Tubing decontamination during the leak test of iodine-125 seeds

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Abstract. Leak tests were made to detect any leakage of radioactive material from inside the iodine-125 seeds applied in brachytherapy. These seeds are used in prostate cancer treatment. In the quality control routine, during seed production, leak tests are performed according to the International Standard Organization – radiation protection – sealed radioactive sources – ISO-9978 standard, and require liquid transfer between recipients. Any leakage causes contamination of the liquid and tubes. The aim of this study is the establishment of decontamination routines for tubes, allowing their repeated use, in the automated assay process.

Key words: brachytherapy • iodine seeds • leak test • sealed radioactive sources

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Introduction

Iodine-125 seeds are used in Brazil in private clinics and hospitals to treat the prostate cancer. Each prostate implantation needs at least 80 seeds [6]. The current demand in the country is estimated to be 8000 seeds per month [5]. This was the reason to make the decision about iodine-125 seeds production in Nuclear and Energy Research Institute (IPEN) a division of Nuclear Energy National Commission (CNEN/SP). Iodine-125 has a half-life of 59.4 d and emits gamma radiation with an average energy of 29 KeV [4]. These seeds are made of an iodine-125 coated silver rod (0.5 mm diameter × 3 mm length) placed inside a titanium welded capsule (0.8 mm diameter × 4.5 mm length). The titanium choice was made because of its biocompatibility. The shape and dimensions of this seed are coincident with the most common iodine seeds in the Brazilian market, making its acceptance easy. Figure 1 shows a schematic drawing of the iodine-125 seed to be produced by IPEN.

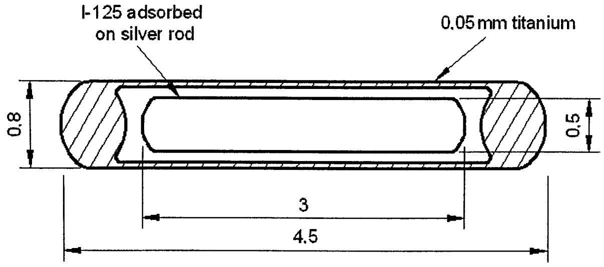

Fig. 1. Iodine-125 seed.

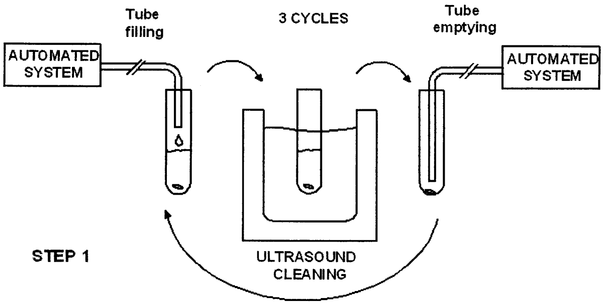

Fig. 2. Cleaning for external contamination (step 1).

The production of iodine seeds requires a quality control system. For this purpose, the general standards for quality control system (Associação Brasileira de Normas Técnicas – NBR ISO-9000) [1] were used. The final step of the seed production is the welding of the titanium capsule, using a laser welding system. This operation allows to encapsulate the radioisotope and its substrate, isolating it from the external environment. Thanks to this, iodine seeds are classified as sealed radioactive sources, according to the International Standard Organization – radiation protection – sealed radioactive sources – general requirements and classification, ISO-2919 [3].

The titanium capsule allows γ-ray energy to pass, preventing any radioactive material leakage. This condition is checked through leakage tests made according to the International Standard Organization – radiation protection – leakage test methods, ISO-9978 standard [2]. This standard establishes conditions and procedures to make leakage tests in the sealed radioactive sources, showing different methods to perform them. The annex "A" of that standard is a guide for the choice of the test method, according to the characteristics of the sealed source. Iodine-125 seeds require the immersion method for leakage tests. In accordance with this method, after welded, seeds must be thoroughly cleaned from external contamination (step 1 showed in Fig. 2).

It is very important to ensure that any trace of radioactive material present in the outer seed surface is removed. The cleaning procedure consists in immersing the seeds in distilled water, inside a plastic tube, and placing the plastic tube in an ultrasound cleaner for 10 min. This cycle is repeated twice, changing the water inside the tube. Afterwards, the seeds are immersed in distilled water at 50°C for 4 h (step 2 showed in Fig. 3).

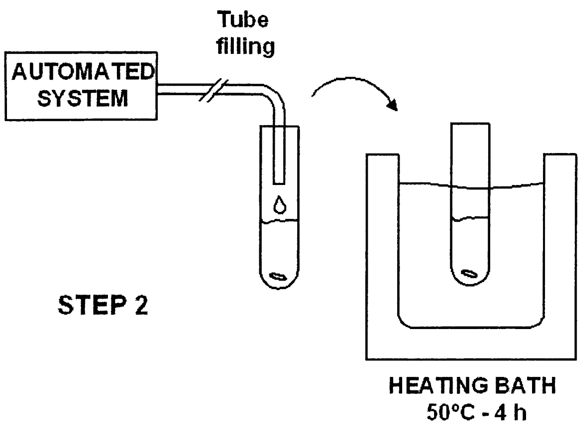

Fig. 3. Immersion in distilled water (step 2).

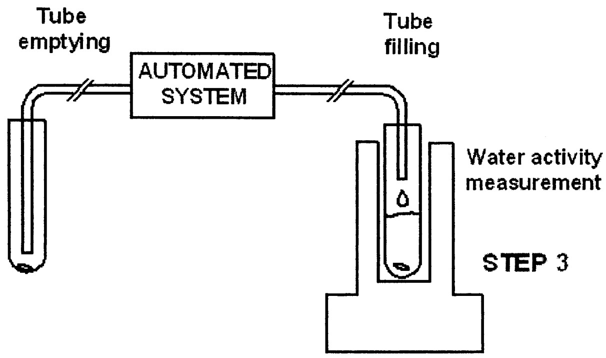

Fig. 4. Activity measurement (step 3).

After that, the seeds are removed and the water activity is measured (step 3 showed in Fig. 4). The limit value of activity in the water is 185 Bq (5 nCi). If the result is above that, the sealed source is considered to have leakage.

In the case when source is untight, the tubes used for transport of washing solution in the automated system is contaminated, needing decontamination in order to continue the process. This study includes results of simulating the contamination of the tubes and the development of procedures of its decontamination. The obtained results allow to determine specification for the automatic quality control system to be implemented in the radioactive seeds production process.

Materials and methods

The performed investigation consisted basically in pouring iodine-131 solution (sodium iodide) through the transport tubes, contaminating it. After that, the decontamination process was tested. Applied procedure consists in batchwise passing of clean water trough the same tubes. In order to transport water, two different pumping systems: peristaltic pump and vacuum pump were tested. The vacuum pump was made by Edwards model EM2. This device had a PTFE (teflon) tube with an internal diameter of 1 mm (Fig. 5).

1. Container with radioactive material.
2. Intermediary container.
3. Radioactive waste container.
4. Vacuum suction.

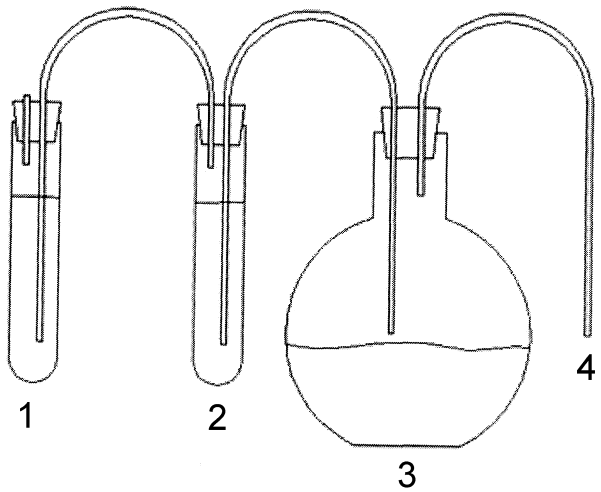

Fig. 5. Vacuum transfer system used in the assay no. 5.

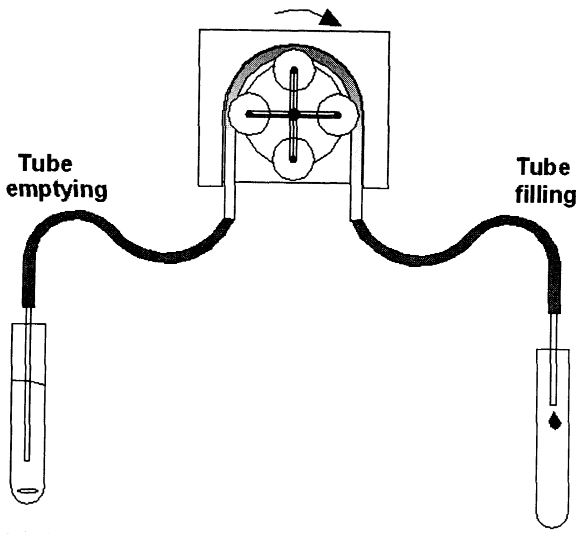

Fig. 6. Peristaltic transfer system.

The peristaltic pump, model Perista-Mini Pump, was produced by ATTO Corporation. This type of pump was equipped with a silicon rubber tube of internal diameter 2 mm (Fig. 6). Two different types of plastic tubes with varying internal diameter and construction materials were used in the investigation. A series of experiments were performed comprising changing such parameters as total washing water volume, flow rate and the number of washing cycles in order to determine optimal conditions for tubes decontamination.

The washing solution activity was measured by an ionization chamber CAPINTEC CRC 15W and a sodium iodine well detector CAPINTEC.

Description of the experiments

Experiment no. 1 – peristaltic system

The tube contamination was provided transferring 37 MBq (1 mCi) of iodine-131 (sodium iodide), added to 2 ml of distilled water. For decontamination, 2 ml of distilled water was transferred through the tube (washing) and its activity was measured. The last step was repeated until the activity stabilized in a minimum value, totalizing 30 washing cycles and a total volume of 60 ml of distilled water. The flow rate used was 3.3 ml/min. This assay was made twice.

Experiment no. 2 – peristaltic system

The tube contamination was provided transferring 37 MBq (1 mCi) of iodine-131 (sodium iodide), added to 2 ml of distilled water. Then, 50 ml of distilled water was transferred without interruption, and segregated (washing). The total volume of water was established based on the result of assay no. 1. After that, 2 ml of distilled water was transferred and its activity was measured. The flow rate used was 3.3 ml/min. This assay was made 30 times.

Experiment no. 3 – peristaltic system

The same as assay no. 2 with 50 ml of distilled water to wash and a higher flow rate (9 ml/min). This assay was made 30 times.

Experiment no. 4 – peristaltic system

The same as assay no. 3, with a higher washing water volume (75 ml) and 9 ml/min flow rate. This assay was made 30 times.

Experiment no. 5 – vacuum pump system

The tube contamination was provided transferring 37 MBq (1 mCi) of iodine-131 (sodium iodide), added to 2 ml of distilled water. Then, 75 ml of distilled water was transferred without interruption (washing) and segregated. The total volume of water was established based on the result of assay no. 4. After that, 2 ml of distilled water were transferred and its activity was measured. The flow rate used was 45 ml/min. This experiment was made 90 times.

Results and discussion

The results of experiment no. 1 are showed in Fig. 7.

The total volume of water used to wash the tube was 60 ml, but the minimum value of activity (around 60 Bq) was reached after overcoming 50 ml. This total volume was used in the next experiment (no. 2), when 50 ml of washing water was passed through the transfer

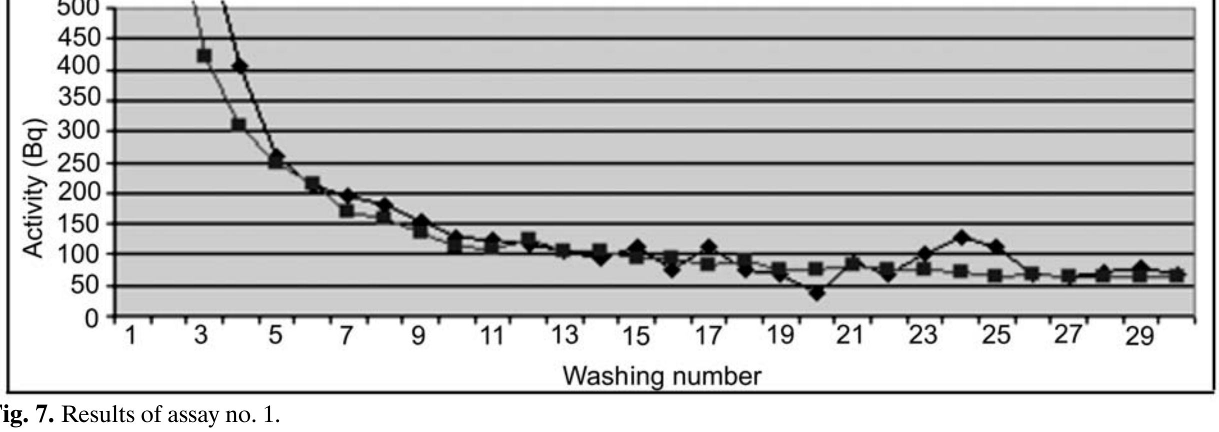

Fig. 7. Results of assay no. 1.

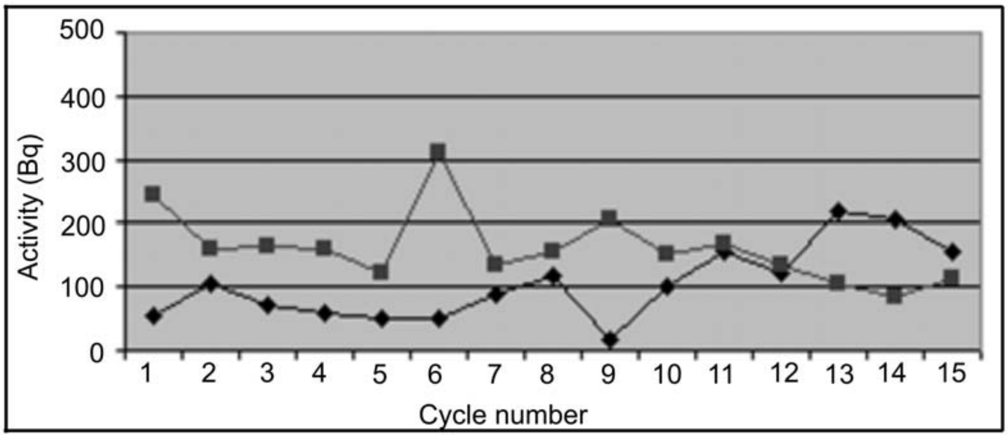

Fig. 8. Results of the assay no. 2.

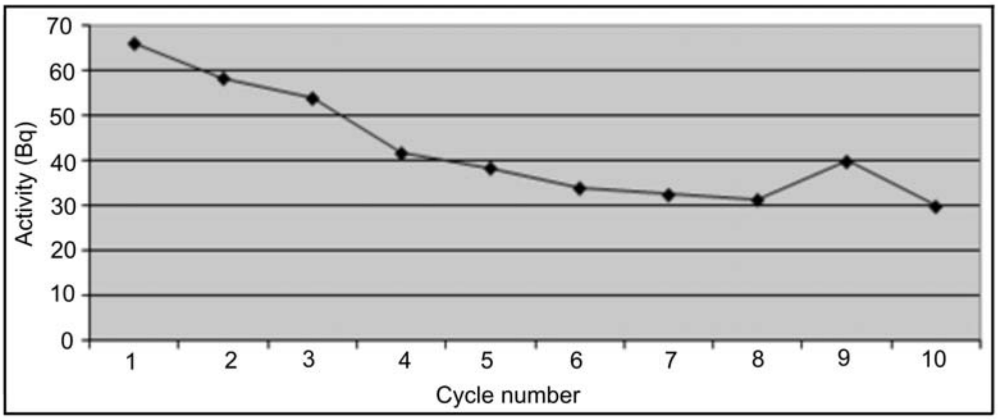

Fig. 9. Result of assay no. 3.

tubes without interruption to clean the tube after the contamination.

The results of experiment no. 2 are showed in Fig. 8.

This washing was not efficient. The minimum activity values reached were not constant enough to warrant efficient cleaning in the automated system. Residual activity value reaching 300 Bq was present in these results. During production test routines, this minimum value could be added to and interfere in the next leakage test. In the next experiment (no. 3) the total washing water volume was maintained (50 ml) and the flow rate was increased (from 3.3 to 9 ml/min).

The result of experiment no. 3 is showed in Fig. 9.

Although the results obtained decreased, comparing with the experiment no. 2, still were having variations in the residual activity values. After 10 cycles, the results showed no good efficiency and experiment no. 3 was finished, to change the parameters again. In the next experiment it was tried to minimize the residual activity values, increasing the total washing water volume (from 50 to 75 ml) and maintaining the flow rate (9 ml/min).

The result of experiment no. 4 is showed in Fig. 10.

These results showed, initially, low activity values, but there was a tendency to increased values. Checking the system, a high activity value was measured in the silicon tube. This activity did not decrease after several washings with distilled water. Thanks to this fact, the use of silicon tube was abandoned. In the next experiment the pumping system and the tube used for transportation was changed.

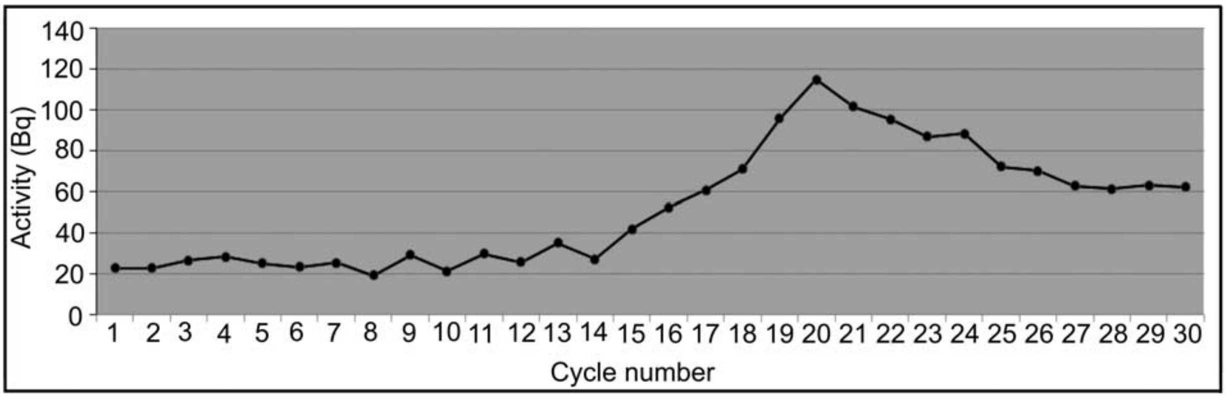

Fig. 10. Results of assay no. 4.

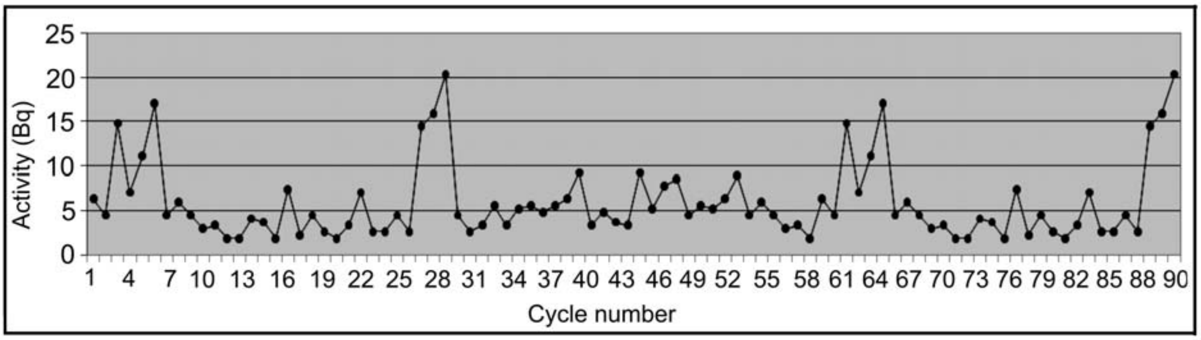

Fig. 11. Result of assay no. 5.

The result of experiment no. 5 is showed in Fig. 11.

After 90 tests, this method had good results with low activity values in the water. Furthermore, repeatability and no significant residual activity in the PTFE tube were observed. The maximum activity value found was 20 Bq (10% of the limit established in the ISO-9978 standard for leakage detection). The tube material had a good influence on the result, as well as on the increase of flow rate. The decrease of the internal diameter of the tubes used for transportation (from 2 to 1 mm) and the changing of the construction material caused a good influence in the results. The flow rate was increased from 9 ml/min to 45 ml/min.

Conclusions

In the iodine-125 seeds production, the automated control quality system will perform leak tests. Serial production needs the system to be always clean for the next tests. It is necessary to guarantee decontamination at low activity values of the tubing used to transfer liquids, in case there is a radioactive material leakage. The choice of the tubes, including different materials and shape evaluation, were performed and these results will be applied to engineering specifications. Although the peristaltic pumping system could represent an easier and simpler engineering solution than a vacuum system, the results were not satisfactory for safe and efficient transportation of liquids and for cleaning the tubes. The main characteristic concerning the materials is the porosity of the silicon rubber, allowing the contaminant to fix in the pores and later be transferred to the water. The internal surface of the PTFE tube is smooth and has no porosity, improving the results.

PTFE tubes will be used to transfer liquids in the system. The suction will be provided by installing a vacuum pump with proper filtration and retention of particles preventing environmental contamination. The high speed of the liquid inside the tubing helps to carry the radioactive material and to maintain activity values low enough to permit reutilization of the hydraulic circuit. The automation system will manage the position of tubes and recipients to change the source and destination of the liquids, in each leak test phase.

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