Title
A FAST AND ACCURATE METHOD FOR MEASURING RADON EXHALATION RATES FROM BUILDING MATERIALS

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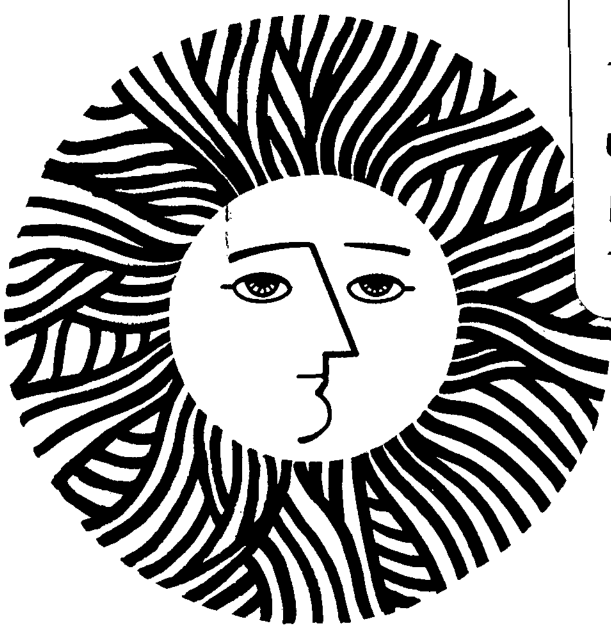

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ABSTRACT

In this paper, we describe a fast and accurate method for measuring radon exhalation rates from building materials. The samples tested are sealed in a chamber from one to a few days. The emanated radon is subsequently adsorbed on glass wool at liquid-nitrogen temperatures and then transferred into scintillation cells where it is counted using a photomultiplier tube assembly. The reproducibility of the measurements is better than 5%.

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Most building materials, such as concrete, gypsum, stone, and brick, contain trace amounts of ^{226}Ra and, consequently, constitute a source of ^{222}Rn in buildings. An inexpensive, sensitive, and relatively fast method for measuring radon emanation rates from building materials has been developed at the Lawrence Berkeley Laboratory as part of its indoor air quality studies, and this method has been used successfully to survey typical building materials used in the United States (In 80a).

The basic apparatus consists of a sealed chamber in which test samples are placed, a transfer system to transport the radon from the chamber to a small alpha-scintillation cell, a photo-multiplier tube counting system to count the alpha decays in the scintillation cells

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(Lucas cells), and a calibration system (In 80b). The collection, transfer, and calibration systems are shown schematically in Figures 1, 2 and 3, respectively. The design of this assembly was adapted from earlier designs by Lucas (Lu 57, Lu 64). Although the samples used in our measurements were fairly small (~ 1 kg) to insure the escape of all diffusible radon generated in the material itself, the system can accommodate any sample size provided the chamber is sufficiently large.

Two fundamental improvements over previous designs have been incorporated in the present system (Jo 76). First, the residence time of a sample in the chamber has been reduced from one month to one day for relatively high radon emanating materials such as concrete and a few days, at most, for other materials. The period is chosen to permit the amount of radon in the chamber to reach enough of its equilibrium value, so that longer accumulation times will not substantially reduce the statistical error of the measured emanation rate (In 80b). A second improvement was replacement of charcoal radon traps in the transfer system with glass-wool traps operated at liquid nitrogen temperatures. The glass-wool traps are easier to operate and maintain in routine use (In 80b).

We can determine the radon emanation rate from the sample in question, given knowledge of the time interval for radon collection, the time periods between the end of collection and the beginning of counting in a Lucas cell, the duration of counting time, the number of counts obtained, and the calibration constant of the counting system and Lucas cell (In 80b).

The operation of the whole assembly proceeds as follows. To begin the collection of radon, the sample is sealed in the collection chamber, a modified four-gallon paint reservoir used in compressed-air paint sprayers. At the end of a 24-hour (or longer) collection period, the inlet valve of the collection container is connected to a dry helium tank and the outlet valve to a water trap (to capture any moisture in the radon-laden air of the collection can), which is connected, in turn, to a glass-wool radon trap (see Figure 1). The water trap is kept in a freon-dry ice bath (-80 ^{o}C) and the glass-wool trap is cooled to liquid nitrogen temperature (-196 ^{o}C). The helium gas, which must be free of CO_2 (< 1%), is flushed through the collection chamber and the two traps at a rate of 1.0 l/min for 1 hour. The helium serves as a carrier gas to move the radon-laden air from the container through the glass wool onto which more than 98% of the radon is adsorbed. After the collection chamber has been flushed, the wool trap is evacuated to less than 50 millitorr, then allowed to warm to room temperature. The desorbed radon in the trap is then gradually transferred to a Lucas cell using a small peristaltic pump and helium as a flush gas (see Figure 2). (The water trap prevents water from getting into the scintillation cell, where it would decrease the counting efficiency of the cell.) After at least three hours have elapsed from the end of the transfer process, allowing the radon daughters to reach equilibrium, the decay of the radon and its daughters is counted on the photomultiplier tube assembly.

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The efficiency of the counting system (the ratio of counts observed to alpha disintegrations in the cell) was determined with the calibration system, which employs a 2" diameter Lucas Cell and a 2" photomultiplier tube, and uses known quantities of radon emanated from standard radium solutions supplied by the National Bureau of Standards. The efficiency of the counting system was 80.4% with a standard deviation of 2.9% (In 80b).

To ensure the proper operation of the system, we tested

- radon leakage in sample containers and rubber tubing: No radon leakage was detected (In 80b).
- the degree of radon adsorption in the glass wool at liquid nitrogen temperature as well as the degree of radon desorption at room temperature: In both cases, over 98% of the radon involved was accounted for (In 80b).
- the reproducibility of the technique, tested by filling five collection cans with identical amounts of radon and repeating the transfer process: The standard deviation of the five measurements was 4.7%.

We have used this system for a year and a half in surveying radon emanation rates from concrete and other building materials commonly used in the United States. Measured exhalation rates ranged from 0.1 to 2.0 pCi kg^{-1} hr^{-1} (In 80a). The standard deviation of a set of three to five measurements on a given sample ranged from 5 to 20%.

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FIGURE CAPTIONS

FIGURE 1. Diagram of radon collection system.

FIGURE 2. Diagram of radon transfer system.

FIGURE 3. Diagram of calibration system for determining the efficiency of radon counting system.

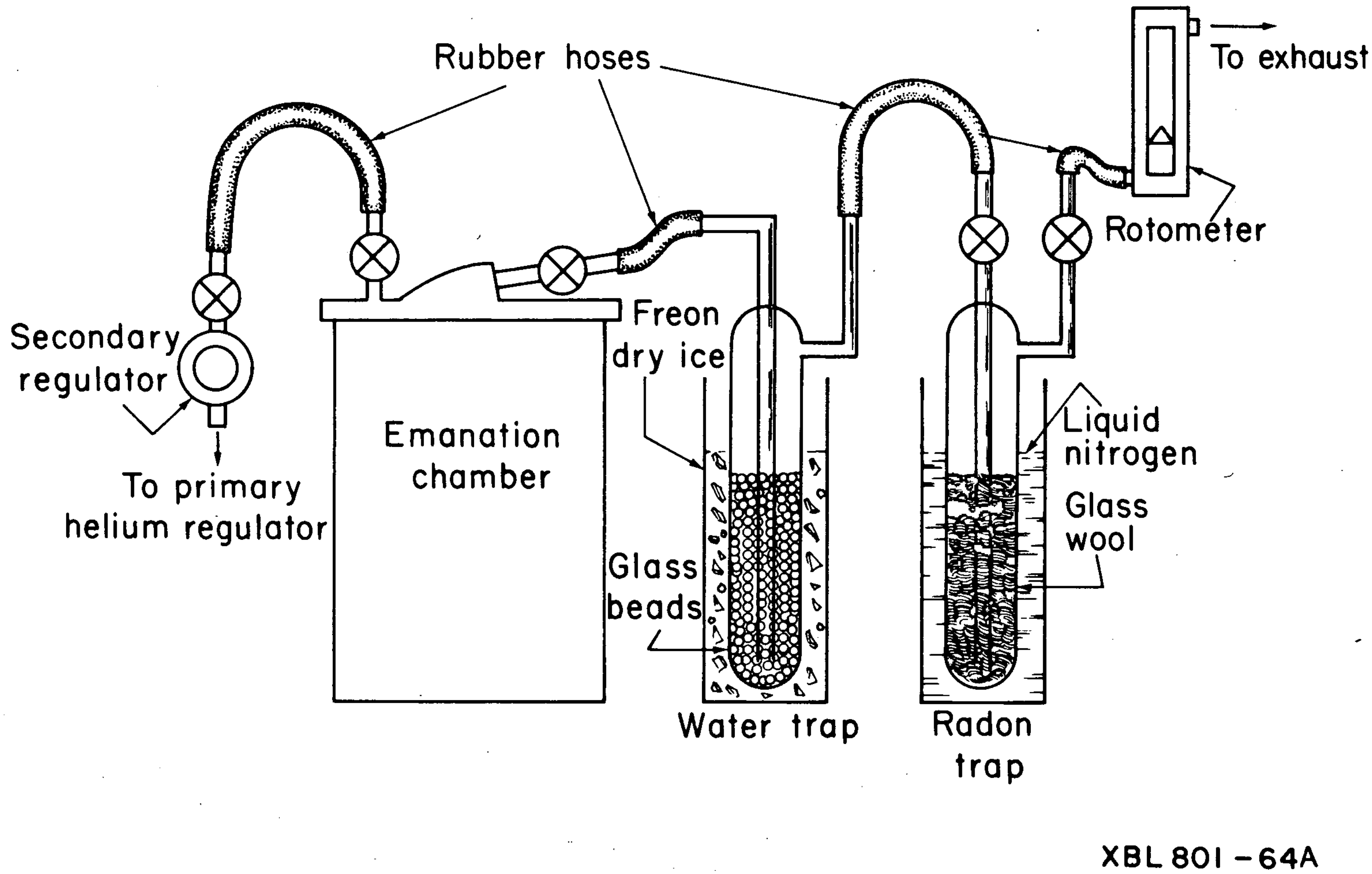
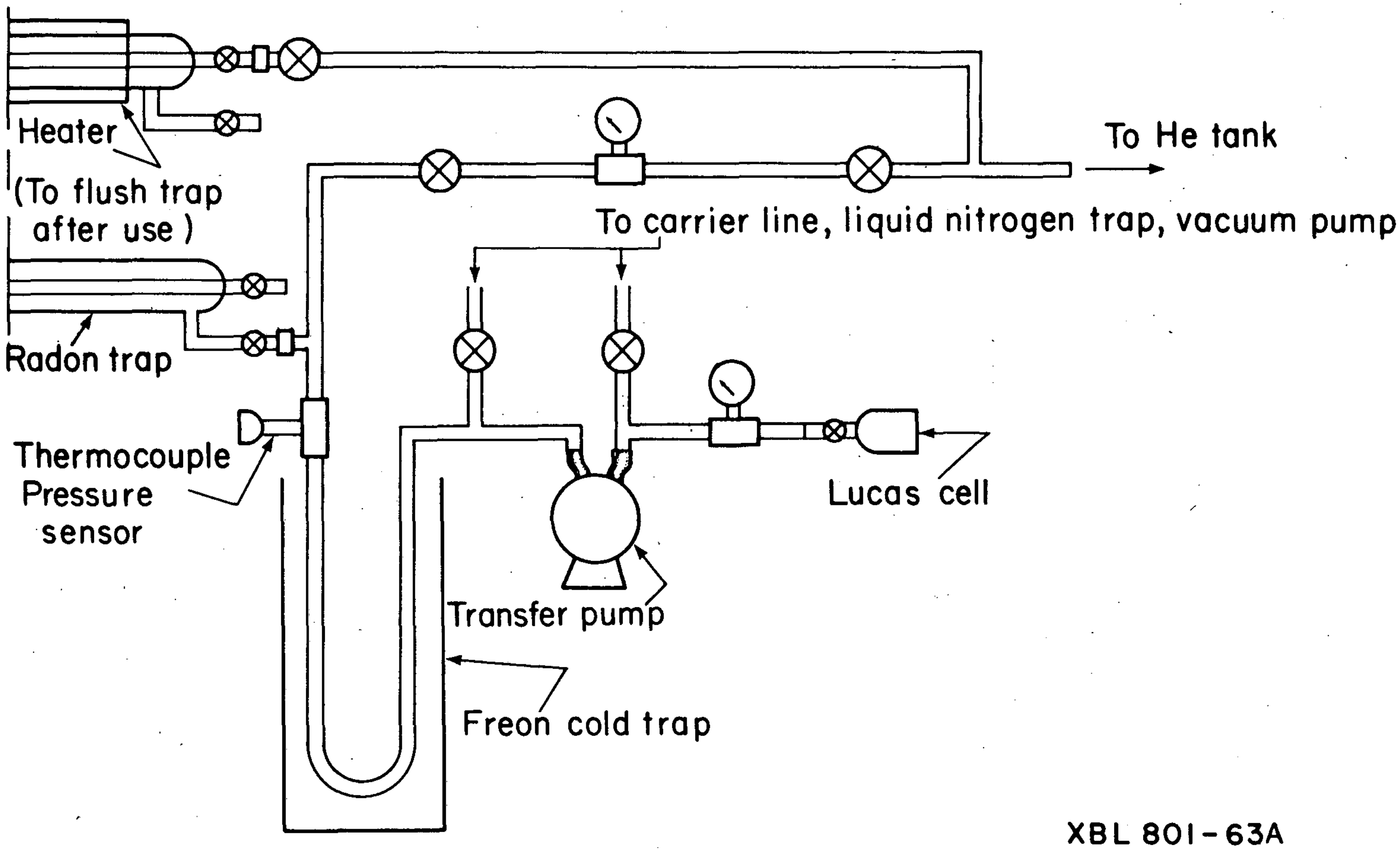

Rubber hoses
To exhaust
Rotometer
Secondary regulator
To primary helium regulator
Emanation chamber
Freon dry ice
Glass beads
Water trap
Radon trap
Liquid nitrogen
Glass wool
XBL 801 -64A

Figure 1



Heater
(To flush trap
after use)
Radon trap
To He tank
To carrier line, liquid nitrogen trap, vacuum pump
Thermocouple
Pressure
sensor
Lucas cell
Transfer pump
Freon cold trap
XBL 801-63A

Figure 2

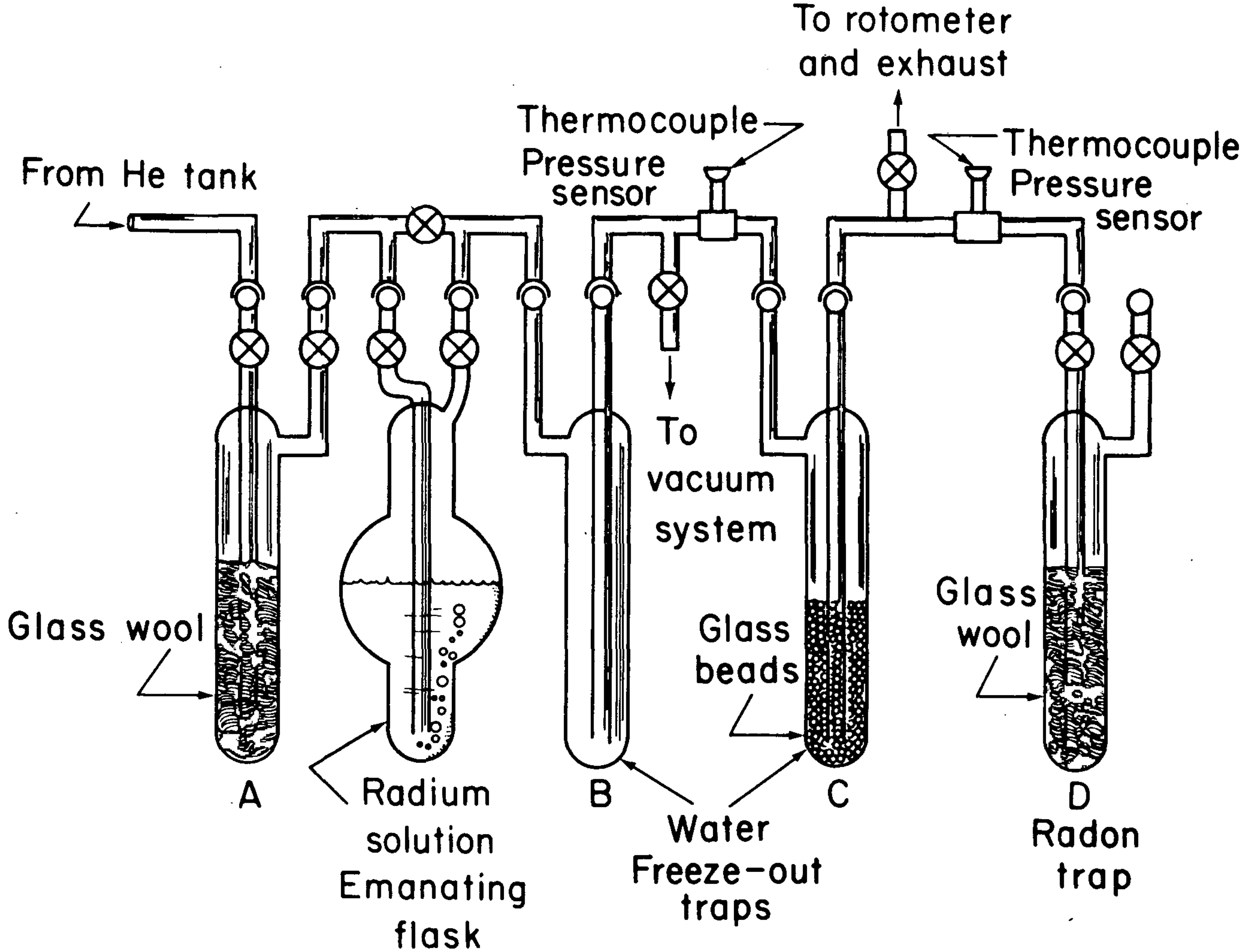


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Figure 3

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