

BRACHYTHERAPY WITH 125-IODINE SOURCES: TRANSPORT AND RADIATION PROTECTION

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ABSTRACT

The estimates for the year 2009 show that 466,730 new cancer cases will occur in Brazil. Prostate cancer is the second most incident type. Brachytherapy, a type of radiotherapy, with Iodine-125 sources are an important form of treatment for this kind of cancer. The “Instituto de Pesquisas Energéticas e Nucleares” (IPEN) created a project to develop a national prototype of these sources and is implementing a facility for local production. The seeds manufacture in Brazil will allow to diminish the treatment cost and make it possible for a larger number of patients. While the laboratory is not ready, the IPEN import and it distributes seeds. This work aim is to present and evaluate the transport procedures and the radiological protection applied to imported sources in order to assist the procedures for the new laboratory implementation. Before sending to hospitals, the seeds are packed by a radioprotector supervisor, in accordance with CNEN NE 5.01 standard “Transporte de Materiais Radioativos” (Radioactive Material Transport). Despite Iodine-125 presents low energy photons, around 29 keV, local and personal dosimeters are used during the transport process, as described in CNEN NN 3.01 standard “Diretrizes Básicas de Proteção Radiológica” (Radiological Protection Basic Guideline). All the results show no contamination and very low exposure, proving the method to be valid. The transport procedure used is correct, according to the regulations. As an result of this work, a new dosimeter should be installed and evaluate in future study.

1. INTRODUCTION

In 2005, the malignant tumors caused 7,6 millions (13%) deaths in the world population. The National Institute of Cancer – INCA estimates 466,730 new cases for 2009 in Brazil [1]. About 49,000 cases will be prostate cancer. This disease, with early diagnosis, may be treated with 125-Iodine brachytherapy. The treatment uses about 100 seeds. Those seeds are imported at US\$ 26.00 each, what is not affordable to all people [1,2,3].

A multidisciplinary team was created in IPEN to develop a national 125-Iodine source and to implement the facility for local production. This will make possible to lower the treatment cost and make it viable for more patients. The development of a radioactive source laboratory implies: to establish radioprotection parameters and to structure radioactive seeds transport procedures. While the laboratory is being assembled, IPEN has distributed imported 125-Iodine seeds to be used in Brazilian hospitals [2].

Brachytherapy is the radiotherapy modality in which the source is placed in contact or within a patient. The dose is delivered continuously, during a short period of time (temporary implants) or during the decay of the source (permanent implants). The brachytherapy 125-Iodine sources are classified as interstitial, LDR - low dose rate, sealed and permanent [4].

2. OBJECTIVES

The objectives of this work are:

- To analyze existing data in order to implement local control dosimeters in the new Iodine-125 sources laboratory;
- To observe the procedures of transport;
- To evaluate the doses received by workers in the group that operates in the production and packaging of the sources.

3. METHODOLOGY AND EXPERIMENTAL PROCEDURE

The methodology used in this work is the evaluation of laboratory radioprotection system, in accordance with rules, set by “Comissão Nacional de Energia Nuclear” (CNEN), CNEN 3.01 [5] and CNEN 5.01 [6]. It will be presented:

- Characteristics of the seeds distributed by IPEN;
- Location of the main monitoring point;
- Characteristics of the groups of workers and the results of personal dosimetry;
- Procedures and documents used in the transport.

3.1 Characteristics of Iodine-125 seeds

The process of radionuclides production in nuclear reactors is based on the capture of thermal neutrons (i.e, neutrons with low kinetic energy, of the order of 0.025 eV) for atoms of a given element [7]. The Iodine - 125 is produced in a nuclear reactor from Xenon-124. It decays by electron capture and internal conversion to Tellurium-125. Photons of 27keV, 31keV and 35keV (mean 29keV) are issued. Given the low average energy of emission, their photons have low power of penetration [4,7].

The Iodine-125 is placed in a small titanium capsule of 0.8 mm external diameter, 0.05 mm of wall thickness and 4.5 mm in length. In Brazil, approximately 33,413 Amersham / GE seeds were purchased in 2008 and distributed by IPEN to 19 clinics [2].

3.2 Description of Installation and Activities

A laboratory for production of Iodine-125 sources is being implemented (room 48 Fig.1). The process is divided into three main parts: adsorption of Iodine on silver cap (production cell 1), seed sealing (production cell 2) and quality control (production cell 3). The production cells have control of pressure and ventilation. To date, some trials have been made. The plan of radioprotection and production automation is being developed. In the next room, the imported sources are separately sorted for transport.

3.3 Dosimeters

- Area control – A-15

A TLD dosimeter is used for local control. They are placed in areas of highest risk in the installation. It is positioned on the wall, where the radioactive material leaves for transport (* outside room 49, in Fig.1). This room, which is isolated by two doors, is considered a

supervised area because it's local output of radioactive product. Products move from the package room (room 49, in Fig.1) to the transport room (room 126, in Fig.1). The dosimeters are evaluated quarterly. Different sources, usually, pass by this dosimeter, such as: Iodine-125 (55% ***), Iridium-192 (30% ***), Bromine-82, Barium-133, Cesium-137, Cobalt-60, Cobalt-57 and Iodine-131 (15 % ***).

*** estimates

- Occupational Control

All individuals have a personal dosimeter to enter controlled or supervised areas. The classification of the assessment locals are showed in Fig.1.

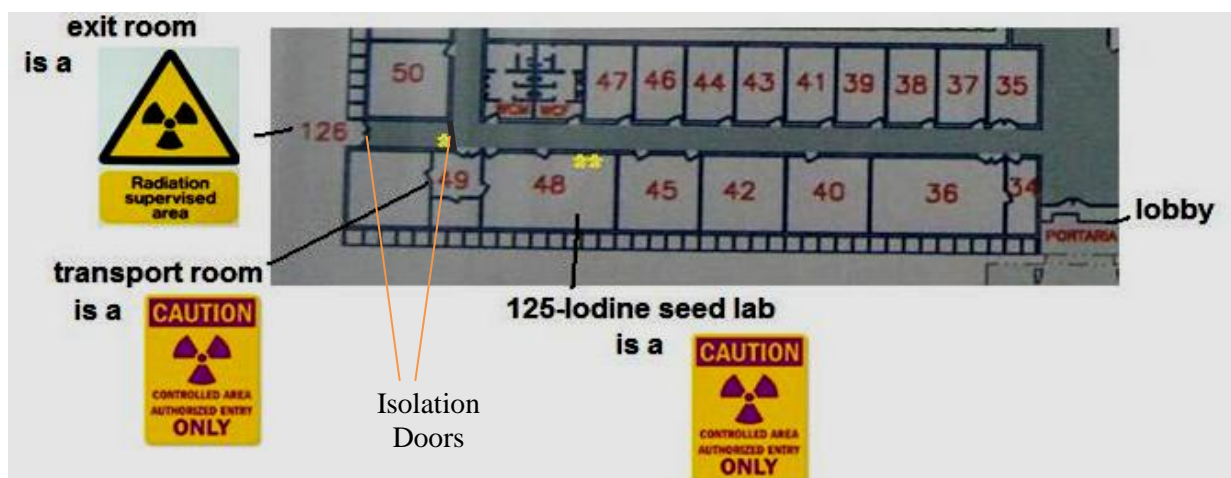


Figure 1. Classification of areas, location of rooms and dosimeter.

Source: Building Layout by Botelho /CTR-IPEN

3.4 Procedures for Transportation

While the production does not start, the imported Iodine-125 sources arrive, usually on weekends, Monday or Tuesday. The technician inspects the packaging and separates accordingly. A radioprotection supervisor also inspects the package. He assesses whether the safety and security were followed by checking the non-leakage source certificate, monitoring the packaging with a Geiger-Muller counter and looking if the labeling are correct. After such certification, the documents are printed and signed. An e-mail is sent to the transport company and the buyers inform that the product is ready for release. IPEN provides all the necessary documents to the carrier and a signed withdrawal note.

3.5 Occupational Exposure

All technicians, trainees, researchers and members of radioprotection have a personal dosimeter to control the received dose. They are evaluated monthly.

4. RESULTS

4.1 Area Dosimeters

4.1.1 Area Dosimeter – Localization at point A-15

The 3 years results of A-15 dosimeter readings are presented in the graph below (Fig.2). The natural exposition was discounted in each data by subtracting the natural exposure value, obtained by a dosimeter for environmental control.

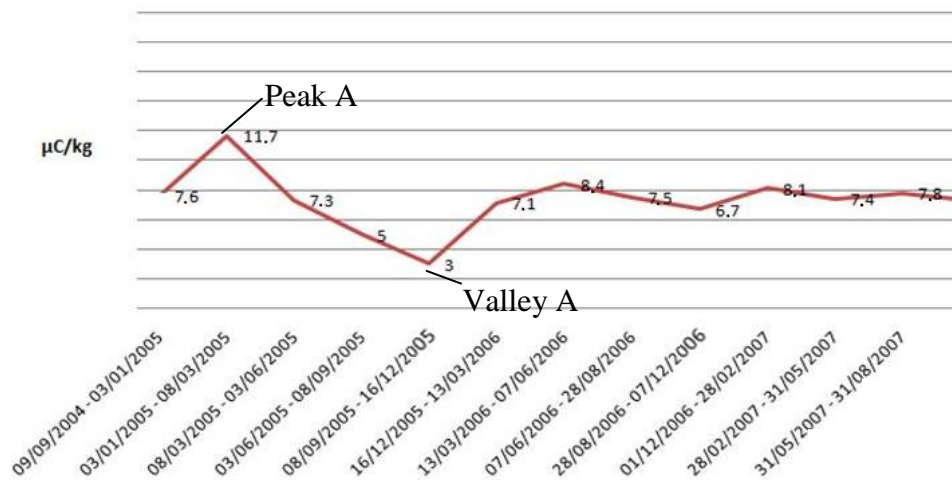


Figure 2. Graph for 3 years of exposures of the area dosimeter.

Researching IPEN documents, it was discovered:

1. Peak A occurred due to:

- Iridium-192 thread was stored near the dosimeter wall;
- The room was used for other researchers to measure activity of Bromine-82 and Cobalt-60;
- Beginning of tests with Iodine-125 seeds.

2. The Valley A was made by:

- The removal of a NaI detector of the laboratory used by other researchers to measure radioisotopes, such as Bromine-82 and Cobalt-60;
- New studies with Iodine-125.

To quantify this exposure, assuming that a worker has received all the exposure that the dosimeter has received, the following calculation was made (Table 1), in accordance with *Sanches* [8]:

$$D_{AR} (\text{Sv}) = 33.7 \cdot X (\text{C/kg}) \cdot 1.27 (\text{converting factor Gy} \rightarrow \text{Sv}) \quad (1)$$

Table 1. Results of the measures in $\mu\text{C} / \text{kg}$ converted to mSv.

	X($\mu\text{C}/\text{Kg}$)	D_{AR}(mSv)
2005	34.6	1.48
2006	29.7	1.27
2007	30.6	1.30

Table 2. Percentage of exposure per year compared with the annual ceiling of permissible 20mSv.

Year	Percentage of 20mSv
2005	7.40
2006	6.35
2007	6.50

Since the dosimeter is in a supervised area (as shown in Figure 1), the values presented in Table 2 are small were compared with the annual ceiling indicated by the standard [5]. A worker who receives the same exposure that the dosimeter does not exceed the limits allowed.

4.2 Occupational Exposure

Table 3 shows the results of the monitoring of individuals involved in handling and distribution of sources over 3 years.

Table 3. Results of 3 years of personal dosimeters of individuals involved with the handling and transport of sources of Iodine-125.

Year / mSv	I 01	I 02	I 03	I 04	I 05	I 06	I 07	I 08
2005	0	0.4	---	0.51	0	---	---	---
2006	0	0	2.67	0	0	4.84	---	---
2007	0	0	0	0	0	0.41	---	0

I- Individual
---: Individual didn't work in IPEN

Based on the personal dosimetry reports, the acceptable levels of dose are presented in Table 4:

Table 4: IPEN's Reference Levels*.

Restriction of dose levels: 10 mSv/year
Levels of dose Registration: 0.20 mSv/month
Investigation Levels:
Effective dose: 6 mSv / year
Dose Equivalent: Skin / Hands and Feet: 150 mSv / year
Dose Equivalent: Crystalline: 50 mSv / year

* This values are set by IPEN'S radiation protection team [9].

As it can be observed, no individual has reached the level of the research presented in Table 4. Many individuals were below the method levels of log-dose. In 2006, individuals I 03 and I 06 were directly involved with the new studies with Iodine-125.

4.3 Transportation Documents and Measures

The transport documents are prepared in four (4) copies:

- Declaration Consignor's of Radioactive Material;
- Emergency Response;
- Radioactive material Withdrawal Declaration (not an imposition by law);
- Packaging quality certificate;
- Extra transport documents (depending of the type of transport).

These copies are sent to: 1st copy to the consignor; 2nd copy sent to CNEN by the consignor, 3rd copy must be in possession of the carrier; 4th copy goes to the destination.

The package dose-rate measure is made by an Automess Geiger-Müller detector, with a measuring range of 1 $\mu\text{Sv} / \text{h}$ - 1000mSv / h.

Surface contamination was undetected. According to the technician, it has never been detected any count above the background radiation. If this occurs, the product has to be separated and a detailed investigation has to be made.

5. DISCUSSION AND CONCLUSION

This work presented the results of occupational and area dosimetry and transport procedures used in handling the imported brachytherapy source of Iodine-125. This analysis will help researchers to develop the system to be employed in the new laboratory to produce these sources in Brazil.

Ratings of 3 years showed that the area dosimeter receive very low exposures. This is due to radioprotection team conducting periodicals research, keeping data under constant surveillance and an well trained staff.

The evaluation of occupational exposures shows that low or no exposure was received by the workers during the 3 years surveyed. This shows that individuals are aware of the effects and necessary cares that they must have, when handling radioactive elements. Since the NaI detector was removed, new data will be evaluated considering only the influence of Iodine-125. However, the data used in this work give an idea of the possible outcome. Probably, the values will be within the acceptable, as shown in Fig.2.

The transport is done in accordance with the law for imported sources. Several extra care steps are taken, as Radioactive material Withdrawal Declaration and the extra copies of the documents. When production begins, few changes should be made. Since production costs in Brazil will be made the treatment more accessible, the tendency is to increase the flow of materials for transport. The radiation protection team will maintain the A-15 dosimeter under careful supervision. Future evaluations will be made and published.

Given new reality into focus, a monitoring dosimeter (at location ** 48, showed in Fig.1), with an visual and sonorus alarm, should be installed in the room. He will help detect contaminations during the seeds production. This work will continue during the laboratory construction.

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