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DECOMMISSIONING OF AN URANIUM HEXAFLUORIDE PILOT PLANT

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ABSTRACT

The Institute of Nuclear and Energetic Researches has completed fifty years of operation, belongs to the National Commission for Nuclear Energy, it is situated inside the city of São Paulo. The IPEN-CNEN/SP is a Brazilian reference in the nuclear fuel cycle, researches in this field began in 1970, having dominancy in the cycle steps from Yellow Cake to Uranium Hexafluoride technology. The plant of Uranium Hexafluoride produced 35 metric tonnes of this gas by year, had been closed in 1992, due to domain and total transference of know-how for industrial scale, demand of new facilities for the improvement of recent researches projects. The Institute initiates decommissioning in 2002. Then, the Uranium Hexafluoride pilot plant, no doubt the most important unit of the fuel cycle installed at IPEN-CNEN/SP, beginning decommissioning and dismantlement (D&D) in 2005. Such D&D strategies, planning, assessment and execution are described, presented and evaluated in this paper.

1.INTRODUCTION

In the last fifty years, Brazil aimed to increase the participation of nuclear energy in the production of electricity. This goal involved the continued research and technology development, including the design, construction and operation of facilities related to nuclear fuel cycle. This also included the industrial and technological capacity to provide electricity from nuclear sources, meeting the principles of safety, economic viability and environmental compatibility.

The country invested in exploration, mining, processing, purification and industrialization of uranium (U) and thorium (Th) ores. The IPEN was Brazil´s pioneer in the research and technological development in this area, contributing to the different stages of purification and production of U and Th compounds, from the nuclear fuel cycle.

The construction and operation of several nuclear fuel cycle units are of relevant importance to the Institute. The uranium purification by ion exchange and solvent extraction, production of ammonium diuranate, uranium oxides, uranium tetrafluoride, production of elemental fluorine and uranium hexafluoride were carried out.

The plant at IPEN operated a uranium concentrate, called "yellow cake", from the processing of monazite sand, to obtain a high purity ammonium diuranate (DUA). Then, this compound was converted to uranium dioxide (UO_2), with characteristics appropriated for its conversion to uranium tetrafluoride (UF_4).

After the technology for the UF_4 production was established, research on technologies of UF_6 production was needed. The production of UF_6 is a chemical reaction between uranium tetrafluoride (UF_4) and Fluorine (F_2). As neither the importation or storage of fluorine, nor its transport from one facility to another are recommended, it was necessary to produce this gas at IPEN. Therefore, a plant for the production of elemental fluorine had to be installed. The UF_6 pilot plant began this operation at IPEN, in 1986.

The UF_6 unit closed its operations in 1992, after producing thirty-five tons of a high purity UF_6, material that was transferred to a Navy Technological Center, the Coordinator of

Special Projects (COPESP). The technology and scientific methodology, then established and controlled, were also transferred.

Brazil is recognized, internationally, as one of the few countries in the world with the complete domain of the nuclear fuel cycle [1,2]. In the 90's, Brazil did not show interest in the nuclear cycle at IPEN and, without investment in the segment, the plants became obsolete and uncompetitive, and gradually discontinued.

As a research institute, the IPEN accomplished its function in the fuel cycle, developing and transferring technology. With the necessity of space for the implementation of new units, the uranium hexafluoride (UF_6) production plant was chosen to be decommissioned, since it presented potential leaking risks, which could cause environmental aggression and serious accidents.

The present study comprises the development of an innovative methodology for decommissioning and dismantlement (D&D) of the Uranium Hexafluoride Production Pilot Plant. A search in the specialized literature pointed out several papers (3-9) covering research nuclear reactor decommissioning and dismantlement. There are no data, however, concerning decommissioning and dismantlement of nuclear material and dangerous chemical reagents present in the nuclear fuel cycle.

Several groups of chemist and engineer at IPEN-CNEN/SP consolidated the developed researches in the facilities of the Uranium Conversion Project (PROCON), during more than twenty-five years, having been responsible for the production of 35 metric tones of UF_6 by year, in the end of the decade 1980. All PROCON plants comprised sections from yellow cake to UF_6 obtaining, such as dissolution and purification operations, chemical reduction and fluoridation of uranium for UF_4 obtaining, generation of elementary fluorine for fluoridation of UF_4 in the UF_6 obtaining.

A flowchart of the nuclear fuel cycle steps at IPEN is showed in figure 1.

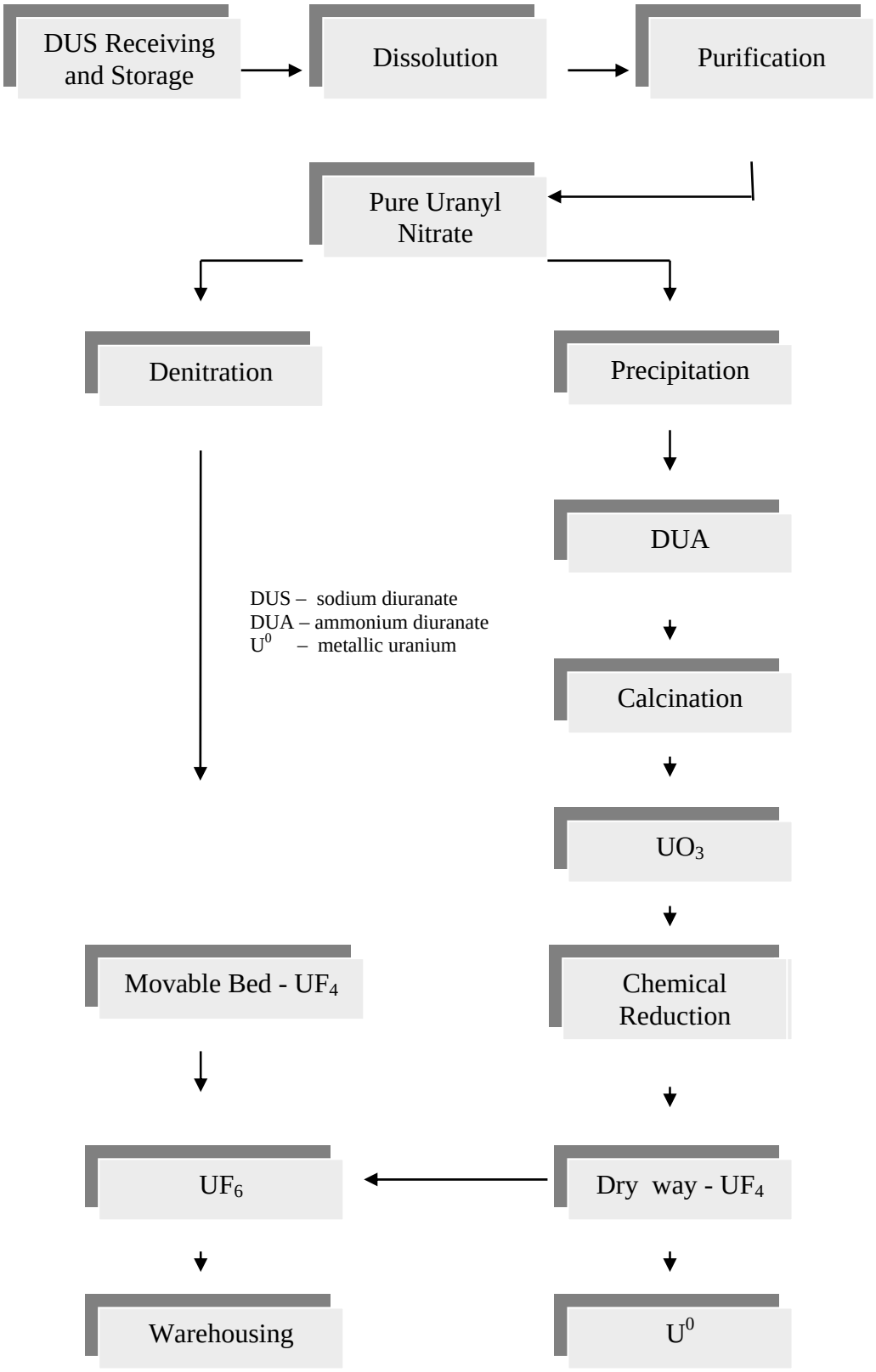

Fig 1. Flowchart of the Nuclear Fuel Cycle steps at IPEN [(1)].

The UF_6 Production Plant began operation at IPEN-CNEN/SP in 1986 and stopped operation in 1992. It was projected and assembled for a nominal capacity of production of 20 $kg \times h^{-1}$ of uranium, contained in natural uranium hexafluoride, expressed as 27 $kg \times h^{-1}$ of UF_4 or 30 $kg \times h^{-1}$ of UF_6. The PROCON facility is presented in the figure 2 and 3.

Fig 2. Pilot Plant Building

Fig 3. Primary Crystallizer Inside Plant

During the operational period, the PROCON staff developed and improved components jointly with the national industry, and soon afterwards established know-how was had been transferred to the company integrant of the project. The country won capable in the fuel cycle know-how, it more than two hundreds of technicians (engineers, physicist, technologists and other) that today apply their knowledge so much in the nuclear area . Brazil had her projected name, being recognized internationally as one of the few countries in the world with the complete domain of the nuclear fuel cycle (1, 7). The figure 3 shows a flowchart of the Uranium Conversion Project that was operational at IPEN-CNEN/SP.

In the literature are cited several papers (2, 6, 8, 9, 10, 11, 13) about nuclear field decommissioning and dismantlement. There are not available data concerning on decommissioning and dismantlement including nuclear material and dangerous chemical reagents, respectively uranium and fluorine compounds, as that manipulated in a Uranium Hexafluoride production facility. The present study comprises the development of an innovative methodology for decommissioning and dismantlement (D&D) of the Uranium Hexafluoride Production Pilot Plant, an integrating unit of the Uranium Conversion Project (PROCON), set up at IPEN-CNEN/SP (14).

2. STRATEGY

The decommissioning and dismantlement (D&D) of the UF_6 plant included the unit of Freon gas production and the unit of Fluorine generation. This plant of UF_6 remained out of operation for a range of 12 years (1993 to 2005). During this period all installations from plant had not received any maintenance. Several components and accessories from plant were denied and relocated, impeding its operating again. Consequently, was impossible to discharge the residual gaseous UF_6 contained inside of the connections and loading lines to crystallizers, the one that came hinder the dismantlement operation. For this reason and because a part of the equipments were exposed at the plant environment conditions, was carried-out a detailed study to check the real equipments status and verify any amount of Uranium Hexafluoride in the internal parts of the primary crystallizers. The possibility of finding Hydrogenfluoride (HF) inside components of the fluorine generation section was evaluated too.

With the long time out of operation, all operation and maintenance capable staff were moved from the UF_6 Plant to another tasks execution. Then, was necessary to contract an external company specialized in equipments dismantlement, however had been inexperienced in nuclear area. The alternative was to capacitate the employees of this company to an intensive course involving theoretical and practical classes and training in Radioprotection, handling of potentially dangerous products, (HF, UF_6) and also in the wearing of special personal protection equipments, such as total supplied air respirator and suits apparatus, as showed in the figure 9.

3. DECOMMISSIONING AND DISMANTLEMENT PLAN

3.1 Planning

The planning for the execution of these dismantlement tasks and decommissioning of the UF_6 Plant was submitted to a rigorous evaluating in the feeding pipes and discharge of UF_6, due to the possibility to find UF_6 (crystallized and gaseous) and UF_4 no reacted. After the preliminary study, several blank tests has been done using blind flanges with PTFE (polytetrafluoride ethylen) committee, beyong was carried out tests with the use of movable wash column (trumpet). In the case of gaseous UF_6 lines, was decided begin the dismounting

process in the secondary one crystallizer, due to the possibility of to find UF_6 to be remote, and also because in charge personal be more able to isolate the primary crystallizer.

3.2 Dismantlement

The dismantlement of the sections that compose the Pilot Plant of UF_6 (elemental fluorine and freon gases) were according to the planning above described, except small alterations concerning on hermetic flanges handling, with PTFE connections, mainly when inside of the pipes or equipments crystallized UF_6 was founded. The figure 4 to figure 9 presents the steps relatives to dismantlement, transportation, storage and safety clothes.

Fig 4 – UF6 Filter

Fig 5 - Secondary crystallizer

Fig 6 – Plant after D&D

Fig 7 – Primary Crystallizer after D&D

Fig 8 – gas washers

Fig 9 – D&D team

3.3 Decommissioning

The decommissioning of this plant included specific procedures of Radioprotection (3, 4, 5), Safeguards (12), Environmental Monitoring (6) and Individual Protection (3, 4, 5, 6, 14). The dismantlement of the sections of elemental Fluorine and Freon gases were carried out according to the planning above described, except small alterations concerning on the handling of the hermetic flanges, with PTFE connections, mainly in the case that inside the

pipes or equipments was founded crystallized UF_6. As the chemical reaction for formation of UO_2F_2 is very fast, it was necessary to develop new techniques for replacement of each part of the lines, case to case.

3.4 Transport and Storage of the Equipment

The choice and selection of an appropriate place for placement of the solitary equipments of the plants decommissioning it was very discerning, due to the dimensions of some equipments and the contained material, the proximity of the place of the plant also weighed a lot in the choice, there was the need of material remove of some deposits, to find the most appropriate place.

4. CONCLUSIONS

The UF_6 Pilot Plant was successfully decommissioned and dismantled, according to initial planning, without serious adjustments. The reasons that contributed to this success were mainly, planning, training, capability and technical attendance.

For the subcontracted company, the group training course was successfully, including theoretical and practical classes in Radioprotection, handling of Hydrogenfluoride, wear of special individual protection equipments (total supplied air respirator and suits apparatus with filters for gasses).

The decommissioning and dismantling of the UF_6 Pilot Plant was successfully obtained with short financial costs, due to previous planning, direct accompanying and supervising of capable in charged group and personal responsabilities (14).

The decommissioning and dismantling of the first UF_6 Pilot Plant in the Brazil and in the world was a very important experience. The problems encountered in the course of decommissioning process allowed IPEN-CNEN/SP to find solutions, enabling their technicians to face futures challenges not only in the others nuclear plants but also in NORM (natural occurring radioactive material) and conventional industries.

The works related to UF_6 Pilot Plant decommissioning and dismantling ended in 2005. All materials were decontaminated and stored.

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