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Non-Emanating Samples of the Rn Series from  $\{^{226}\text{Ra}$ ,  $\{^{228}\text{Th}$  and  $\{^{227}\text{Ac}$

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## APPLIED SCIENCE DIVISION

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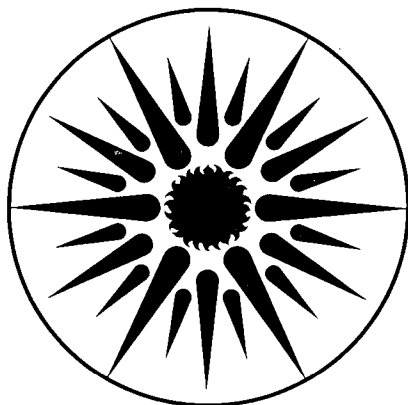
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*Health Physics*

**NON-EMANATING SAMPLES OF THE Rn SERIES  
FROM  $^{226}\text{Ra}$ ,  $^{228}\text{Th}$  AND  $^{227}\text{Ac}$**

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# NON-EMANATING SAMPLES OF THE Rn SERIES FROM $^{226}\text{Ra}$ , $^{228}\text{Th}$ AND $^{227}\text{Ac}$

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Key words:  $^{222}\text{Rn}$ , decay-product samples, calibration, alpha sources

The short-lived decay products of  $^{222}\text{Rn}$  are  $^{218}\text{Po}$  and  $^{214}\text{Po}$ ,  $\alpha$ -emitters with energies of 6.00 and 7.69 MeV, respectively, and  $^{214}\text{Pb}$  and  $^{214}\text{Bi}$ ,  $\beta$ -emitters that include branches with endpoint energies of 0.64 and 3.27 MeV, respectively. Because of the considerable difference between the energies of each pair of these radionuclides, the concentration of decay products in the air can be measured with good accuracy by means of portable scintillating or semiconductor spectrometers (Ruzer and Labushkin 1965, Labushkin and Ruzer 1965, Nazaroff 1988).

In order to determine decay-product concentrations accurately, it is necessary to calibrate the appropriate equipment by one of three methods: by producing standard aerosols of radon decay products, by fabricating standard samples of the decay products, or by using other types of sources that yield radiation of the appropriate type and energy range.

The last approach is the most common, but suffers the disadvantage of utilizing radiation that does not correspond exactly to that emitted by the decay products. On the other hand, use of a decay-product aerosol in an environmental chamber -- while the ultimate controlled test of the performance of a decay product monitoring technique -- is inconvenient for normal calibration purposes. The ideal technique for most purposes would be a long-lasting decay-product source having a configuration that is similar to that in which decay products are typically collected in the actual monitoring device, i.e., on a filter. However, due to the small half-life of the radon decay products, fabrication of such a sample presents great difficulties.

Nonetheless, a cooperative effort between our Institute and the Radium Institute in Leningrad has succeeded in producing non-emanating samples of each of the Rn decay series (Volkova et al. 1966). Each sample consists of a foil onto which is deposited, first, a substance that retains Rn with 95 - 97% efficiency, then a thin layer of the appropriate long-lived parent radionuclide (in a solution that is evaporated), and finally a thin foil to retain the 3 - 5% of Rn that would otherwise emanate. The peak width (FWHM) due to loss in the source is  $\leq 50$  keV. Samples with activities in the range 40 to 4000 Bq have been fabricated with areas from 5 to 20 cm<sup>2</sup>.

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Figure 1 shows  $\alpha$  spectra from a  $^{222}\text{Rn}$ -series sample fabricated in this manner from a  $^{226}\text{Ra}$  solution. The spectra were obtained using a scintillation spectrometer (a  $\text{CsI(Tl)}$  crystal with a thickness of  $\sim 100\mu\text{m}$ ) with resolution 3.5% and a semiconductor (Si) detector with resolution 0.5%, i.e., approximately 30 keV. Samples of this type and quality can greatly simplify calibration of decay-product measurement devices. A similar non-emanating sample has been developed for the  $^{220}\text{Rn}$  and  $^{219}\text{Rn}$  series together, yielding spectra such as seen in Figure 2. Such non-emanating samples have been used for many years with no sign of deterioration or leakage of Rn.

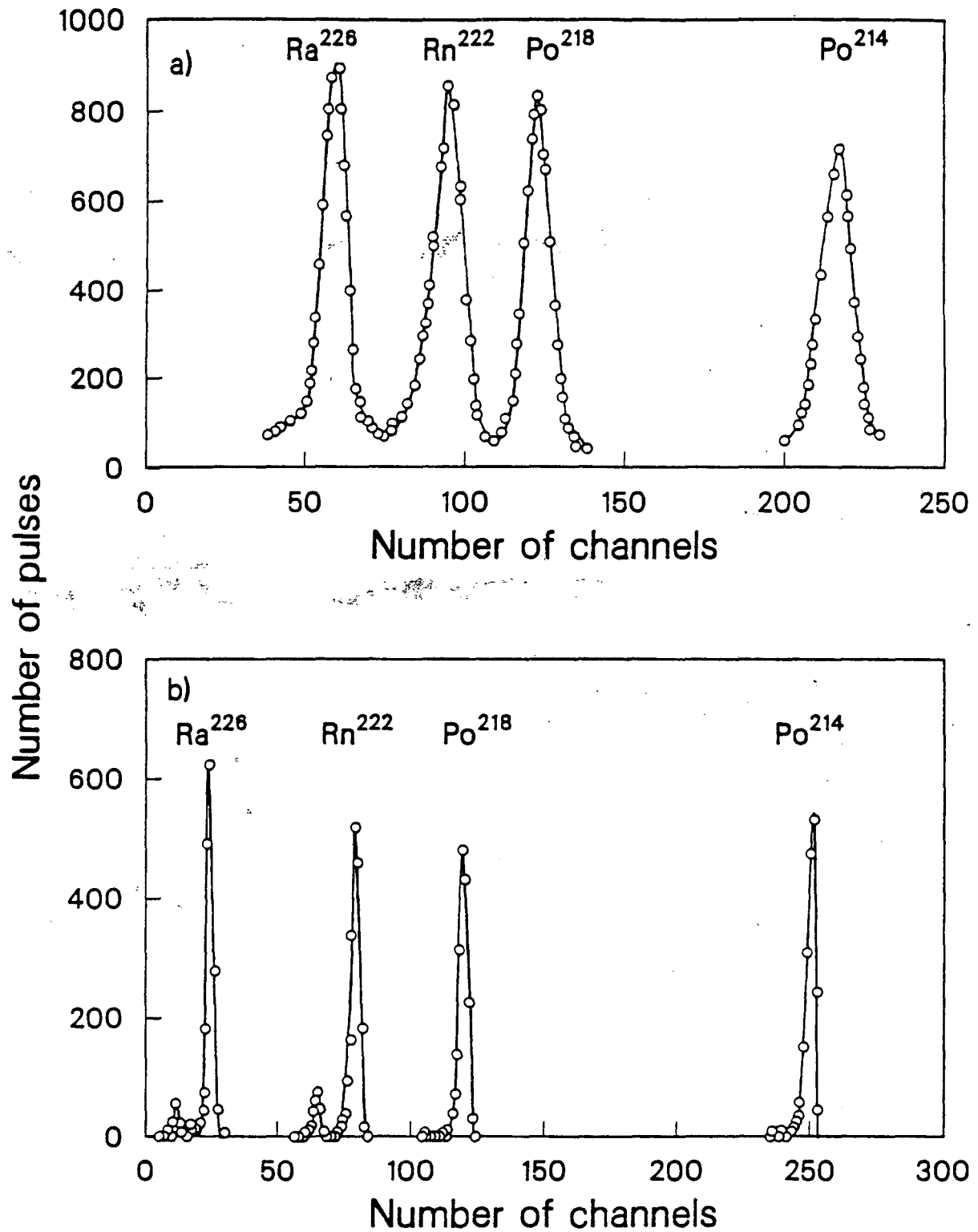
Non-emanating samples of this kind can be useful in measuring concentrations of decay products of each of the  $^{222}\text{Rn}$ ,  $^{220}\text{Rn}$  and  $^{219}\text{Rn}$  series, as well as in studies of the unattached fraction of  $^{218}\text{Po}$ . They can also be used for more general purposes, such as for calibrating instruments for measuring concentrations of artificial radioactive aerosols such as  $^{239}\text{Pu}$  and  $^{210}\text{Po}$  and for linearity testing and energy-resolution measurement for a wide range of  $\alpha$  energies.

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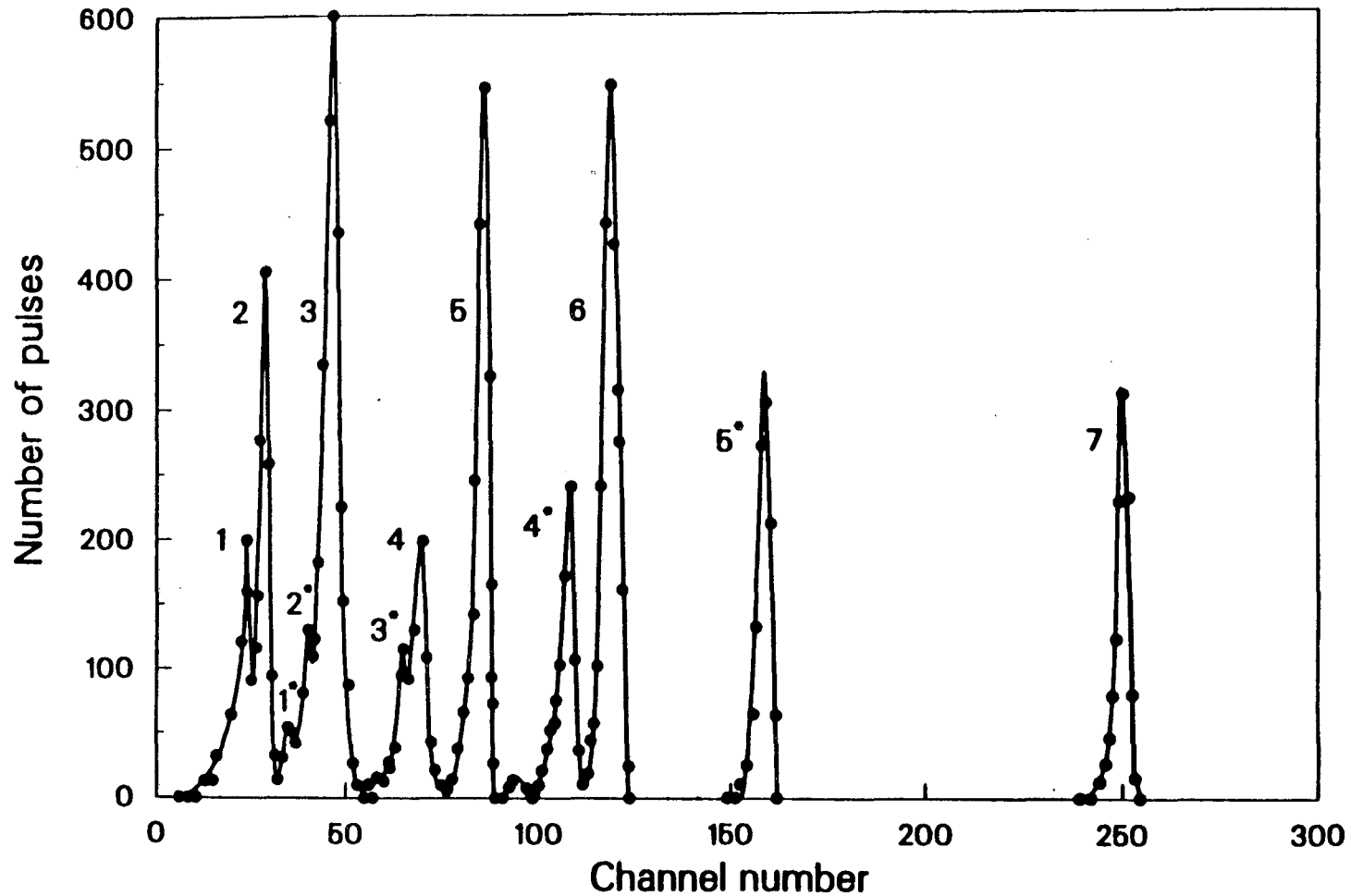
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XCG 893-4640

Figure 1: Alpha spectra from a  $^{222}\text{Rn}$ -series non-emanating sample. The upper spectrum was obtained using a  $\text{CsI(Tl)}$  scintillator, the lower a semiconductor detector. The small unidentified peak to the left of the  $^{222}\text{Rn}$  peak (lower spectrum) is due to the 5.3-MeV  $\alpha$  particle from  $^{210}\text{Po}$ , which has grown into the sample over a period of more than a year.





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Figure 2: Alpha spectrum from a  $^{220}\text{Rn}$  and  $^{219}\text{Rn}$  series sample obtained using a semiconductor detector. The numbered peaks correspond to the following  $\alpha$  particles: in the  $^{228}\text{Th}$  ( $^{220}\text{Rn}$ ) series -- peaks 1 and 2, 5.34 and 5.42 MeV (from  $^{228}\text{Th}$ ); peak 3, 5.45 and 5.69 MeV ( $^{224}\text{Ra}$ ); peak 4, 6.05 MeV ( $^{212}\text{Bi}$ ); peak 5, 6.29 MeV ( $^{220}\text{Rn}$ ); peak 6, 6.78 MeV ( $^{216}\text{Po}$ ); and peak 7, 8.78 MeV ( $^{212}\text{Po}$ ) -- and in the  $^{227}\text{Ac}$  ( $^{219}\text{Rn}$ ) series -- peaks 1\* and 2\*, 5.61 and 5.71 MeV ( $^{223}\text{Ra}$ ); peak 3\*, 5.90 MeV ( $^{227}\text{Th}$ ); peak 4\*, 6.55 MeV ( $^{211}\text{Bi}$ ); and peak 5\*, 7.39 MeV ( $^{215}\text{Po}$ ). (Alpha energies here and in text taken from Browne and Firestone 1986.)

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