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Analysis of the necessary radioprotection procedures in manufacture and transport of iodine-125 sources used in brachytherapy

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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 tipe 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 (Energy and Nuclear Research Institute) 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. This study aim is to evaluate the transport procedures and the radiological protection requirements used with imported Iodine-125 sources as a guide for establish new parameters for local production. Before sending to hospitals, the seeds are packed and classified by a radiation protector superviser, 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 Guidances). All the resoults show no contamination and very low exposure, proving the method valid. The transport proceedure used is correct according to the regulations. For local production, new detectors should be implemented.
Keywords: radiation protection, brachytherapy, Iodine-125, seeds manufacture.

Análise dos procedimentos de radioproteção necessários na manufatura e no transporte de fontes de iodo-125 usadas em braquiterapia

***Resumo**. As estimativas para o ano de 2009 mostram que 466.730 novos casos câncer irão ocorrer no Brasil. Para homens, o câncer de próstata é o segundo tipo mais incidente. A braquiterapia com fontes de Iodo-125 é uma importante forma de tratamento para este tipo de câncer. O Instituto de Pesquisa Energéticas e Nucleares IPEN-CNEN/SP criou um projeto para desenvolver um protótipo nacional dessas fontes e implementar um laboratório para a produção local. A fabricação das sementes no Brasil diminuirá os custos, o que permitirá maior acesso ao tratamento. Este trabalho visa avaliar os procedimentos de transporte e os requisitos de proteção radiológica empregados com fontes de iodo-125 importadas a fim de adequá-los para uso no novo laboratório. Antes de serem enviadas aos hospitais, as sementes são embaladas e classificadas por um supervisor de radioproteção, em conformidade com a norma CNEN NE 5.01 "Transporte de Materiais Radioativos". Apesar do Iodo-125 apresentar baixa energia fótons, cerca de 29 keV, dosímetros locais e pessoais são utilizados durante o processo de transporte, conforme descrito na norma CNEN NN 3.01 "Diretrizes Básicas de Proteção Radiológica". Os resultados não apresentaram contaminação ou exposição ocupacional relevante, validando o método existente. O procedimento transporte utilizado está correto, de acordo com os regulamentos. Com o início da produção local, novos detectores devem ser implementados.*
Palavras-chave: proteção radiológica, braquiterapia, Iodo-125, manufatura de semente.

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1. Introduction

In 2005, the malignant tumors caused 7,6 millions (13%) deaths in the world population. The Instituto Nacional do Câncer (National Institute of Cancer) – INCA estimates 466,730 new cases for 2009 in Brazil. About 49,000 cases will be prostate cancer[1]. This desease, 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 [2,3].

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

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 de decay of the souce (permanent implants). The brachytherapy 125-iodine souces are classified as intersticial, LDR - low dose rate, selead and permanent [2,4].

2. Methodology and Experimental Procedure

The methodology used in this work is the evaluation of Laboratory radioprotection system, in accordance with rules 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.

2.1 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 [06.]. 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 [2,7].

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].

2.2 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 01), seed sealing (production cell 02) and quality control (production cell 03) [2]. 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.

2.3 Dosimeters

- **Area control – A-15**

A TLD dosimeter is used for local control. They are placed in areas of highest risk in the installation. He is positioned on the wall, where the radioactive material leaves for transport (* ouside room 49, in Fig.1). They 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.

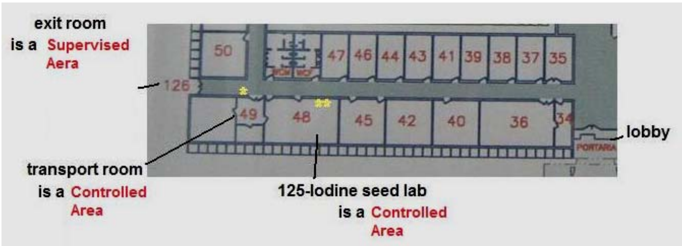

Figure 1: Classification of areas and location of rooms and dosimeter.
Souce: Building Layout by Botelho /CTR-IPEN

2.4 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 radiation protection supervisor inspects the package with a Geiger-Muller counter, specifies source parameters (such as transport index and UN number), confer documents and releases the package to transport. An email 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.

2.5 Occupational Exposure

All technicians, trainees, researchers and members of radiation protection staff use a personal dosimeter, which is evaluated monthly, to monitor the received dose.

3. Results

3.1 Area Dosimeters

The 6 years results of A-15 dosimeter readings are presented in graph (Fig.2).

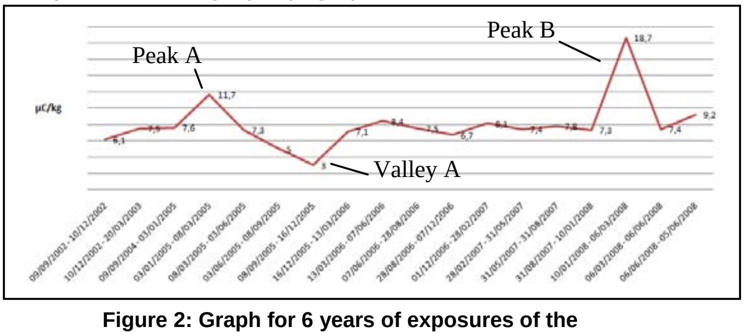

Figure 2: Graph for 6 years of exposures of the dosimeter-15.

Researching IPEN documents, it was discovered:
1. Peak A occurred due to some causes:
- Beginning of Iodine-125 sources prototype test;
- Iridium-192 thread was stored for research near the dosimeter wall;
- The room was used for other researchers to measure activity of Bromine-82 and Cobalt-60;
- Intense studies with Iodine-131;

2. Peak B happened because it was the highest Iridium-192 thread production.

3. 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.

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

$$D_{AR}\ (Sv) = 33.7.\ X(C/kg).\ 1.27^{*} \qquad (01)$$

***** (converting factor Gy → Sv)

Table 3: Results of the measures in μC / kg converted to Sv.

	X(μC/Kg)	D_{AR}(Sv)
2005	34.6	1.48
2006	29.7	1.27
2007	30.6	1.30

For a workload of 2000 hours/year, the highest amount of exposure is 7.40% of the maximum permitted dose (Tab. 4).

Table 4: Percentage of exposure per year compared with the annual ceiling of permissible 20mSv.

	% de 20mSv
2005	7.40
2006	6.35
2007	6.50

Since the dosimeter is located in a controlled area, the data were compared with the maximum annual limit (20mSv). The values are small, about 1,40 mSv.

3.2 Occupational Exposure

Table 5 shows the results of the monitoring of individuals involved in handling and distribution of sources over 4 years.

Table 5: Results of 4 years of personal dosimeters of individuals involved with the handling and transport of sources of Iodine-125.

Year	I 1	I 2	I 3	I 4	I 5	I 6	I 7
2005	0	0.4	---	0.51	0	---	---
2006	0	0	2.67	0	0	4.84	---
2007	0	0	0	0	0	0.41	---
2008	0	0	0	0	0	0	0

I- Individual

---: Individual didn't work in CTR

Based on the personal dosimetry reports, the acceptable levels of dose are presented in Table 6:

Table 6: Reference Levels used by IPEN*.

Restriction of dose levels**: 10 mSv/year**
Levels of dose Registration**: 0.20 mSv/month**
Investigation Levels:
Effective dose: 6 mSv / year or 1 mSv in any month
Dose Equivalent: Skin / Hands and Feet: 150 mSv / year or 20 mSv in any month.
Dose Equivalent: Crystalline: 50 mSv / year or 6 mSv in any month

* Based on the guidelines

As it can be observed, no individual has reached the level of the research presented in table 6. Many individuals were below the method levels of log-dose.

3.3 Documents and Mesures for Transportation

The transport documents are prepared in four (4) copies, distributed as the regulation orders. These documents are:
- Declaration Consignor's of Radioactive Material;
- Emergency Response;
- Radioactive material Withdrawal Declaration (not an imposition by law);
- Packaging quality certificate;
- Transport documents (depending of the type of transport).

The packaging activity measure is made by an Automess Geiger-Müller detector, with a measuring range is 1 μSv / 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.

4. Discussion and Conclusion

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

The existing area dosimeters are in contact with various radioactive isotopes. Ratings of 6 years showed very low exposures (about 1,40mSv). The maximum value per year allowable by the NN 3.01 CNEN standard is 20mSv.

The evaluation of occupational exposures shows that low or no exposure was received by the workers during the 4 years surveyed. This shows that individuals are aware of the effects and necessary cares that they must have, when handling radioactive elements. Most of them manipulate other isotopes. A new proportional dosimeter will be installed at the manufacture laboratory. The work will continue during the laboratory construction.

The transport of documents is done in accordance with the law for imported sources. Several extra care steps are taken, as Radioactive material Withdrawal Declaration. Virtually, no contamination of the packaging should occur. When production begins, few changes should be made. Since production costs in Brazil will made the treatment more accessible, the tendency is to increase the flow of materials for transport. Given this new reality into focus, a monitoring dosimeter and TLD area control (at location ** 48, showed in Fig.1) should be installed in the room. More results will be evaluated in future work.

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