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Decommissioning of Nuclear Fuel Cycle Facilities - IPEN's Experience

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ABSTRACT

Since its foundation in 1956, IPEN has played a decisive role in the development of the nuclear science and technology in Brazil. As an evidence of the multidisciplinary character of the scientific and technological work being carried out at IPEN/CNEN-SP could be mentioned activities such as radioisotope production, nuclear radiation applications, nuclear reactors, materials science, nuclear fuel cycle, radiological safety and dosimetry, laser applications, biotechnology, materials, chemical processes and environment. The Institute recent history has shown a major participation in the technological development of all steps of the nuclear fuel cycle. Fuel cycle activities 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. Nevertheless, radical changes of the Brazilian nuclear policy in the beginning of 90's determined the interruption of activities and facilities shutdown. The problem of dismantling and decommissioning of deactivated facilities has been target of concern at IPEN considering that there was no experience/expertise in this field at all. Two facilities were actually dismantled at IPEN recently. On one hand there is the problem of facilities maintenance/surveillance. On the other hand there are the usual lack of resources and different problems involving each facility such as documentation, planning, risk assessment, decommissioning cost estimating, selection of dismantling techniques, decontamination costs x waste disposal, decontamination techniques, extent of decontamination, availability of waste disposal space, safety and staff training among others. However, in spite of the mentioned problems, a team has already dismantled two pilot plants: ADU (impure) dissolution / uranyl nitrate purification and part of the thorium nitrate (mantle grade) production. In this work, besides a small introduction about IPEN and the nuclear fuel cycle activities performed, are described the different facilities, the main problems and a concise report about the dismantling of the above mentioned facilities.

1. INTRODUCTION

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 centers 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 MW; 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); nuclear fuel for research reactors fabrication facilities; 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.

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 at 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. Besides this, there was the usual lack of resources.

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 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 Institution different priorities such as radioisotope production or research reactor operation and fuel production. On the other hand, there is the problem of dismantling and/or decommissioning costs, mainly considering that there was no experience/expertise in this field at all at IPEN. It is necessary to recovery reliable data/drawings about the facilities and to determine their present status in terms of chemical and radiological contamination levels of equipment/soil/buildings, after more than then years since the facilities shutdown.

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.

2. NUCLEAR FUEL CYCLE PILOT PLANTS OF THE IPEN

Most Brazilian nuclear fuel cycle R&D activities were accomplished at IPEN, in laboratory and pilot plant scale. Most facilities were built in the 70-80 years. The IPEN´s pilot plants are distributed in groups and the groups are located in six different buildings:

Building one - CQMA:
Dissolution (Impure Yellow Cake);
Uranyl Nitrate Purification.

Building two - CQMA:
Calcination of ADU to UO_3 and ADU Precipitation;
Denitration by Fluidized Bed (NUH to UO_3);
UF_4 Production - Aqueous route;
UF_4 Production - Moving Bed route Units I and II;
Thorium Sulfate Dissolution and Thorium Nitrate Purification.

Building three - PROCON:
Fluorine Production

Building four - PROCON:
UF_6 Production

Building five - PROCON:
UF_6 Transfer.

Building six – CELESTE-I:
Reprocessing Laboratory.

3. DISMANTLING OF PILOT PLANTS ACCOMPLISHED AT IPEN

In spite of the difficulties mentioned before, two facilities were actually dismantled at IPEN recently, even without previous experience, training support or detailed planning. The dismantled facilities were the Thorium Sulfate Dissolution (part of the Thorium Nitrate Production Pilot Plant) and UF_4 Production Pilot Plant - Aqueous Route, in the Building 2 of CQMA; the ADU Dissolution (Impure Yellow Cake) and Uranyl Nitrate Purification Pilot Plant, in the Building 1 of CQMA.

The dismantling operations were performed in two 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 Plant, in the Building 1 of CQMA.

The dismantling of the two facilities at IPEN was accomplished without a meticulous planning was proceeded. This because there is not prepared personnel for the function. The facilities were dismantled in a non-orthodox way, in spite of a lot of radiological and environmental concerns, consequence of the poor expertise and lack of information and experience at IPEN in the subject.

The first facilities mentioned above were smaller than the second and there were some funds allocated to solve the problem. A structure assembling company was contracted to dismantling operations, assisted by IPEN´s engineers and technicians. The experience was not satisfactory because the company's personnel had no experience with radioactive materials and the most activities were concluded with the intervention of IPEN´s staff, what was not anticipated.

After that, a preliminary report was prepared with the basic procedure to be adopted for the fuel cycle facilities dismantling at IPEN [1]. As the others mentioned facilities were more complex than the first and there were not enough funds, it was decided to perform the dismantling operations only with IPEN personnel. In this case, the operations were accomplished being removed initially the smaller and simpler equipments in the first floor (equipments were distributed in 4 levels, in a metallic structure), in the second and so successively. Then were removed the equipments that interfered with the subsequent operations and finally the largest and more complex equipment. After the equipment and piping removal of all the levels, the structure was dismounted and decontaminated when possible. Finally, the contaminated structure was cut into pieces for placement in drums or steel boxes. The planning did not foresee this sequence minutely. The operations were interrupted periodically. The engineers came together with operators and they evaluated the risks and the following actions. It was adopted an empiric procedure (trial and error), in the most careful way possible, and the referred units were disassembled. There is an IPEN internal report about the operations performed and the results obtained [2]. In the figure 1, it can be observed the removal of a dissolution reactor.

Figure 1: The removal operations of the impure yellow cake dissolution reactor.

The dismantled units were partially decontaminated [3]. The equipment was storied in another building. Part of this equipment was contaminated and the decontamination was not possible. Before the beginning of the dismantling, so that the possibility of superficial decontamination could be evaluated of each one of them, the existent equipments were inventoried in the facility, such as: chemical reactors; storage tanks; vacuum filters; extraction, wash and reversion columns; liquid transference pumps; diaphragm pumps; ventilation; piping; filters; valves and connections, besides the metallic structures. The equipments and components were classified in three categories: disposable; reusable in processes with radioactive materials (use in restricted areas); reusable in free areas.

In the figure 2, it can be observed the structure cutting operation and the storage of contaminated parts in a steel box. In the figure 3, it can be observed the immersion tank and the ultrasonic equipment employed for the decontamination process. In the figure 4, it can be observed the monitoring of structural elements and piping contamination. In the illustration of figure 5 it is shown the transport of large components and the provisory storage of equipments removed from the facility in another building.

Figure 2: Structure cutting with oxyacetylene torch and storage in steel box.

Figure 3: Immersion tank and ultrasonic equipment used for decontamination.

Figure 4: Monitoring of structural elements and piping contamination.

Figure 5: The transport of large components and the equipment storage in another building.

In addition, it was decided that the building should be released for use without any restrictions, which is a non-radioactive facility. Then, after the equipment removal from the facility, a contaminated layer was withdrawn from the floor and the walls and put in drums as it can be observed in figure 6, besides an external view of the facility.


Figure 6: Contaminated layer removal and external view of the facility.

4. CONCLUSIONS

In our point of view, the main difficulty with relationship to the pursuit of the dismantling activities of the nuclear fuel cycle pilot plants at IPEN is related to the mobilization of the different areas necessary to any decommissioning program. This decision depends on a political will, besides budget availability. Particularly, the planning needs the involvement of different competences and skills. It would be very important to create an institutional "culture" addressed to the decommissioning problem. The definition of the decommissioning as an institutional priority and personnel's qualification in the different disciplines that constitute the subject is indispensable.

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