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INTERNAL ABSORPTION OF GAMMA RAYS IN RADIUM-BERYLLIUM NEUTRON SOURCES

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ABSTRACT

When neutron sources composed of beryllium powder mixed with a radium salt are prepared commercially, it is sometimes desirable to determine the actual amount of radium in such a source by gamma-ray comparisons with a radium standard. To do this it is necessary to know the amount of absorption of gamma rays within the source and its container.

To compute this correction, a knowledge of the absorption coefficient of the beryllium powder is required, and the equations involved are difficult to work with in the case of a cylindrical source such as is commonly used. Therefore, this internal absorption has been determined experimentally for a source contained in a brass cylinder of 8-mm internal diameter and 24.5-mm internal length with walls 1 mm thick. This cylinder contained a mixture of 1,237 mg of finely powdered beryllium and radium sulfate containing 139.7 mg of radium element. From measurements made in the usual way with a gamma-ray electroscope with 1 cm of lead filtering, the absorption correction was found to be 5.1 percent.

The determination of internal absorption of gamma radiation of radioactive substances within the radioactive salt itself can, in most practical cases, best be made experimentally. The problem has been treated mathematically by Thirring [1] and also by E. v. Schweidler [2] for the case of a sphere of radioactive material. For other configurations, such as a cylinder usually met with in practice, the computations become more difficult. An expression for the internal absorption in a cylindrical radium preparation in a glass tube of 2.66-mm internal diameter has been developed by Holuba.[3] Aside from the mathematical difficulties involved, the results of such calculations are subject to errors arising from inaccurate knowledge of absorption coefficients as well as from the fact that the simple exponential absorption law is not valid in the case under consideration.

A similar problem is presented by neutron sources consisting of a mixture of beryllium powder and a radium salt enclosed in a brass capsule. It is often desirable to determine the actual amount of radium in such a source by comparison of its gamma radiation with that from a radium standard. When comparing radium preparations of approximately equal size, the internal absorption is so nearly the same in each case that it can be neglected. This is no longer true

[1] H. Thirring, Physik. Z. **13**, 266 (1912).
[2] E. v. Schweidler, Physik. Z. **13**, 453 (1912).
[3] M. Holuba, Sitzber. Akad. Wiss. Wien [IIa] **146**, 285 (1937).

when the radium salt is mixed with a relatively large quantity of powdered beryllium.

To obtain more exact information as to the amount of internal absorption in neutron sources of this type, the measurements described below were made. Briefly stated, they consist in mixing a measured amount of radium salt with a quantity of beryllium powder, enclosing the mixture in the usual type of brass cylinder, to form a neutron source and comparing the external gamma radiation of the source thus formed with that from the same quantity of radium salt before mixing it with the beryllium.

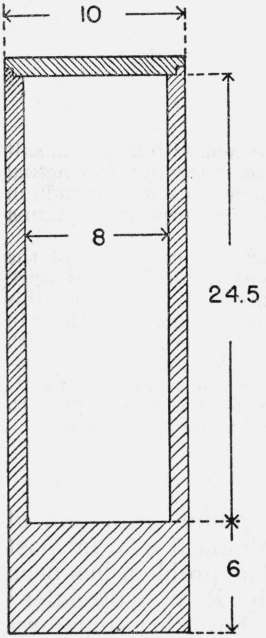

FIGURE 1.—Cross section of neutron source drawn to scale.

Dimensions are in centimeters.

A solution of radium chloride containing approximately 140 mg of radium was treated with sulfuric acid and the radium precipitated as sulfate. After carefully drying the radium sulfate it was sealed in a thin-walled glass tube and permitted to reach radioactive equilibrium. The amount of radium element was then determined by comparing its gamma radiation with that from a radium standard containing 141.5 mg of radium. The amount of radium element in the radium sulfate was thus found to be 139.7 ± 0.2 mg.

Since both the radium sulfate and the radium standard were contained in glass tubes of approximately the same wall thickness and the amounts of salt in the two were nearly the same, no correction for internal absorption is necessary.

The neutron source was prepared by mixing 1,237 mg of beryllium powder with the radium sulfate containing 139.7 mg of radium. The metallic beryllium was ground in a mortar until all of it would pass through a 60-mesh screen, after which it was thoroughly mixed with the radium sulfate. This mixture was then carefully packed into a brass cylinder, constructed as shown in figure 1, just large enough to hold the mixture. The dimensions of the cylinder are shown in the figure. The cover was soldered in position and the source permitted to reach radioactive equilibrium.

Gamma-ray measurements of this neutron source made by placing the neutron with its axis parallel to the face of an electroscope at a distance of about 150 cm, gave an apparent radium content of 132.9 ± 0.2 mg. The electroscope used for all comparisons had walls of lead 1 cm thick. The amount of filtration had some effect on the amount of absorption, but the differences were small for lead filters greater than 0.5 cm in thickness. As a result of these measurements, the absorption correction to be applied to the value for the apparent radium content of the neutron source in order to determine its actual content is 5.1 percent. This includes the correction for absorption

in the beryllium powder and in the 1-mm brass walls of the container. This correction can be expected to vary but slightly for preparations of similar shape and diameter over a range of 1 or 2 mm in either direction. Consequently, it may be used to determine the actual radium content for such sources within the usual limits of accuracy, that is, ± 0.5 percent.

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