CAN YOU FIND HOT HOUSES BY RADON DECAY PRODUCT SCREENING?

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ABSTRACT

It is well known that radon decay products attach to surfaces inside houses, and the famous Watrass house with a very high indoor radon concentration was discovered in the early 1980s when the radiation from these decay products was detected on the clothes of the Mr. Watrass after he left the house. This paper describes some preliminary experiments on decay product screening that suggest that this method might be useful in screening for houses with moderately elevated radon concentrations. In one experiment, alpha decay screening on clothing worn in two houses with indoor concentrations of about 10 pCi/L produced significant alpha counts for at least one hour after exposure. This effect appears to be highly sensitive to both the clothing fabric and to where on the body it is worn. In a second experiment, wipe samples from TV screens in two houses with indoor concentrations of about 4 pCi/L produced significant alpha counts for at least one hour after the wipe. Screening tests of alpha decay on clothing might used to survey people in public places, like shopping malls, who would be likely to have recently come from their homes. Wipe tests from TV screens might be used to survey targeted groups, such as the workers in an office building, who could be asked wipe a tissue across their TV screen just before leaving for work.

INTRODUCTION

It has proven to be much more difficult than anticipated to encourage widespread radon testing in order to find houses with elevated levels. One reason for this apathy may be the fact that conventional radon screening test methods require special test devices that must be brought into the home, and these test methods do not directly indicate any effect on anyone or anything in the house. It is difficult to become alarmed over long-term, invisible, abstract risks, and so radon is easy to ignore. A radon screening method that directly indicated a person's body, clothing and possessions were radioactive might be perceived as a more significant risk.

This report discusses a two methods for directly demonstrating that home radon concentrations can make the occupants and their possessions measurably radioactive, even after they leave the house. In addition to increasing the awareness of radon so that more people will be encouraged to test and mitigate, this technique could provide a method to screen for high radon houses. The technique consists of screening for the radiation emitted by radon decay products deposited on people and television (TV) screens sets inside the home. Ironically, one of the first indications of the U.S. indoor radon problem came in the early 1980s when the decay products deposited on Stanley Watrass led to the identification of very high radon levels in his house. These decay products were detected by portal monitors at the Limerick nuclear power plant where Watrass worked. However, decay product screening (DPS) does not seem to have been suggested as a screening tool for houses with moderate radon levels.

Preliminary experiments by GEOMET in houses with moderate radon levels confirm that radon decay products can build up on clothing and on television screens within a few minutes to levels that can be detected for an hour or more with inexpensive radiation monitors. This suggests that DPS could be used to screen for houses with high radon by either testing for decay products on clothing, or by asking the occupants to bring a sample of dirt collected by wiping a tissue across the face of their television screen. The demonstration that radioactivity in their houses would provide a graphic demonstration of the indoor radon problem.

THEORY AND PREVIOUS MEASUREMENTS

Decay Rate of Radon Decay Products

How fast do radon decay products decay? Figure 1 shows the theoretical alpha activity and the gamma activity of the radon decay products versus time. These plots were calculated using the familiar Bateman equations published in 1910. The approximate half life is about 45 minutes for a mixture of radon decay products. This rate suggests that any screening program

should concentrate on persons who have left their houses within one or possibly two hours. Figure 2 shows the individual contributions to alpha activity of the various radon decay products.

Gamma Versus Alpha Detection

It is not obvious from the decay curves whether alpha or gamma radiation should be used for screening. Our initial guess is that alpha is preferable since there is no significant background, and therefore every count is suspicious. A hand-held detector can be used for alpha, and the orientation of the detector is not significant with regard to environmental background. Gamma may be more difficult to evaluate because there is a background level from the earth and building that makes it difficult to use an unshielded hand-held monitor. Changes in the gamma detector orientation may significantly change the background count rate. Therefore most of the GEOMET experiments have therefore been done with an alpha radiation monitor. Both types of detectors would have to be held in contact or very close to the material being screened.

Attachment of Decay products to Skin and Clothing

We know from the Watrass case that very high indoor radon concentrations (over 1000 pCi/L) will produce measurable decay product radiation for several hours, but what about concentrations closer to 10 pCi/L? One relevant reference on radon decay product deposition in houses is Arthur Scott's paper on radon daughter deposition (1). Scott reports the deposition rates on a variety of stationary vertical and horizontal surfaces (walls, floors and tables). No data for deposition on people was reported.

Scott's data suggests that if deposition rates on people are similar to the deposition rates on walls and floors, the we could measure the alpha activity shown in Figure 3 with a typical alpha monitor. For instance, one hour after leaving a house with 10 pCi/L, an alpha monitor (Ludlum Model 1000 scaler with Model 43-2 alpha scintillator) would pick up about 2 counts per minute (cps) on the skin or clothes. If the house were 100 pCi/L the count rate would be about 20 counts per minute. These count rates suggest that it would take several minutes to screen a person who had just left a house with 10 pCi/L. However, this calculation does not take into account the possibility that certain fabrics or parts of the body may have significantly different attachment rates than the materials tested by Scott.

Initial Experiments

In order to determine the potential for using DPS on houses at moderately elevated levels, an experiment was conducted on March 19, 1993. David Saum entered the house with moderately elevated radon levels on 3/19/93 and worked for 25 minutes in the basement where a continuous radon monitor indicated about 10

pCi/L. He then returned to the GEOMET lab within 15 minutes and used a hand-held alpha detector to measure the alpha and gamma activity of his skin and clothes. Levels as high as 67 cpm were measured on the knee of the pants. The pants were made of a 60/40 polyester blend fabric. Measurements on skin, socks, hair and shirt were much lower (1 to 6 cpm). On 3/29/93 a similar experiment in the same house produced similar results. These measurements demonstrate that brief exposures to moderate home radon concentrations produce measurable alpha activity on some types of clothing.

On 4/12/93, wipe tests were conducted on TV screens in two houses with radon concentrations of about 4 pCi/L. A facial tissue was wiped across the face of the TV screens in each house (the sets were on) and a faint dirt deposit was noted on both tissues. Within 45 minutes the tissues were tested for alpha activity at the GEOMET lab and activities of 97 and 45 cpm were measured. These measurements suggest that charged TV screens attract dust particles with attached decay products, and these decay products could be used to screen for moderately elevated radon concentrations.

Sensitivity to Clothing Fabric

The 3/19/93 clothing DPS experiment suggests that certain fabrics have a much higher affinity for radon decay products than the Scott paper would suggest. Figure 3 shows the measured activity on two types of clothing after the 20 minute exposure to approximately 10 pCi/L. The diamonds show the measurements near the knee of pants made of 60/40 cotton polyester blend fabric. The ovals show measurements made on orlon socks. A 100% cotton shirt showed practically no activity. Hair, skin, and leather showed slight activity. This data suggests that certain fabrics (e.g. polyester) attract many more radon decay products than others (e.g. cotton). If we knew which fabrics had the highest attraction, then we could screen people more quickly. Rubbing the fabric did not seem to have much effect on the alpha activity.

The measurements on the pants and socks varied considerably across the fabric. The knee of the pants showed much more activity than the sides of the leg or the bottom of the pants. The sock activity was higher at the bottom than at the top. This suggests that there may be a sensitivity decay product attachment to motion or some other factor. If we understood this variation, then it might allow us to speed up the screening procedure.

The EPA Las Vegas Laboratory has conducted some recent radon chamber experiments with a clothed dummy exposed to a concentration of 100 pCi/L that fail to show significant alpha activity on the clothing (2). This may indicate that motion of the human body inside clothing is a vital component in the attachment of the decay products to the clothes. The movement might build a static charge that increases the attachment rate.

Conclusions from Initial Experiments

The GEOMET experiments suggest that after relatively short exposure in a house with moderate radon levels, some items of clothing and TV screens can pick up enough radon decay products so that a quick alpha screen can detect them up, even after one to two hours. More work needs to be done to identify the fabrics and locations on the body with the highest decay product attachment potential.

Test Equipment Required for DPS

Alpha monitors that could be used for quick decay product screening are available for around $1,000 or less. Besides sensitivity and ease of use, some useful features include: a speaker that allows the unit to "beep" with each count, and a timed counter that automatically tallies cpm. For example, the current Ludlum Measurements, Inc. catalog lists at least three monitors suitable for DPS, ranging in cost from $700 to $1200.

POTENTIAL USE OF DPS

DPS utilizing clothing might be done in a public place like a shopping mall. The person doing the screening would have a hand-held alpha counter, and they would have to be trained to identify the types of clothing and locations that have the highest decay-product attachment potential. Anyone volunteering to be tested would be asked how long it has been since they left their house. Of course, anyone being tested would be told that DPS is not a calibrated measurement of indoor radon, and just because they test low, they should still test their house with a multi-day screening test. In addition, the low risk from the radiation being measured on their clothing should be explained, while the much higher risk from inhaling decay products when they are in their houses should be emphasized.

DPS using wipe tests from TV screens might be useful in screening targeted groups such as the workers in an office building. An announcement could be made that the test would be conducted on a given morning, and that anyone who wished to participate should turn their TV set on in the morning for a few minutes and then wipe a tissue across the screen just before they left the house. These tissues would be collected as the workers arrive at the office, and the alpha activity of each tissue could be measured in about one minute. High readings would be followed up with conventional screening tests.

CONCLUSIONS

On the basis of GEOMET's preliminary look at the theory and the initial test results, DPS appears to be a very promising approach to graphically demonstrating the threat of indoor radon and for screening for hot houses. Some initial conclusions:

1. alpha detection looks more promising than gamma detection,

2. houses as low as 4 pci/L might be detected if the alpha screening is done within an hour,

3. DPS is very sensitive to fabric type and position on the body,

4. The count rate for simple alpha detector is high enough to do a scan in a few seconds for hot houses and a more detailed scan in a couple of minutes.

5. The alpha monitor cost is $700 to $1100.

RECOMMENDATIONS FOR FURTHER DPS DEVELOPMENT

In order to determine the potential of DPS, the initial experiments need to be confirmed and extended:

1. Radon chamber studies should be conducted to measure the precise relationships between decay product deposition and clothing type, movement, radon concentration, etc. Similarly, TV screen deposition rates should be studied in radon chambers.

2. Pilot studies should be conducted to see how these techniques work under field conditions. Follow-up tests with conventional radon test kits should be made to see what radon levels are actually found in homes where the occupants have measurable alpha activity.

3. The following questions may warrant a literature search and more extensive experiments:

   a. How much exposure time is required to build up an equilibrium level of decay products?

   b. What types of alpha emitters could cause false alarms in DPS testing, and is gamma screening preferable in some situations?

   c. Are there any other relevant factors that may be important such as humidity, motion, building operation, or temperature?

REFERENCES

1. Scott, A., "Radon Daughter Deposition Velocities Estimated for Field Measurements", Health Physics, Vol 45, No. 2, pp. 481-485, August 1983.

2. Phone message from R. Hopper, EPA Las Vegas Laboratory, to D. Saum, July 1993.

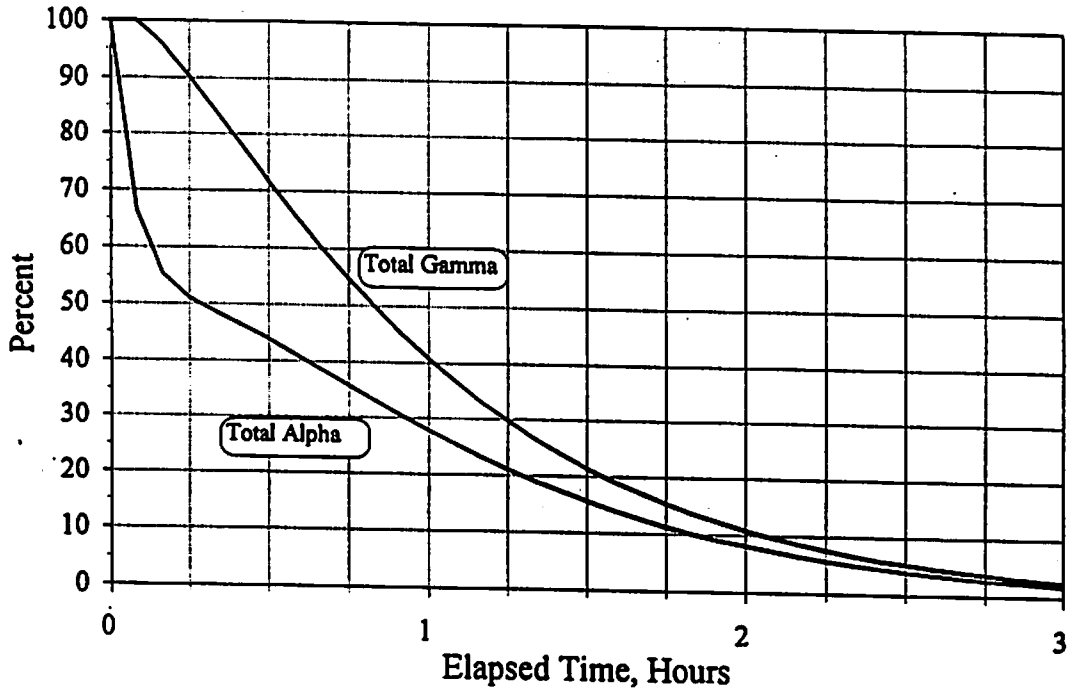

Figure 1 Theoretical Decay of Radon Decay Products

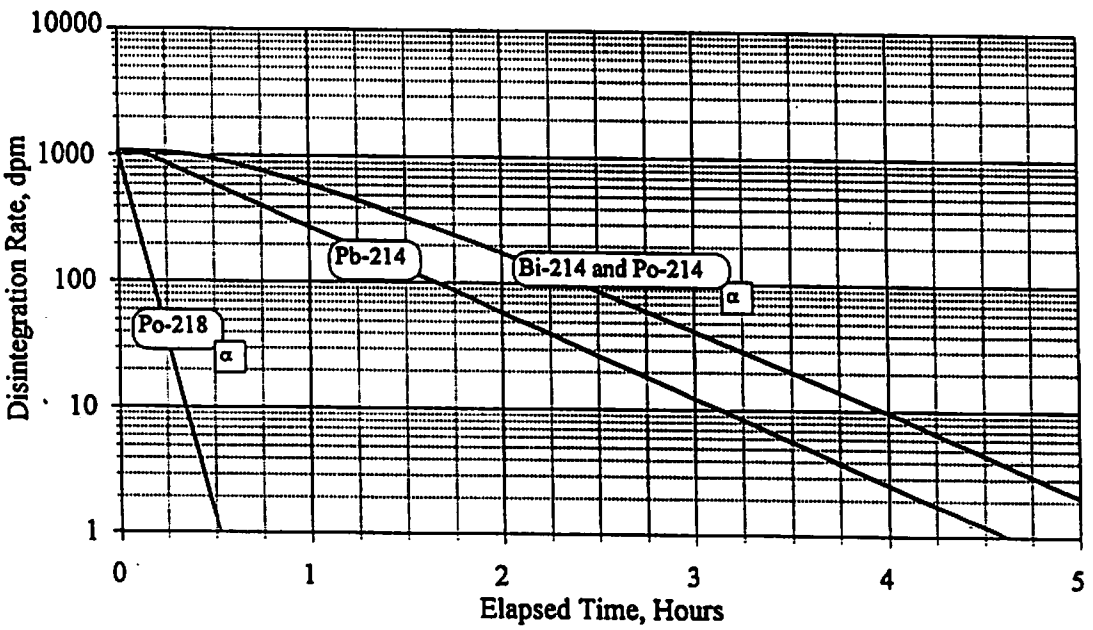

Figure 2 Theoretical Alpha Activity of Radon Decay Products

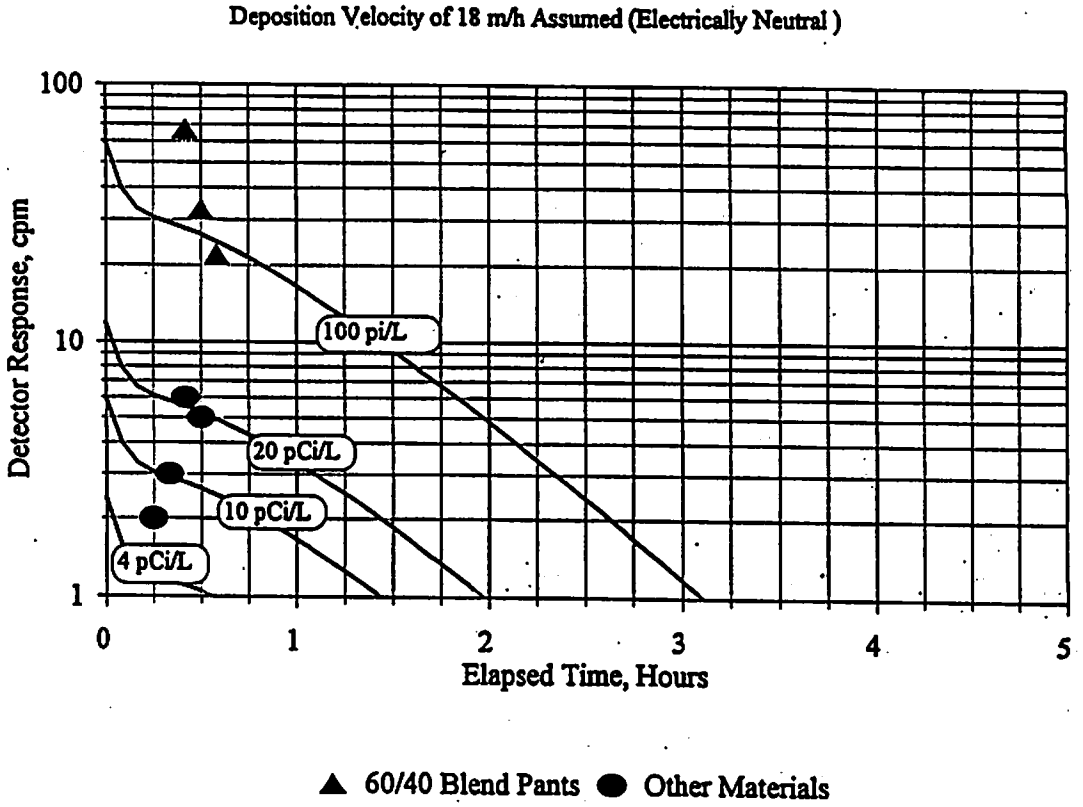

Figure 3 Alpha Activity: Theoretical and Measured