TECHNICAL NOTES

A Simple Method for the Air Monitoring of Xenon-133

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A simple and inexpensive method to monitor the air for Xe-133 is described. The procedure requires only standard 10-cc evacuated tubes, a scintillation well counter, and a dose calibrator—standard equipment in most nuclear medicine laboratories. Air contamination in the range of the maximum permissible concentration in restricted areas (10pCi/cc) can be detected easily by this technique.

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There has been increasing use of Xe-133 recently, not only in gaseous form for pulmonary function and imaging studies but also dissolved in saline for the measurement of blood flow. For both respiratory and i.v. modes of administration, xenon is excreted by the lungs and therefore some mechanism is required for collection and removal of the expired air. Even under ideal circumstances some leakage of radioactive gas into the ambient air is inevitable, and good radiation-safety practice requires some kind of check on the frequency and extent of such leakage. Because gaseous radioactivity in low concentrations is not easily detectable in air with standard radiation monitors, gas monitors designed expressly for this purpose have been produced commercially. Unfortunately these instruments are expensive and, although portable, they are somewhat unwieldy and are not convenient for the rapid survey of large areas. Scintillation detectors adapted for this purpose tend to be even less mobile and have the added disadvantage of recording nongaseous background activity as well. Furthermore, for a laboratory in the process of evaluating the need for and value of studies requiring xenon, or initiating research with this agent, a gas monitor is not likely to be available. For these reasons we developed a simple, effective, and inexpensive means of measuring Xe-133 contamination of room air.

MATERIALS AND METHODS

Red-top Vacutainers rated at 10 cc were used. To measure the Xe-133 content of the air at a given place and time a technologist inserted an open-ended needle through the stopper of the tube, waited 2 or 3 sec for the tube to fill, removed the needle, and labeled the tube for time and place. In this way many different parts of a room could be monitored nearly simultaneously. Optimum locations for such monitoring include areas near the floor, at "breathing level," and in areas where air flow appears likely to be less than average. Several adjacent rooms can be checked within a few minutes by this technique. At the technologist's convenience, the tubes can be counted against a known standard in a scintillation well counter. In this way a direct reading of Xe-133 in μCi per cubic centimeter of room air can be determined easily and accurately and a record of contamination maintained.

To ascertain the consistency of tube "draw," 100 Vacutainers were obtained from many different parts of the hospital and weighed. Each tube was immersed in water upside down and a needle was inserted through the stopper. After the tube had filled with water, the needle was removed with the tube still inverted. The tube was then dried and reweighed. The difference in weight for each tube represented the draw in grams (and hence cubic centimeters) of water.

The standard was made by introducing 100-200 μCi of Xe-133 into one of the red-top tubes. This level of activity can be measured accurately in most dose calibrators. The activity was then allowed to decay over a large number of half-lives until an amount small enough to be counted in the well counter remained. The activity remaining was calculated using the 5.27-day half-life of Xe-133.

To minimize the potential problem of long-lived gaseous contaminants in the standard, several precautions were observed. The standard was made up immediately upon arrival of the shipment of xenon and a relatively small amount of xenon was used (100-200 μCi). Both of these precautions tend to limit the absolute amount of long-lived contaminants that might be introduced into the standard. In addition, use of a window just wide enough to bracket the xenon peak (81 keV) minimizes the effects of any possible contamination, even though it imposes a lowered Xe-133 counting rate.

To determine whether there was any leakage or redistribution within the tube because of adsorption onto the rubber stopper,

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the standard tube was counted in the dose calibrator over a period of several weeks and the results were compared with those expected from decay alone.

Once the standard had decayed to a level of activity within the approximate range of the well counter, the activity was periodically measured and counts were plotted against time over a period of several weeks. The resulting decay curve was then compared with the theoretical decay curve derived from the 5.27-day half-life of Xe-133. Significant dead-time losses would be evidenced by a deviation from the expected curve at high count rates. In this way, the maximum counting rates possible without dead-time correction could be determined. Significant levels of long-lived gaseous contaminants could be recognized by a flattening of the actual curve and consequent deviation from the theoretical decay curve.

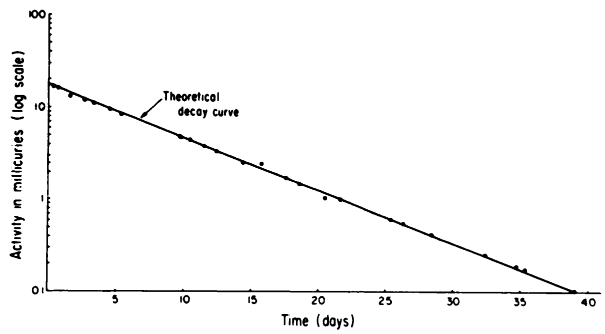

FIG. 1. Xenon-133 activity in standard tube as measured over approximately seven half-lives in dose calibrator. Note correspondence with theoretical decay curve.

RESULTS

The average draw of the 100 random 10-cc Vacutainers was 10.21 cc with a s.d. of 0.19 cc. The largest deviation from the mean was 0.45 cc, or 4.5%.

The measured activity of Xe-133 in the standard tube determined in the dose calibrator is plotted against time in Fig. 1. For purposes of comparison, the activity anticipated from decay alone is represented by the solid line. It is apparent that the curves nearly coincide and that therefore there is neither loss of xenon from the tube nor significant adsorption on the rubber stopper. The latter would change the counting geometry and produce a deviation from the expected curve.

The counting rate of the standard as measured in the well counter is plotted against time in Fig. 2. The counting rate anticipated from decay alone is represented by the solid line. The close agreement between actual and theoretical demonstrates that there is neither significant dead-time loss at count rates at least up to 200,000 counts per minute nor significant long-lived gaseous contamination. This particular standard would have been useful over a period of at least 30 days.

From the standard tube it was possible to calculate the number of counts per minute that represents the maximum permissible concentration (MPC) for restricted areas (10pCi/cc). For the 10-cc red-top Vacutainers and the counting equipment used this value was 30 cpm.

DISCUSSION

Rummerfield (*1*) suggested in 1971 that Xe-133 in room air could be monitored utilizing its solubility in water. In his technique a known volume of possibly contaminated air was drawn into a syringe containing a known volume of water. After agitation the water was transferred to a sealed test tube and counted in a well counter. Comparison with a standard was suggested for the purposes of quantitating the results. LeBlanc pointed out that equally satisfactory results could be obtained much more easily by counting the air sample directly (*2*). For the past 4 years we have used a similar method, as described above.

The MPC for Xe-133 in room air in restricted areas is 10pCi/cc. Commercial air monitors for the purpose of measuring such low levels are expensive, and many hospitals do not feel that they can justify the expenditure. Other laboratories with enough radioxenon studies to warrant purchase of a monitor might still find a simple system useful during equipment malfunction or in the event of a suspected leak when the monitor is in another room and the gas might dissipate before it could be measured. In these cases our system might be useful.

A possible source of error in this method is the slightly irregular draw of the 10-cc red-top Vacutainers used. But the maximum deviation from the expected draw was less than 5%, an error that would seem well within acceptable limits for this purpose. Further sources of possible error are leakage of xenon from the standard tube or redistribution within it due to adsorption on the rubber stopper. That these did not occur is shown in Fig. 1 by the near coincidence of the measured activity curve with the theoretical decay curve. Errors due to instability of equipment can be eliminated by counting against the standard. As a result of decay, a new standard has to be made up at approximately monthly intervals and allowed to decay for a suitable period (1½–2 mo).

The sensitivity of this method depends on sample and background count rate and counting times as described by Loevinger and Berman (*3*). According to their nomogram, the detection of Xe-133 concentrations at levels approaching the MPC for restricted areas (10pCi/cc) is readily possible. For our counting system, for example, with a background counting rate of 50 cpm and a counting rate at the MPC for restricted areas of 30 cpm, a counting time of 5 min each for sample and background would be sufficient to determine the MPC counting rate to an error of about 20%. To attain the sensitivity (0.3pCi/cc) necessary to monitor unrestricted areas, however, this method would require prohibitively long counting times.

The advantages of this method are convenience, simplicity, and low cost. Tubes and needles can be kept readily available in every room where xenon is used, handled or stored, and no delay need occur before sampling the site of a suspected leak. The major disadvantage is the possibility of missing an unsus-

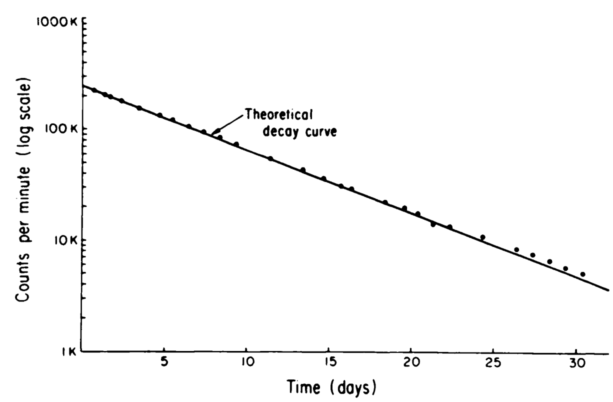

FIG. 2. Xenon-133 count rate in standard tube as measured over approximately six half-lives in a scintillation well counter. Again there is close correspondence with theoretical decay curve.

pected leak because the air is not checked at the right time; but even an expensive commercial air monitor can be in only one place at a time and cannot fully solve this problem.

ACKNOWLEDGMENT

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