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THE USE OF CALIBRATED IONIZATION CHAMBER FOR THE CERTIFICATION OF ^{226}Ra RADIOACTIVITY

J.M. Lee, K.B. Lee, S.H. Lee, and T.S. Park

KRISS, Daejeon, Rep. of Korea, jmlee@kriss.re.kr

Abstract: The efficiency of a ^{226}Ra aqueous solution source in the radium-radon secular equilibrium against the gamma reference ionization chamber in KRISS has been obtained both by calculating from the photon energy-dependent efficiency curve of the ionization chamber and by measuring with an ^{226}Ra standard source. The two results of calculation and measurement have showed such a good agreement that the gamma reference ionization chamber may be used to certificate the radioactivity of ^{226}Ra aqueous solutions in the secular equilibrium and its traceability could be linked to the multi-radionuclide calibration of the ionization chamber.

Keywords: radon-222, radium-226, reference ionization chamber, radioactivity certification.

1. INTRODUCTION

The measurement of ^{222}Rn activities in the environment has been an important issue in the light of the high portion of natural radiation exposure to public due to radon and its decay products. Even though several methods can be used to calibrate the continuous radon monitors in air the use of an ^{226}Ra aqueous solution source has its own advantage. A solution source can for example be prepared easily rather than gaseous and solid sources and almost all the radionuclides are standardized or absolutely-measured using their aqueous solution forms. But it is known that it is not easy to standardize ^{226}Ra because it builds (or forms) a decay chain.

It is not helpful to take an advantage of an aqueous solution source if ^{226}Ra cannot be standardized and so the calibration is not traceable. The use of the gamma reference ionization chamber [1] which is normally used to maintain the activity standards of gamma-emitting radionuclides may be an alternative of constructing its traceability. In this work the gamma reference ionization chamber in KRISS is used to certificate a ^{226}Ra aqueous solution source in the radioactive equilibrium state with its decay products. The reference ionization chamber has been calibrated with other gamma-emitting nuclides measured by absolute methods since its installation. The photon energy-dependent efficiency curve of the ionization chamber can be constructed by analyzing the contribution of the main gammas from each radionuclide to the ionization chamber response.

2. MATERIALS AND METHOD

The reference ionization chamber [2] in KRISS memorizes its responses (nuclide efficiencies) to the unit activities of about 40 gamma-emitting nuclides standardized by the absolute measurement methods. Of the measured nuclide efficiencies such single gamma-ray emitting nuclides as ^{51}Cr and ^{54}Mn were used to normalize an energy-dependent efficiency curve of the reference ionization chamber obtained by a Monte Carlo simulation. The chamber efficiency of a ^{226}Ra aqueous solution source in its radioactive equilibrium (radium-radon) is a sum of the nuclide efficiencies of ^{226}Ra and its decay products. The contributions of all the gammas from a ^{226}Ra source in its secular equilibrium could be calculated from the energy-dependent curve.

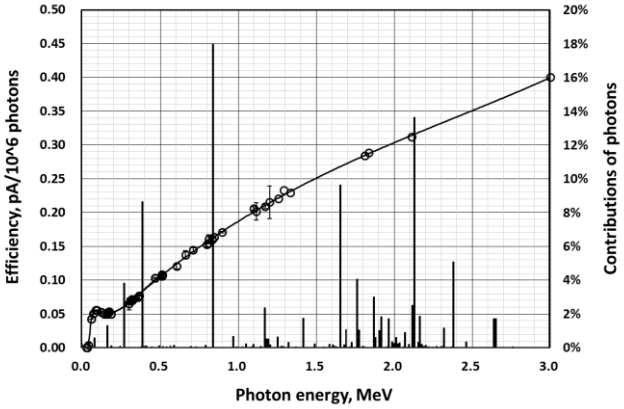

Fig. 1. Gammas from a ^{226}Ra and its decay products and their contributions to the reference ionization chamber.

A ^{226}Ra aqueous solution standard source (SRM 4960) in a flame-sealed glass ampoule from NIST was used to confirm the chamber efficiency for a ^{226}Ra source in the secular equilibrium. The mass of ^{226}Ra in 5 mL of 5 % by weight HNO_3 was 4.930 μg as of 1967-09-01 and its relative standard uncertainty 0.50 %.

Another ^{226}Ra aqueous solution source in a flame-sealed KRISS-type glass ampoule was prepared to check the

variation of the response with the time by the source. The long-term instability of the chamber is monitored and corrected by using a solid ^{226}Ra sealed source.

3. RESULTS AND DISSCUSSION

The efficiency of a ^{226}Ra source calculated by using the efficiency curve of the chamber was (0.3228 ± 0.0015) pA/MBq. 270 gammas from ^{226}Ra and its decay products were considered for the calculation. The effect of the decay products of ^{210}Pb on the efficiency was excluded and it is less than 0.006 % even when those nuclides have the same activities as that of the ^{226}Ra.

The efficiency measured by a ^{226}Ra aqueous solution standard source from NIST was (0.3242 ± 0.0017) pA/MBq. The two ampules of KRISS and NIST have similar dimensions and so the influences of their geometry and thickness differences on the efficiency were neglected.

Fig. 2 shows a temporal variation of the chamber response to a ^{226}Ra source in a 3.732 g aqueous solution contained in a 5 mL flame-sealed glass ampule.

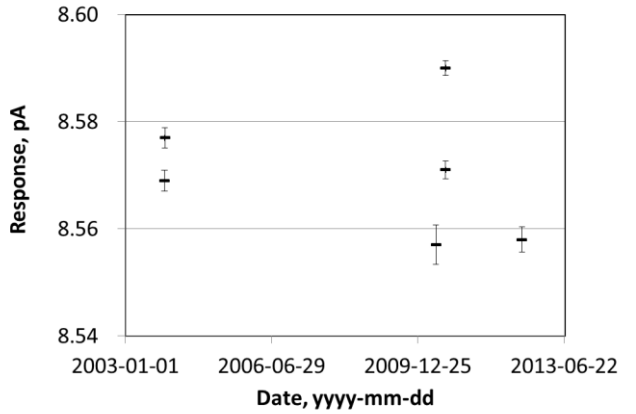

Fig. 2. A temporal variation of the chamber response to a ^{226}Ra aqueous solution (3.732 g) contained in a flame-sealed glass ampule (5 mL)

4. CONCLUSIONS

The efficiency of a ^{226}Ra aqueous solution source in the radium-radon secular equilibrium against the gamma reference ionization in KRISS was calculated from the energy-dependent efficiency curve of the ionization chamber and measured by using a ^{226}Ra aqueous solution standard source from NIST. The two efficiencies showed a good agreement and the difference was 0.43 %.

From the comparison study it may be concluded that the reference ionization chamber can be used to certify ^{226}Ra aqueous solution sources to be used for the calibration of radon monitors. The certification of ^{226}Ra sources is not directly traceable into the standardization of ^{226}Ra but may be traceable into the other gamma-emitting nuclides measured by absolute methods.

5. REFERENCES

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