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Preliminary Shielding Design Results for Sr-82/Rb-82 Generator Prototype Development

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1. Introduction

Sr-82/Rb-82 generator have been widely used for the cardiac desease diagnostics using PET (Positron Emission Tomography) in the world. To meet increased worldwide demands, many large accelerator-based RI production facilities, such as IPF (Isotope Production Facility) of LANL (Los Alamos National Laboratory, USA) [1] and BLIP (Brookhaven Linac Isotope Producer) of BNL (Brookhaven National Laboratory, USA) [2], have been producing Sr-82. For the Sr-82/Rb-82 generator, two commercial generator products, CardioGen-82 [3] and Ruby-Fill [4] are supplied by Bracco Imaging and Jubilant Radiopharma.

The KOMAC (Korea Multi-Purpose Accelerator Complex) of KAERI (Korea Atomic Energy Research Institute) has been developing the Sr-82 production technology using the 100-MeV proton linear accelerator of the KOMAC and a Sr-82/Rb-82 generator with small activity Sr-82 for the animal testing. In this paper, the preliminary shielding design results of Sr-82/Rb-82 generator prototype are described.

2. Methods and Results

2.1 Sr-82/Rb-82 Specifications

To determine the specifications of our generator, we referred to the materials distributed by the FDA (U.S. Food and Drug Administration), which concerns CardioGen-82. According to the FDA, the recommended dose of Rb-82 chloride is 1480 MBq (40 mCi) for usual adult (70 kg) with a range of 1110~2220 MBq (30~60 mCi). The intravenous infusion rate is 50 mL/min., not to exceed a total volume of 100 mL. [5] The CardioGen-82 consists of Sr-82 adsorbed on a hydrous stannic oxide column with an activity of 90~150 mCi Sr-82 at a calibration time.

We decided the activity loaded to our generator prototype to 10 mCi. The dosage for animal testing can be estimated 13~170 uCi considering the weight of six-weeks old mouse and rat, 30 and 200 g.

For the calculation of shielding capacity of the generator case, we have to estimate the activities of other radioisotopes such as Sr-83 and Sr-85 that are coproduced with Sr-82 and could not be chemically separated. At EOB (End of Bombardment), the Sr-85/Sr-82 and Sr-83/Sr-82 ratios are typically 4 and 0.4 according to the BLIP's experiences. [6] The Sr-82 production specifications and the estimated values of our generators are summarized in the Table 1. For the calculation, we used the activity of Sr-82 as 15 mCi for the conservative calculation.

Table I: Sr-82 Specifications for calculations

Parameters	Sr-82 product specifications (BNL)	Sr-82/Rb-82 generator prototype (KOMAC)
Sr-82	100 mCi	15 mCi
Sr-85	≤ 500 mCi	80 mCi
Sr-83	≤ 0.15 mCi	0.02 mCi
Rb-82	≤ 0.15 mCi	0.02 mCi
Rb-84	≤ 0.15 mCi	0.02 mCi

2.2 Conceptual Design

The shielding structure of the Rb-82 generator prototype of the KOMAC was decided based on the specification of the hydrous stannic oxide column, the routing of the inlet/outlet pipes and additional space for experiments. The first conceptual design of our generator is shown in the Fig. 1.

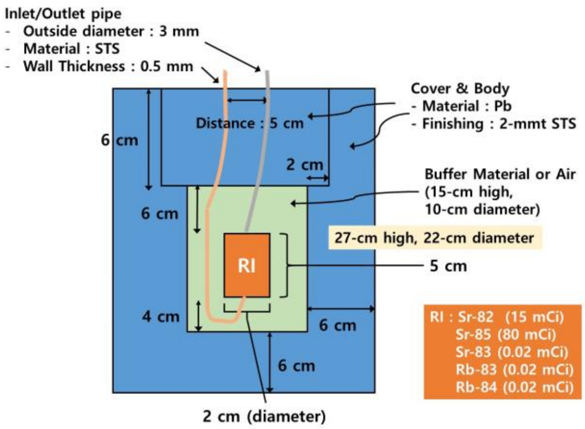

Fig. 1. The first conceptual design of the KOMAC's Sr-82/Rb-82 generator prototype.

The most important part of the generator is the column filled with hydrous stannic oxides on which Sr-82 adsorbed. The first mock-up of the column is shown in the Fig. 2 with their dimensions. The hydrous stannic oxides are contained in the STS 316 pipe sealed with the Swagelok fittings. The diameter of the column is 9.5 mm and the length is 30~40 mm. The maximum total length of the column including the sealing is 75 mm and the maximum total diameter is less than 20 mm.

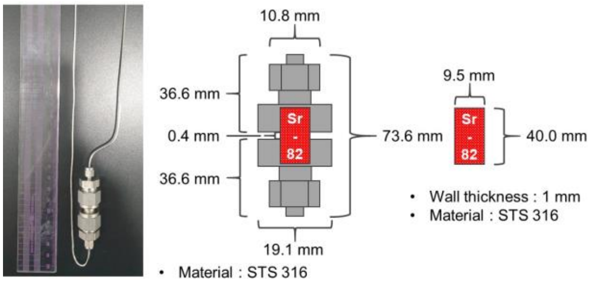

Fig. 2. Photograph of the column mock-up and dimensions of the column.

2.3 Calculation Using MCNPX

To estimate the shielding capacity, the surface dose distributions were calculated using MCNP code simulations. The geometry used for the calculation is shown in Fig. 3.

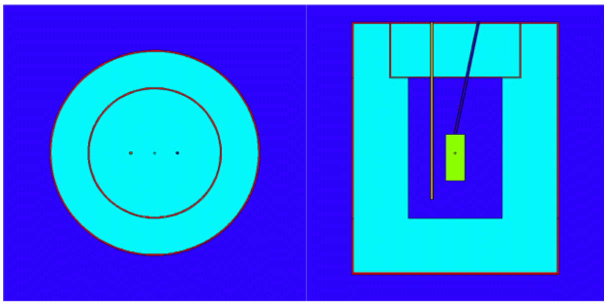

Fig. 3. The geometry for the calculation of the shielding capacity for the Rb-82 generator prototype.

The calculation results are displayed in the Fig. 4. As shown in the Fig. 4, the highest surface dose, 1.6 mSv/hr is caused by the outlet pipe filled with Rb-82 (~1 mCi). And the second highest dose, 60 uSv/hr is caused by the inlet pipe because it is faced to the column.

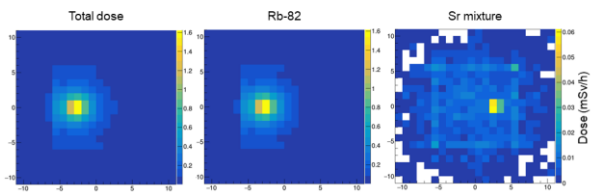

Fig. 4. The calculation results using ANSI/ANS 6.1.1 photon function.

To eliminate the radiation effects from the column through inlet pipe we modified the design as shown in the Fig. 5. The calculation results shown that the surface dose can be reduced to 10 uSv/hr by changing the inlet pipe routing not to be faced to the column.

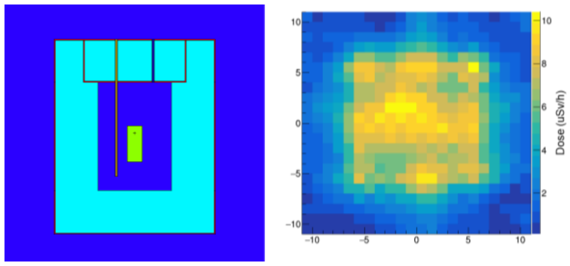

Fig. 5. The modified design and the calculation results.

3. Conclusions

The preliminary shielding design and calculation of shielding capacity for Sr-82/Rb-82 generator prototype of KOMAC was performed. The 6 cm-thick lead shielding wall can shield the radiation from the column filled with Sr-82 and other radioisotope mixture. The results told us that we have to be careful for the inlet pipe routing inside the generator. The optimization work to reduce the weight and volume of the generator shielding structure have to be done. It can be possible to reduce the space for column and optimization of the inlet/outlet pipe routing.

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