cells, Nanotechnology, Biomaterials, Environment, Polymers, Lasers. With the end of most Fuel Cycle research and development activities, the area occupied by the former facilities constitutes a significant and useful resource. They can be fully or partially reutilized for a variety of purposes and programs. Besides the full release of some facilities as ”green areas” (priority programs), some buildings can be used as interim storage facilities (for equipment and wastes) . Decision regarding the reuse of the different facilities has been made on a case-by-case basis. During this period, IPEN has been restructured in 13 Research Centers. With the end of most nuclear fuel cycle activities, the former facilities were distributed in four different centers: Environmental and Chemical Technology Center - CQMA; Fuel Cell Center - CCC; Materials Science and Engineering Center - CCTM; Nuclear Fuel Center - CCN. Each center has adopted a different strategy and priority to face the D&D problem and to reintegrate the areas. Resources depend on the specific program developed in each area (resources from other sources, not only CNEN).

3. Dismantling and decommissioning background in the IPEN

The decommissioning strategy for the old facilities dedicated to the technological domain of the Nuclear Fuel Cycle follows an approach of advancing gradually in dismantling, since the resources and technical conditions are available. The reasons of such approach are the need of political decisions related to the destiny of the facilities, lack of financial resources and of specialized personnel in the decommissioning issue, besides the fact that decommissioning is not an institutional priority in the present.

In spite of the difficulties mentioned above, some facilities were actually dismantled at IPEN recently, even without previous experience, training support or detailed planning. Orthodox D&D models/technologies could not be followed, because there is not prepared personnel for the function. Poor expertise and lack of information and experience at IPEN in the subject provoked some degree of improvisation. Nevertheless, the operations were accomplished with a lot of radiological and environmental concerns, following strict procedures (3, 4).

In the first phase of the activities, in the period between 2003 and 2005, the main objectives and priorities were a preliminary rising of the nuclear facilities status, seeking the decommissioning. A preliminary report was prepared with the basic procedure to be adopted for the fuel cycle facilities dismantling at IPEN (5, 6). This rising allowed knowing each installation that should be decommissioned better, establishing a decommissioning strategy based on the institutional needs, besides trying to fill out the main gaps in terms of lack of appropriate technical knowledge to the decommissioning and to identify the main technical obstacles that would be faced in the facilities dismantling. A fundamental aspect of the dismantling process of a disabled nuclear facility is the removal of the material retained in the process equipment and the final disposition of the radioactive wastes generated during the operations. The dismantling operations were performed in four phases:

- 2000 and 2001 years, were dismantled the Thorium Sulfate Dissolution and UF_4 Production Pilot Plant - Aqueous Route in the Building 2 of CQMA;
- Between 2002 and 2003 years, were dismantled the ADU Dissolution (Impure Yellow Cake) and Uranyl Nitrate Purification Pilot Plants, in the Building 1 of CQMA. In the place where the facilities were set up IPEN has built new laboratories for the Environmental Program for use without restrictions (as green areas). These activities have been performed in 2006 and 2007;
- Between 2005 and 2006, occurred the dismantling of the Uranium Hexafluoride Conversion Pilot Plant. In the place where the UF_6 conversion facility was set up it has been built part of the laboratories for development of the Fuel Cell Program, whit releasing for use without restrictions;
- In 2007, is being accomplished the decommissioning of the UO_2 Pellets Fabrication Pilot Plant.

4. Conclusion

Some facilities demanded special attention, or will in the future when the dismantling will be considered, requiring preliminary operations of treatment of retained materials and/or wastes. It is the case of the existence of organic wastes (TBP and pyridine containing U and Pu) stored in tanks, inside the hot cells of the CELESTE-I Lab. Besides the raising of the status of the fuel cycle facilities and the improvement of the preliminary dismantling plan, we have accomplished some studies of innovative/adaptive technological solutions to solving the mentioned retained material or waste problems, with emphasis on the use of chemical technologies, such as molten salt oxidation, to decompose hazardous materials and wastes related to decommissioning. It is very clear that we have to improve all steps involving decommissioning such as planning, regulatory requirements, cost estimating, cost-benefit analysis, need for and extent of decontamination, selection of decontamination techniques, assessment of the waste amount from the dismantling, dismantling techniques, staff training and so on. The interchange of knowledge and personnel empowerment should not be limited only to the treatment processes, but to all connected areas mentioned. During the dismantling & decommissioning activities in the IPEN, we have had the support of the IAEA by means of the Research Project IAEA BRA-12800. The knowledge obtained thanks to the project was extremely useful in the decisions and activities regarding the continuation of the D & D activities and releasing of the areas.

5. References

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