QUALIFICATION OF RADIUM SOURCE PACKAGING BY THE MEASUREMENT OF THE RADON ESCAPE RATE

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ABSTRACT

The extensive use of radium sources in radiotherapy and in industry during the first half of the 20th century has yielded waste of different types (needles, tubes, luminescent paints etc.) with various concentrations of radium. These waste products have the characteristic to produce radon, a radioactive gas and its progeny radionuclides. These are of natural origin, but they still require precaution to be taken in order not to increase significantly the radiological risk to workers and to present and future populations.The management of these waste products implies the use of specific packaging that reduces as much as possible the radon transfer from the radium source to the storage facility, in order to comply with the different regulations.

So, the efficiency of the packaging as a radon barrier must be controlled. We have developed a test method to estimate the radon leakage of different containers by the measurement of radon degassing from the packaging. With this methodology, we can measure radon leakage rates as low as 10^{-5} $Bq.s^{-1}$.

INTRODUCTION

Some industries produce radium rich waste (treatment of ores to extract uranium, phosphates, rare earths). One of the special features of these products is that they give off a rare radioactive gas, radon, with variable emission rates depending on the intrinsic properties of the material (humidity, grain size, radium content etc.). The health risk from the radon is, in fact, due to its short life progeny which, once inhaled, can be fixed in the lungs and be harmful. That is why there are Annual Intake Limits (L.A.I.) for potentially exposed workers.
Radium containing waste can be packaged in container of different types before being stored on suitable sites. It is very difficult to design a long term, absolutely radon-tight package.
Therefore, a certain rate of leakage is tolerated, a function of the final storage conditions at site (particularly the presence or absence of ventilation).
That is why it is important to be able to quantify as precisely as possible the rate of radon leaking from the packaging of the radium waste, and why a strict methodology for testing the packaging has been developed.

1 - PRINCIPLE

To find the radon leakage rate of different type of packages, it is necessary to have what is called a "reference " radium source and to know its radon emission rate. This is put into the packaging to be tested. Everything is then put into a confinement chamber. The leakage rate of the packaging depends on the measurement of the radon collected in the chamber.

2 - DESCRIPTION OF THE TEST APPARATUS

The test apparatus comprises (figure 1):

- a stainless steel, perfectly sealed confinement chamber,
- a radon 222 measuring instruments (silicon detector, scintillation flask),
- a circuit sweeping the confinement chamber which ensures ventilation rate of 1 per hour.

3 - CHARACTERIZING THE LEAKAGE FROM RADIUM SOURCE PACKAGING

3.1 - Studying the "reference" source

In order to determine this radon emission rate of the "reference" radium source, it is put into the confinement chamber. The change in radon activity $A_{(t)}$ in it is measured. Under these conditions, the radon concentration follows a law of the following type:

$$A(t) = A_{\infty}(1 - e^{-\lambda t})$$

in which:

- $A(t)$: radon activity in time t ($Bq.m^{-3}$)
- A_{∞} : radon activity reached at $t \rightarrow \infty$ ($Bq.m^{-3}$)
- λ : radioactive constant of Rn 222 ($2.1\ 10^{-6}\ s^{-1}$)

Now,

$$A_{\infty} = \frac{E}{\lambda V}$$

in which E is the radon emission rate of the source ($Bq.s^{-1}$), and V is the volume of the confinement chamber. The "reference" radium source is preferably one of high activity (~10^7 Bq) with a radon emission rate around 10 $Bq.s^{-1}$.

3.2 - Testing the packaging

The radium source, qualified in this away, is put into the packaging to be tested. This is then put into the confinement chamber which is closed and the circulation starts. As previously, the change in activity of the radon inside the chamber is continuously followed.

In general, the radon concentration in the confinement chamber changes as shown in Figure 2.

Let:

- A_v : volumetric activity of radon 222 ($Bq.m^{-3}$) in the chamber
- V : confinement volume (m^3); V = [(volume of the chamber) - (volume of the packaging to be tested)]
- λ : constant for decrease in radon 222 ($\lambda = 2.1\ 10^{-6}\ s^{-1}$)
- t : time (s)
- P_F : radon produced in the confinement chamber by leakage from the packaging ($Bq.s^{-1}$).

This can be written as follows:

$$\frac{dA_V(t)}{dt} = \frac{P_F}{V} - \lambda A_V$$

with $A_V = 0$ for $t = 0$. So that P_F can be estimated using the formule :

$$P_F = \frac{A_V(t)\lambda V}{1 - e^{-\lambda t}}$$

Thus, for a radon activity in the chamber of 100 $Bq.m^{-3}$, P_F is in the region of $2.5\ 10^{-5}\ Bq.s^{-1}$.

4 - CONCLUSION

A methodology has been developed in order to quantify as precisely as possible the radon-tightness of containers intended for storing sources of radium 226. With this technique, it is possible to measure radon leakages as low as $10^{-5}\ Bq.s^{-1}$. We can also estimate the reduction of the radon emission rate of the "reference" radium source due to the packaging.

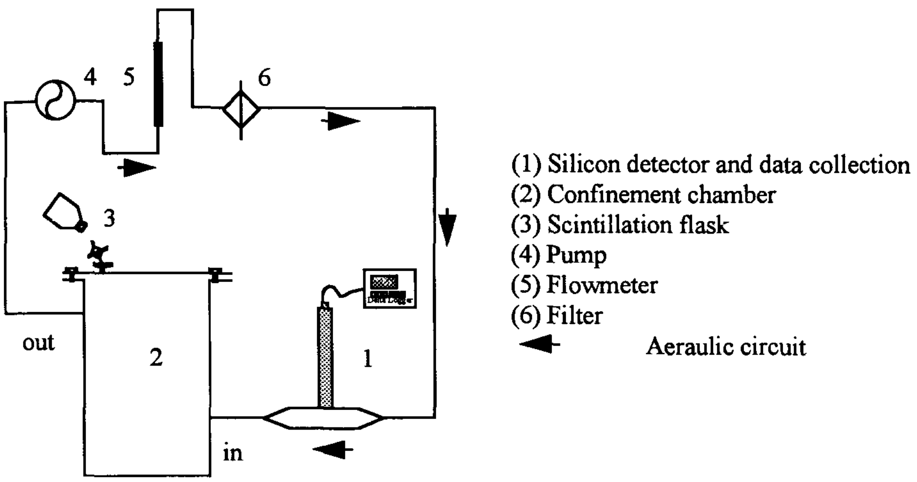

Figure 1 - Testing Apparatus

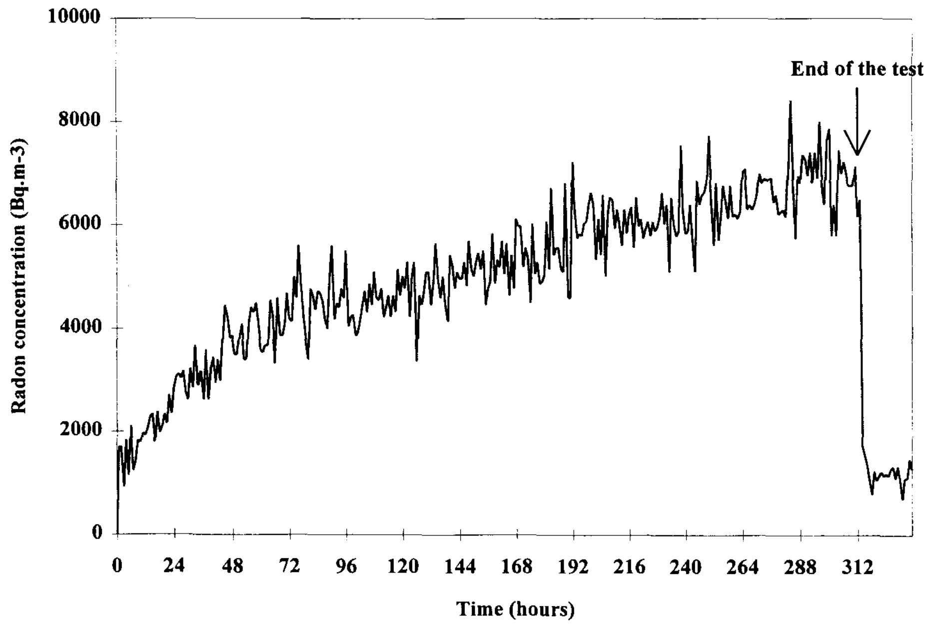

Figure 2 - Test of radium packaging: evolution of the radon concentration inside the confinement chamber due to the radon leakage from the packaging.