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^{192}Ir SOLID SOURCES ACTIVITY MEASUREMENTS

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ABSTRACT

This work presents the results related to activity determination of ^{192}Ir solid sources, applied in industrial gammagraphy, produced by the Sealed Sources Laboratory in the Radiation Technology Center (CTR) at IPEN-CNEN/SP, which is certified to deliver the sources to the national industry. These sources are formed by adding up to twenty ^{192}Ir pellets, with activities from 296 GBq (8 Ci) up to 0.63 TBq (17 Ci) each, supplied by NORDION Inc. The activity measurements were performed by using a well-type ionization chamber, manufactured for this purpose at CTR, connected to a Keithley Programmable Electrometer (model 617), fully computer-controlled by means of specially designed software written in C, which also provides complete statistical analysis of data and a user friendly interface. The chamber current-voltage response was studied as a function of ^{192}Ir activities ranging from 27 GBq (0.75 Ci) to 4.1 TBq (110 Ci), under constant geometrical conditions. Also, the correction factors for self-absorption of photons within the pellets and sample holders, which correspond to the fractional transmission of gamma-rays from ^{192}Ir in each source, were taken into account by means of the PENELOPE simulation code. The results obtained have shown both the linearity of the ionization current and the absence of appreciable recombination or diffusion losses.

1. INTRODUCTION

Ionization chambers serve in many standards laboratories as secondary standard measuring systems and are used to maintain the results of activity measurements from primary standardization [1, 2]. Generally, such a chamber takes the cylindrical geometry, with a well in which a radiation source is placed and which is called a well-type or $4\pi\gamma$ ionization chamber. When operated in the saturated region, the ion current solely depends on the geometry of the source and the detector. Besides, it can remain stable over very long periods of time. A comprehensive review concerning activity measurements with ionization chambers can be found in reference [1], by H. Schrader.

This work presents the preliminary results related to activity determination of ^{192}Ir solid sources, applied in industrial gammagraphy, produced by the Sealed Sources Laboratory at IPEN-CNEN/SP, which is certified to deliver the sources to the national industry.

The production of the sealed sources is very demanding. Therefore, the development of an acquisition system, remotely controlled by a PC, adds the required features to improve the established laboratory routine.

The pellet activities were measured by using a well-type ionization chamber manufactured for this purpose at Radiation Technology Center at IPEN-CNEN/SP. So as to verify the response and the reliability of the system, various measurements using standard radioactivity sources have been performed.

Also, the correction factors for self-absorption of photons within the pellets and sample holders, which correspond to the fractional transmission of gamma-rays from ^{192}Ir in each source, were taken into account by means of the PENELOPE simulation code [3].

2. EXPERIMENTAL SETUP

The chamber (sketched in Fig.1), at a volume of 2070 cm^3 and fifteen inner collecting electrodes, 15 mm apart, was filled in with pure argon under a pressure of 0.1 MPa. The detector was connected to a Keithley model 617 Programmable Electrometer, fully computer-controlled by means of specially designed software written in C, which also provides complete statistical analysis of data and a user friendly interface.

A high DC voltage power supply (Stanford, PS300) was applied to the ionization chamber and the voltage input was set manually.

3. RESULTS

The chamber current-voltage response (Fig. 2) was studied as a function of ^{192}Ir activities from 27 GBq (0.75 Ci) up to 4.1 TBq (110 Ci), under constant geometrical conditions.

The determination of the saturation current plays an important role in ionization chamber calibration. Basically, two methods have been proposed in the literature [5-7]. The first one suggests that the saturation current should be determined by plotting the (I, V) data in the (1/I, 1/V) mode (Fig. 3). The straight line obtained, extrapolated to (1/V) = 0, yields the saturation current (I_{sat}) for each activity. The other one considers the (I, I/V^2) plot as being adequate to calculate the saturation current.

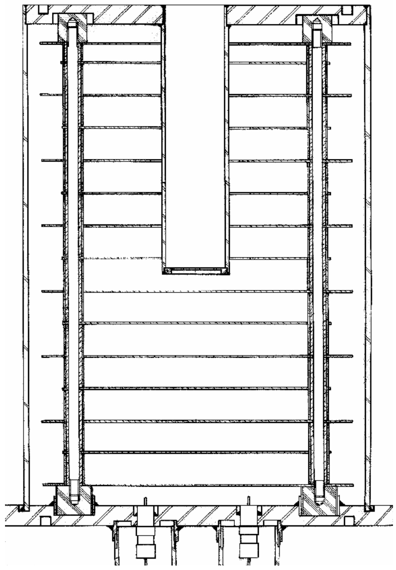

Figure 1. Well-type ionization chamber used over this work.

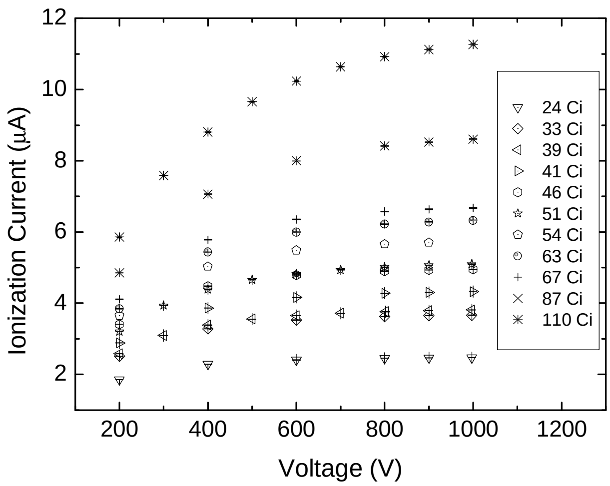

Fig. 2. Chamber current-voltage response for different source activities.

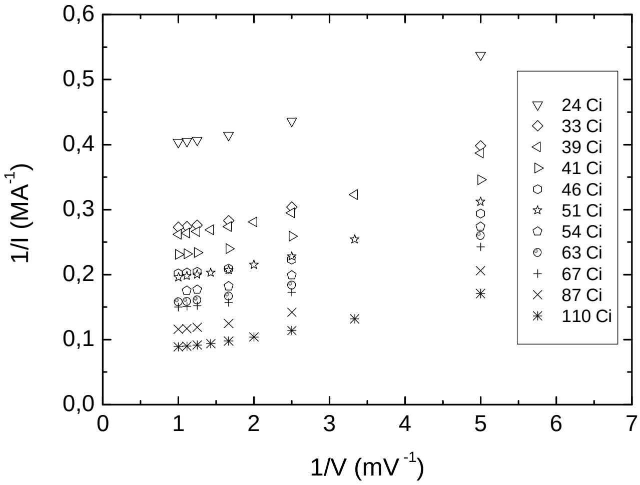

Fig. 3. Characteristic plot (1/I, 1/V) for determining the I_{sat} current.

Making use of the values of I_{sat} as assigned before, preliminary calibration curves of the chamber (Fig. 4) were obtained. The results have shown both the linearity of the ionization current and the absence of appreciable recombination or diffusion losses for this activity range. In the range of activity studied, one can see that, as pointed out by Mustafa and Mahesh [7] (I, I/V^2), the plot offers an underestimated value of I_{sat}.

Due to the geometrical arrangement of the sources, a correction factor for self-absorption of photons in the pellets was applied in the calibration curve above. Table 1 shows the different combination of pellets used in the sources studied in this work, including the fractional transmission of gamma-rays from ^{192}Ir through each one, which were calculated employing the PENELOPE simulation code.

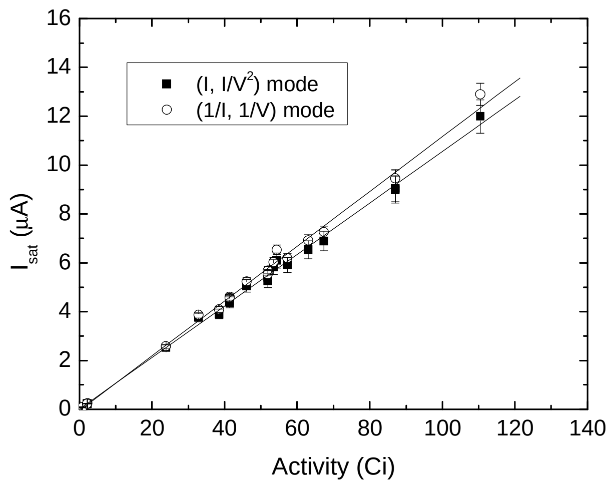

Fig. 4. Calibration curves of the chamber.

Table 1 – Fractional transmission of gamma-rays from ^{192}Ir for some sources studied over this work. The associated statistical uncertainty is ~1%.

Source Activity (Ci)	Number of Pellets	Fractional Transmission
24	4	0.793
33	6	0.748
39	5	0.768
41	7	0.729
46	8	0.716
54	9	0.704
63	11	0.682
67	12	0.675
87	16	0.648
110	18	0.638

4. CONCLUSIONS

The preliminary tests have shown that the operation of the ionization chamber used is quite satisfactory. The values of I_{sat} evinced both the absence of appreciable recombination or diffusion losses and the linearity of the ionization current for activities as high as 4.1 TBq (110 Ci). Furthermore, the computational program developed for fully controlling the acquisition system exhibited a stable and reproducible behaviour.

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