

## **HOT CHEMISTRY LABORATORY DECOMMISSIONING ACTIVITIES AT IPEN-CNEN/SP, BRAZIL**

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### **ABSTRACT**

IPEN's fuel cycle activities were accomplished in laboratory and pilot plant scale and most facilities were built in the 70-80 years. Nevertheless, radical changes of the Brazilian nuclear policy in the beginning of 90's determined the interruption of several fuel cycle activities and facilities shutdown. Since then, IPEN has faced the problem of the pilot plants decommissioning considering that there was no experience/expertise in this field at all. In spite of this, some laboratory and pilot plant decommissioning activities have been performed in IPEN in the last years, even without previous experience and training support. One of the first decommissioning activities accomplished in IPEN involved the Hot Chemistry Laboratory. This facility was built in the beginning of the 80's with the proposal of supporting research and development in the nuclear chemistry area. It was decided to settle a new laboratory in the place where the Hot Chemistry Laboratory was installed, being necessary its total releasing from the radioactive contamination point of view. The previous work in the laboratory involved the manipulation of samples of irradiated nuclear fuel, besides plutonium-239 and uranium-233 standard solutions. There were 5 glove-boxes in the facility but only 3 were used with radioactive material. The glove-boxes contained several devices and materials, besides the radioactive compounds, such as: electric and electronic equipment, metallic and plastic pieces, chemical reagents, liquid and solid radioactive wastes, etc. The laboratory's decommissioning process was divided in 12 steps. This paper describes the procedures, problems faced and results related to the Hot Chemistry Laboratory decommissioning operations and its reintegration as a new laboratory of the Chemical and Environmental Technology Center (CQMA) – IPEN-CNEN/SP.

### **1. INTRODUCTION**

Since its foundation in 1956, IPEN has played a decisive role in the development of the nuclear science and technology in Brazil. Fuel cycle related activities were accomplished in laboratory and pilot plant scale and most facilities were built in the 70-80 years. Nevertheless, radical changes of the Brazilian nuclear policy in the beginning of 90's determined the interruption of several fuel cycle activities and facilities shutdown. Since then, IPEN has faced the problem of operation and maintenance of those pilot plants and laboratories. Due this, the decommissioning and new uses for some facilities have been considered.

Decommissioning could be understood as the actions or procedures taken at the end of a nuclear or radiologic facility's operational life to take it permanently out of service with suitable regard for the health, safety and protection of workers, public and the environment. The final objective of the decommissioning process can be to make the facility or area available for other purposes. In this case, can be necessary the facility dismantling and to accomplish a set of actions and operations to remove or reduce the radioactive (and,

sometimes, the chemical) contamination level and other risks found in the site. The decommissioning process and the management of radioactive materials and radioactive waste are closely linked issues that require an integrated approach. [1-4]

Nevertheless, when a facility decommissioning was firstly considered at IPEN there were some problems like no experience or expertise in this field at all. Some capabilities and conditions were identified as important for the success of the task such as planning, risk assessment, decommissioning cost estimating, selection of dismantling techniques, decontamination costs x waste disposal, decontamination techniques available, extent of decontamination necessary, documentation, availability of waste disposal space, safety and staff training among others. In spite of the mentioned problems, some laboratory and pilot plant decommissioning activities have been performed in IPEN in the last years [5-8], even without previous experience and training support.

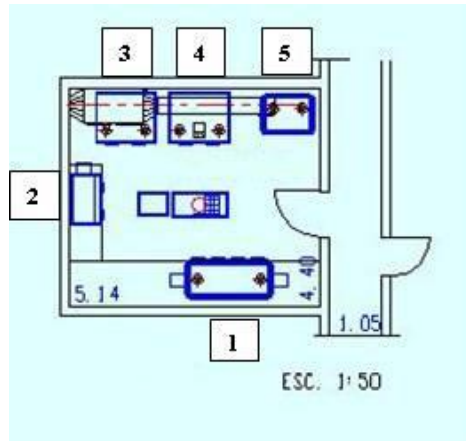
One of the first decommissioning activities accomplished in IPEN involved the Hot Chemistry Laboratory that was built in the beginning of the eighties with the objective of chemical characterization support to the research and development to the nuclear fuel cycle. By that time, the Radiologic Protection Division authorized the laboratory operation limited at levels of traces. During the laboratory activities period the operations were accomplished with samples of irradiated nuclear fuel, standard solutions of plutonium-239 and of uranium-233.

## **2. HOT CHEMISTRY LABORATORY DECOMMISSIONING**

The Hot Chemistry Laboratory decommissioning was accomplished with the involvement of specialists of the several areas of IPEN. The coordination, the planning and the execution of the decommissioning activities were in charge of researchers and technicians of the Reprocessing (4) and the Isotopic Characterization (3) Laboratories, of the Radiological Protection (4) and Radioactive Waste Management (2) Groups, besides personnel of the Transport and Support Sections (3). The figures between parentheses mean the total of people of each area involved in the decommissioning task. In the Fig. 1 can be observed the layout of the Hot Chemistry Laboratory, with the disposition of the 5 glove-boxes, but only 3 were used for radioactive and hazardous materials processing.

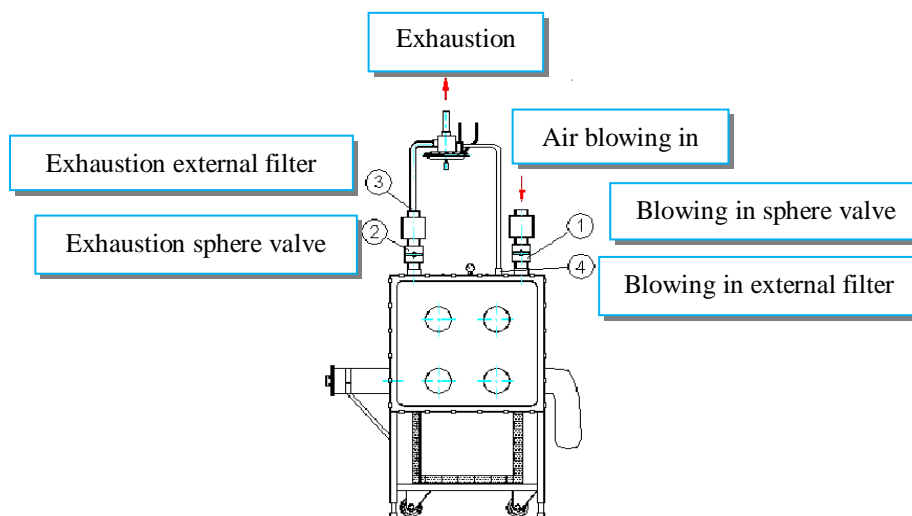
### **2.1. Preliminary operations**

The glove-boxes are closed systems, with controlled atmosphere, used in the work with alpha emitters and hazardous materials. The suitable ventilation system (Fig. 2) shall assure the operators' safe work even in the eventual interruption of the electric power supply. The use of sphere valves allows keeping the glove-boxes tightness during a determined period of time until the failure in the ventilation system can be corrected. Before the beginning of the decommissioning operations, to assure the safety of the personnel in charge of the change of gloves, waste removal and transport of the equipment operations, it was indispensable the previous adaptation of the glove-boxes to safety norms for high toxicity waste manipulation. The glove-boxes used for radioactive material were those ones identified as 1, 3 and 4 in the Fig. 1.



**Figure 1. Layout of the Hot Chemistry Laboratory with five glove-boxes.**

In the preliminary glove-boxes preparation activities, sphere valves were attached to the equipment for air blowing in and for air exhaustion. It was necessary the fabrication of two different PVC connection types (Fig. 3), the first one connects the sphere valve the glove-boxes, the second one connects the sphere valve to the filter.

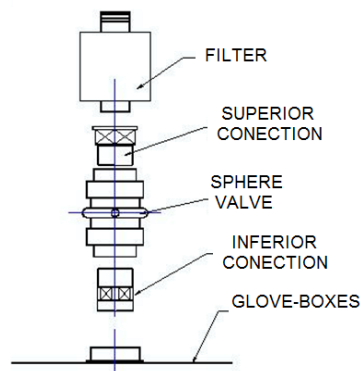


**Figure 2. Ventilation system adaptation necessary before the decommissioning operations.**

## 2.2. Hot Chemistry Laboratory decommissioning planning

The first action accomplished for the decommissioning planning was a meeting among all the personnel of the different groups involved in the operations. In this meeting several items were discussed and some actions were established:

- An oral summarized report was done by the person in charge of the Hot Chemistry Laboratory about the facility, describing the activities developed at the laboratory during the operation period and about the future activities that would be developed;
- It were defined the coordinators of each involved area in charge of the technical activities;
- It was defined the need of an inspection in the facility with the purpose of evaluating the laboratory safety conditions for the execution of the decommissioning with the smallest possible risk;
- It was defined the need of a detailed planning describing all the activities to be executed, with the elaboration of safety manuals and the photographic registration of all activities;
- It was defined the decommissioning objective of total release of the space (*as green area*) used by the Hot Chemistry Laboratory. This implicated in the removal of the empty glove-boxes and of all contaminated material that should be conditioned inside drums.



**Figure 3. Detail of the superior and inferior connections of the valve-filter assemblage.**

The detailed planning of the decommissioning operations was divided in 12 stages:

- 1) Definition of the teams involved in each phase and of the operation schedule;
- 2) Definition of the necessary individual protection equipment (IPE) and of the materials and support tools;
- 3) Elaboration of safety's manuals and of the execution procedures for all activities in each phase of the operation, with the respective risk assessment;
- 4) Removal of the all non-contaminated material from the laboratory;
- 5) Exchange of all gloves of the glove-boxes;
- 6) Adaptation of the ventilation systems of all glove-boxes;
- 7) Inventory and classification of all materials existent inside the glove-boxes;
- 8) Removal of all no contaminated material from the glove-boxes;
- 9) Removal of all wastes from the glove-boxes;
- 10) Decontamination of the glove-boxes for transport;
- 11) Removal of the glove-boxes from the laboratory and transport of them to the Radioactive Waste Management Laboratory;
- 12) Packaging and transport of the controlled material under supervision of the IPEN's safeguard team.

As previously described, the task group involved personal of different Departments and specialties, and each specific group chose a coordinator in charge of the technical activities of the respective area. The decommissioning group was constituted by 16 specialists among coordinators, supervisors and operators. The detailed decommissioning operations were accomplished in accordance with the proposed schedule, in agreement with the initially established period of 6 (six) months.

The individual protection equipment (IPE) and different materials used were stored in the a support room near the laboratory and they are constituted of *tyvec* type worker's overalls, cotton worker's overalls, worker's cloth gloves, worker's latex gloves, rubber gloves for the glove-boxes, facial mask, Dräger combined filter CA N 662, short pipe plastic shoes, long pipe plastic shoes, towels, plastic flask with cover for solid waste, adhesive ribbon, plastic bags (for the "bag-in-bag out" system), plastic soldering machine, cotton and paper towels, decontamination reagents (such as alcohol, nitric acid, EDTA), mask cleaning solution (Milton) and drums for solid waste packaging. Besides these, radiologic protection monitors and dosimeters were used. These materials were prepared before each operation. A cost-benefit evaluation indicated not to be necessary the internal decontamination of the glove-boxes, since they would be used in the manipulation of radioactive wastes.

### **2.3. Elaboration of Safety's Manuals and Execution Procedures for all activities involved in each phase of the operations, with risk assessments**

A document was written containing the basic procedures to assure maximum safety for the workers and minimum risk for the operations, based on [9]. The document entitled "Safety and Radiologic Protection Procedures for the Glove-Boxes Transference Operations from the Hot Chemistry Laboratory for the Radioactive Waste Management Laboratory" had the following sections:

1. *Procedure for Gloves Exchange of the Hot Chemistry Laboratory Glove-boxes;*
2. *Procedure for Adaptation of the Glove-boxes' Ventilation System of the Hot Chemistry Laboratory;*
3. *Cleaning of the Glove-boxes for Removal of the Plutonium Standards, Several Contaminated Materials and Radioactive Waste Solutions.*

### **2.4. Removal of non-contaminated material from the Laboratory**

Initially it was made the removal of the screening detector for the Reprocessing Laboratory storeroom. The lead bricks were numbered for easy reassembling. An external monitoring of the glove-boxes 2 and 5 was accomplished before their removal for another area.

### **2.5. Gloves Exchange in the Glove-boxes**

There are not norms defining the useful life of a glove. The operation developed inside the glove-boxes will determine the substitution period. However, after established the change time interval, it should be respected independently of the gloves' frequency use.

Due to facility long inactivity period, it was necessary the change of the gloves of all glove-boxes. The new gloves should be tested as for their tightness before the change operation. The change of gloves is accomplished in agreement with the procedure described in the Operational Handbook of the Facility CELESTE-I. All operation should be monitored by the Radiologic Protection. After the end of the gloves exchange operation, the old gloves should

be removed by the system "bag in-bag out" and deposited in the drum for compactable solid waste.

Below are listed some recommendations with regard to the use of gloves in glove-boxes:

1. To replace the gloves before they be damaged.
2. To indicate in the adhesive ribbon the dates of the gloves substitution.
3. To examine the integrity of the gloves periodically.
4. Before using a glove, to do tests to detect flaws or production defects.
5. During the use, the best test is the hands monitoring before and after introducing them in the gloves (for no visible defects).
6. The rings should be monitored/decontaminated during and after the change of gloves.
7. The use of adhesive ribbon and safety ring is a) to avoid that the glove leaves the groove easily; b) to reduce the deleterious light effects and heat on the gloves material.
8. It is indispensable the use of protecting mask during the exchange.
9. During the operation cotton gloves should be used as additional safety measure.

## 2.6. Adaptation of the glove-boxes ventilation system

The glove-boxes n° 1 (Fig. 4) already possesses a valve installed in the exhausting system. Only the air blowing in system requests the assembling of a sphere type valve.

Description of the operation in the Glove-box no. 1:

1. Removal of the blowing in external filter;
2. Adaptation of the sphere valve inferior and superior connections;
3. Adaptation of the filter to the superior connection;
4. Assembling of the valve-filter group (inferior connection, sphere valve, superior connection and filter) in the Glove-Box n° 1.



**Figure 4. Glove-box n° 1.**

The glove-boxes n° 3 and 4 (Fig. 5), analyzed from the operators' safety point of view, should have suitable ventilation systems, as a sphere type valve in the exhaustion system and in the blowing in air system, to keep the glove-boxes' tightness. To avoid that during the placement of the sphere type valves the glove-boxes operate without exhaustion, or better, to assure that the pressure inside the glove-boxes is always bellow the laboratory pressure, an auxiliary system shall be used. The auxiliary system (Fig. 6) comprehends the hose, the filter and the sphere valve connected to the glove-box n° 5 that was removed for the CELESTE-II Facility.



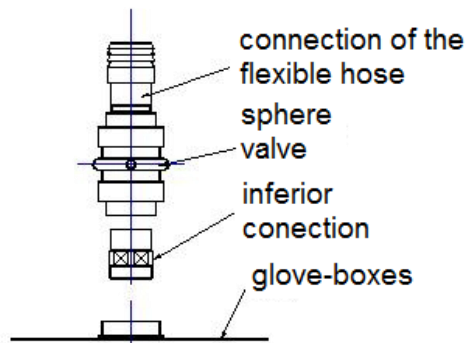
**Figure 5. Glove-boxes n° 3 (left) e 4 (right).**



**Figures 6. Auxiliary system with filter and sphere valve (left) and hose (right).**

### **2.6.1. Description of the operational procedure in the glove-box n° 3**

1. Assembly of an auxiliary group (Fig. 7) (inferior connection, sphere valve and connection for flexible tube);
2. Removal of the blowing in external filter;
3. Installation of an auxiliary group in the glove- box's blowing in; (*sphere valve should be totally open*)
4. To slacken the clamp that fastens the flexible hose to the exhausting filter;
5. Connection of the auxiliary group flexible hose and, simultaneously, to remove the flexible hose of the exhausting filter;
6. Removal of the exhausting filter;
7. Assembly of the valve-filter group;
8. Placement of the group valve-filter in the glove-box's exhausting;
9. Connection of the flexible hose of the system of the exhausting system to the group valve-filter and, simultaneously, to remove the hose of the auxiliary group; (*in this instant the exhausting operates with the original flow again*)
10. Removal of the flexible tube connection from the auxiliary group;
11. Placement of the superior connection in the blowing in sphere valve;
12. Placement of the blowing in external filter in the superior connection.



**Figure 7. Auxiliary Group**

### **2.6.2. Description of the operational procedure in the gloves-box n° 4**

1. Assembly of the auxiliary group (inferior connection, sphere valve and flexible tube connection);
2. Removal of the blowing in external filter;
3. Installation of the auxiliary group in the glove-box's blowing in; (*sphere valve should be totally open*)
4. To slacken the cramp that fastens the flexible hose to the exhausting filter;
5. Connection of the auxiliary group's flexible hose and, simultaneously, to remove the flexible hose from the exhausting filter;
6. Removal of the exhausting filter;
7. Assembly of the valve-filter group;
8. Placement of the group valve-filter in the glove-box's exhausting;
9. Connection of the flexible hose of the exhausting system to the valve-filter group and, simultaneously, to remove the auxiliary group's hose; (*in this instant the exhausting operates with the original flow again*)
10. Removal of the flexible tube connection from the auxiliary group;
11. Placement of the superior connection in the blowing in the sphere valve;
12. Placement of the blowing in external filter in the superior connection.

### **2.7. Inventory and classification of all material in the glove-boxes**

Some aspects were considered [10,11] before the beginning of the task aiming the minimization of the radioactive waste to be generated during the operations. It was prepared an inventory of all material contained in the 5 glove-boxes. It was defined that the removal of all materials from the glove-boxes would be done through plastic bags using the system "bag in-bag out" (Fig. 8). Therefore, it would be necessary to prepare several plastic bags for the safety removal of all solid and liquid wastes.

In the glove-boxes 1, 3 and 4, that contained the contaminated materials, at first it was made a previous selection to separate the solid and liquid materials. They were classified in accordance with their size or similarity, what facilitated the removal using the "bag in-bag out" system.



**Figure 8. Materials removal from the glove-boxes using the “bag in-bag out” system.**

## **2.8. Removal of all non-contaminated material from the glove-boxes**

The non-contaminated materials stored inside the glove-boxes 2 and 5 were removed also by the "bag in-bag out" system. However, they were not conditioned in the radioactive waste specific drums. After the evaluation performed by the Radiologic Protection personnel, through monitoring and smear test, the material was released.

## **2.9. Removal of all wastes from the glove-boxes**

This operation was done for cleaning and removal of all materials and equipments from the glove-boxes (by system "bag in-bag out"). These materials and equipment could interfere in the final glove-boxes transference operation. Among the materials, there were inactive solutions, flasks of samples; solid wastes and liquid wastes stored in plastic containers. The experience of the operators of Reprocessing Laboratory and Hot Chemistry Laboratory indicated that the solutions should be transferred for other flasks before the removal from the glove-boxes. This operation was performed carefully.

Solid material constituted about 95% of the waste stored in the glove-boxes. Besides those materials contained inside of the glove-boxes, there were about 300 lightning rods containing  $^{241}\text{Am}$  stored in the Hot Chemistry Lab. This material was packed in plastic bags inside a closed box. Additionally, inside the glove-boxes there were 3 flasks with Pu standard solutions and a flask with about 120mg of Pu in the powder form (Fig. 9). These materials were transferred later to the IPEN's Reprocessing Laboratory under the Supervision of the IPEN's Safeguards Group. During the laboratory decommissioning, three (3) drums were used (Fig. 10) for storage of all radioactive wastes generated during the operations.

## **2.10. Glove-boxes decontamination before the transport and exhausting system removal**

The first approach would be the total internal decontamination of all glove-boxes before the transference. However, in reason of the low activity present and the possibility of using some glove-boxes in the lightning rods dismantling process for removal of the  $^{241}\text{Am}$  (process performed in the Radioactive Waste Management Laboratory of IPEN), it was decided to suppress the decontamination step to avoid the unnecessary generation of large amount of radioactive wastes.

The release of the Hot Chemistry Laboratory also involved the dismantling of the centrifugal fans and ventilation system (Fig. 11 left). Before the operation, these items were monitored to verify the level of contamination of the absolute filters (Fig. 11 right).



**Figure 9. Pu standards packaged for transference to the IPEN's Reprocessing Laboratory.**



**Figure 10. Drums employed for storage of the radioactive wastes generated in the glove-boxes decommissioning operations.**



**Figure 11. Exhausting system dismantling (left) and monitoring of the exhausting system absolute filters (right).**

## **2.11. Transport of the glove-boxes to the Radioactive Waste Management Laboratory**

To remove the glove-boxes from the Hot Chemistry Laboratory it was necessary to withdraw the access door and to demolish the walls allowing the access of the stacker. The operation was accomplished in a Saturday to reduce risks and interferences, possible in such kind of operation, since the laboratory was located in a building dedicated to several activities, mainly linked with the Laser's development.

Some alternatives were considered to isolate the glove-boxes during the transport. Finally, it was decided just to involve the glove-boxes in plastic foils (Fig. 12) as a way to assure that, in the case of fall during the transportation, there would not be spread out of the contamination. Another discussed point was the transport type that would be used, a truck or a stacker. It was concluded that the transport could be done carefully in a safe way through the use of the stacker.



**Figure 12. Glove-box and its plastic protection transported using a stacker.**

## **3. CONCLUSION**

The Hot Chemistry Laboratory decommissioning was accomplished without any type of incident and it constituted an experience that allowed the accumulation of experience in the field dismantling and decommissioning of nuclear fuel cycle facilities and laboratories. In the process, operational planning and procedures handbooks were prepared, taking into account mainly the safety of operators and environment. The accumulated experience will be very useful in similar operations in the future decommissioning of other nuclear fuel cycle facilities and of IPEN.

## **ACKNOWLEDGMENTS**

We would like to express gratitude to the researchers and technicians of the Reprocessing Laboratory and the Radiologic Protection that gave support to the execution of the decommissioning task and to International Atomic Energy Agency - IAEA for the support to the Research Project BRA 12800.

## REFERENCES

1. *Decommissioning of Medical, Industrial and Research Facilities*, **Safety Guide No. WS-G-2.2**, IAEA SAFETY STANDARDS SERIES, International Atomic Energy Agency, Vienna, 1999.
2. *Decommissioning of Nuclear Fuel Cycle Facilities*, **Safety Guide No. WS-G-2.4**, IAEA SAFETY STANDARDS SERIES, International Atomic Energy Agency, Vienna, 2001.
3. *Guidance for Inspectors on Decommissioning on Nuclear Licensed Sites*, **Internal guidance of HM Nuclear Installations Inspectorate (NII)**, Nuclear Safety Directorate (NSD), NUCLEAR SAFETY DIRECTORATE which is part of the Health and Safety Executive's (HSE), London, U.K., March, 2001.
4. *The Decommissioning and Dismantling of Nuclear Facilities: Status, Approaches, Challenges*, **Radioactive Waste Management**, NEA – Nuclear Energy Agency, OECD – Organization for Economic Co-operation and Development, Paris, 2002.
5. P.E.O. Lainetti, *Decommissioning of Nuclear Fuel Cycle Facilities - IPEN's Experience*, **Proceedings of the 7th ENAN Meeting on Nuclear Applications**, Santos, SP, Brazil, 2005.
6. P.E.O. Lainetti, *Decommissioning of Nuclear Fuel Cycle Facilities in the IPEN-CNEN/SP*, **Proceedings of the ENC 2007 – European Nuclear Conference**, Brussels, 16 to 20 September, 2007.
7. P.E.O. Lainetti, M.B. Figols, M.A.F. Pires, *Reintegration of Areas of Dismantled Nuclear Fuel Cycle Pilot Plants as New Laboratories of CQMA-IPEN*, **Proceedings of the 8th Enan Meeting on Nuclear Applications**, Santos, SP, Brasil, 2007.
8. P.E.O. Lainetti, A.A. Freitas, A.C. Mindrisz, R.L. Camilo, *Decommissioning of Nuclear Fuel Cycle Facilities in the IPEN-CNEN/SP*, **IAEA-TECDOC-1602 Innovative and Adaptive Technologies in Decommissioning of Nuclear Facilities**. Final report of a Coordinated Research Project 2004-2008, International Atomic Energy Agency, Vienna, October 2008.
9. **Standard CNEN.NE 3.01 Diretrizes Básicas de Radioproteção** (Radiation Protection Directives) – *Resol. CNEN 12/88*.
10. *Methods for Minimization of Radioactive Waste from Decontamination and Decommissioning of Nuclear Facilities*, **Technical Reports Series No. 401**, International Atomic Energy Agency, Vienna, 2001.
11. *Management of Problematic Waste and Material Generated During the Decommissioning of Nuclear Facilities*, **Technical Reports Series N° 441**, International Atomic Energy Agency, Vienna, 2006.