

SUMMERTIME SHORT-TERM NEGATIVE RADON TESTS NEED TO BE RETESTED IN WINTER

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Abstract—The Alabama Radon Program conducted a study to see if short-term radon tests performed during the summer air-conditioning season, and having results less than the U.S. Environmental Protection Agency (U.S. EPA) action level of $1.48 \times 10^2 \text{ Bq m}^{-3}$ (4.0 pCi L^{-1}), were a reliable means in determining whether a house is in need of a radon removal system. Using a database of past Alabama Radon Program tests, individuals whose homes had tested less than the action level during the previous air-conditioning seasons of 2003, 2004, and 2005, were offered a free kit to conduct a wintertime retest. The study was done by mail, utilizing an initial contact letter, with participating homeowners being mailed liquid scintillation radon detection kits in January of 2006, performing the test, and mailing the completed test vial to the laboratory for analysis. There were 186 valid wintertime retests successfully completed statewide, with 27% having results greater than or equal to $1.48 \times 10^2 \text{ Bq m}^{-3}$. One hundred and six of those retests were in the known highest radon incidence areas of Alabama, where 41% tested at or above the U.S. EPA action level, some significantly higher. This study demonstrates that in the known high radon areas of Alabama there exists approximately a one-in-three chance that a house tested in the summertime and having a radon concentration of less than the action level will have a wintertime retest result equal to or greater than the action level. *Health Phys.* 93(1):74–77; 2007

Key words: radon; ^{222}Rn , indoor; radioactivity, environmental; radiation protection

INTRODUCTION

IN A 2006 survey of Alabama mitigators, the mitigators estimated that approximately half of the radon removal systems currently being installed in Alabama were a result of radon discovered during a real estate transaction-related radon test. The Alabama Radon Program, a partnership

between the Alabama Department of Public Health and the Alabama Cooperative Extension System, has for many years encouraged individuals to require a radon test as a part of their purchase of any new residence, as it is an important step in the reduction of cumulative radon exposure. In the U.S. Environmental Protection Agency's (U.S. EPA) *Home Buyer's and Seller's Guide to Radon* (U.S. EPA 2005), both long-term (greater than 90 d) and short-term (between 2 and 90 d) tests are advocated, but due to the time-dependent nature of a real estate closing, only radon tests of short-term duration (2 to 4 d) are routinely utilized. In Alabama, most residential real estate transactions occur in the warmer months of May through September, according to the records of the North Alabama Real Estate Information Service (2005). Therefore, the purpose of this study was to see if short-term radon tests performed during the summer and having results less than the U.S. EPA action level were a reliable means of determining whether a house is in need of a radon removal system. Funding for this project was provided in part by a grant from the U.S. EPA through the Conference of Radiation Control Program Directors, Inc. (CRCPD).

Both the initial summertime tests and the wintertime follow-up tests in this study were done with short-term passive devices. The assumption is made that the results would be the same as if these tests had been made using a continuous radon monitor as is typical in real estate transaction-related radon testing in Alabama. For the purpose of making a recommendation to the occupants, the Alabama Radon Program compared the average of the summertime and wintertime passive radon tests to the U.S. EPA action level.

U.S. EPA established their action level of $1.48 \times 10^2 \text{ Bq m}^{-3}$ in relation to the average radon concentration over a full year. The current industry practice for radon testing related to real estate transactions is not to test for a full year. The guidance in the U.S. EPA's two most widely circulated publications, *A Citizen's Guide to Radon* (U.S. EPA 2004) and *Home Buyer's and Seller's Guide to Radon* (U.S. EPA 2005), both advocate using a

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testing period of far less than a full year to ascertain if a residence should be considered in need of mitigation due to excessive radon. The concept of annual average is not emphasized in the U.S. EPA materials provided to the public. For example, the summary on the inside cover of the *Citizen's Guide to Radon* says "Fix your home if the radon level is 4 picoCuries per liter (pCi/L) or higher," and the summary information on the inside cover of the *Home Buyer's and Seller's Guide to Radon* says "Fix the home if the radon level is 4 picoCuries per liter (pCi/L) or higher," with no indication in either case of the duration over which said radon level exists. Thus, the predominate practice among real estate professionals in Alabama is that once a residence has a properly conducted (per U.S. EPA publications) radon test with valid results above the U.S. EPA action level, that residence is considered to have a known radon problem requiring mitigation prior to sale. For the homeowner trying to sell their house, any properly conducted radon test with results greater than the U.S. EPA action level is a radon problem.

MATERIALS AND METHODS

Dating back to 1987, the State of Alabama's radon program has maintained records by zip code of homes tested for radon in Alabama, and now maintains over 36,000 records. The percentage of residences with initial short-term radon tests greater than the U.S. EPA action level within a given zip code is utilized as an indicator of the relative potential for the residences within that zip code to have a radon test in excess of the U.S. EPA action level. Analysis of this one-house, one-result database appears to indicate that elevated residential radon is detected less frequently when the radon test is made in the summer, indicating a possible seasonal bias in radon concentrations. Since 2001, the Alabama Radon Program has sold or distributed radon test kits and maintained a confidential database of names, addresses, and radon test results of those who utilized radon test kits from their distribution. To ascertain the effectiveness of summertime short-term real estate transaction-related radon tests to correctly predict the need for a radon mitigation system, 489 individuals who had tested for radon between May 20 and September 24 in 2003, 2004, or 2005, utilizing a radon test kit obtained from the Alabama Radon Program, and having radon results less than the action level, were sent a letter in November 2005 offering them a free retest in January of 2006. Those 489 individuals included all summertime negative tests during those three years from Alabama's high radon counties as defined by being U.S. EPA Zone One. Of the

original 489 letters sent out, 300 returned written acceptance of the offer, and those participants were mailed short-term liquid scintillation radon test kits with instructions to retest in the same location as their previous summertime test. The liquid scintillation test kits utilized in the study were purchased from AccuStar Laboratories of Medway, Massachusetts.

Of the 300 individuals to whom test kits were distributed, 31 were sent quality control duplicates and asked to perform those tests side by side with identical opening and closing times. Of the 31 individuals who were sent duplicates, eight did not mail their completed test vials back to the laboratory; apparently they never conducted the retest. Another three exposed their duplicate vials longer than the maximum allowable 96 h, thus making their test results invalid. And one individual returned their duplicate test vial after it was too late for accurate analysis. A total of 19 sets of duplicates produced valid test results. Two of the valid duplicate results were completed after February 24 and thus not considered winter; and one pair of duplicates was utilized in a different house than the prior summertime test. Therefore, 16 of the valid duplicate results were averaged and used as a part of the valid wintertime retests. With one exception, the duplicates were within standards of Exhibit 3-2 of U.S. EPA's *Protocols for Radon and Radon Decay Product Measurements in Homes* (U.S. EPA 1993). The one exception had both vials exceeding the U.S. EPA action level with a relative percentage difference of 68% between the two results. Upon questioning, that homeowner admitted that the two tests were done simultaneously on opposite sides of the same room.

Seasons redefined

For radon testing in Alabama, we defined summertime from May 20 until September 24 because those are the dates the daily average temperature is 21 degrees Celsius or greater at the Huntsville Airport. The areas of Alabama with the greatest occurrence of initial indoor radon test results greater than the U.S. EPA action level are in north Alabama on the same general latitude and with the same general climate as Huntsville. During this time, the outside air is typically significantly warmer than the constant ground temperature and, due to air-conditioning, the temperature inside the residence is typically lower than the outside air temperature.

November 28 through February 24 was selected as the arbitrary period of winter radon testing. Before and after those dates, the average daily high temperature at the Huntsville Airport is above the area's constant ground temperature. Further, during those dates, the outside air typically is consistently colder than the interior temperature of residences.

Participation and response

The wintertime retests were mailed to the 300 participants during the first three weeks of January 2006. This mailing period was chosen in hopes that the retests would be completed during the winter heating season. A total of 235 participants or 78% returned their test kits by mail to the laboratory. Of the 235 attempted residential tests, 29 were invalid, as 14 were received by the laboratory too many days after completion of the test to produce a valid result, 10 had been exposed longer than the maximum 96 h allowed, 3 could not be evaluated because the opening or closing times and dates were not provided, 1 was returned opened, and 1 was invalid because it had been tampered with prior to return.

Data pertaining to the address and floor level tested in the wintertime retest houses were compared with similar information from the initial summertime test data and homeowners were contacted to resolve any discrepancies. Results with unresolved discrepancies were removed from being considered wintertime retests. Two results of retests were removed because the wintertime test was performed at a different address than the summertime test and one result was removed because the wintertime test was done on the first floor while the summertime test had been done in the basement. Then results of retests completed after February 24 were removed as they were not considered wintertime retests of previous summertime negative radon tests. Thus, 186 participants successfully retested in the winter.

RESULTS

Of the 186 retests statewide, 63% tested higher in winter than in their previous summer test, 6% tested the same, and 31% tested lower in winter than in their

previous summer test. More importantly, 27% of the 186 results statewide had wintertime test results greater than or equal to the action level. The primary concern of this study was to examine the reliability of short-term summertime radon tests in the areas where a high percentage of homes are known to have radon problems. There were 106 successful wintertime retests in zip codes where our database of initial residential tests shows over 22.5% of the homes test above the U.S. EPA action level. Of those 106 high radon zip code retests, 43 (or 41%) had wintertime radon test results equal to or greater than the U.S. EPA action level, despite having summertime measurements less than the U.S. EPA action level. As shown in Fig. 1, during the winter retest in high radon zip codes, 11 (or 10%) had radon concentrations of more than five times the U.S. EPA action level and 21 (or 20%) had radon concentrations of greater than twice the U.S. EPA action level.

For 30 (or 28.3%) of the 106 high radon zip code retests, the average of the summertime test and the wintertime test exceeded the U.S. EPA action level and the state recommended a radon mitigation system. For 13 (or 12.3%), the wintertime test result exceeded the U.S. EPA action level but the average of the summertime test and the wintertime test did not and the state recommended they conduct a long-term radon test for a full year to determine the need for a radon mitigation system. For those whose summertime and wintertime radon tests were both less than the U.S. EPA action level, the state thanked them for their participation.

Interpretation

The authors postulate that the observed variation is temperature driven. In Alabama, during the radon testing

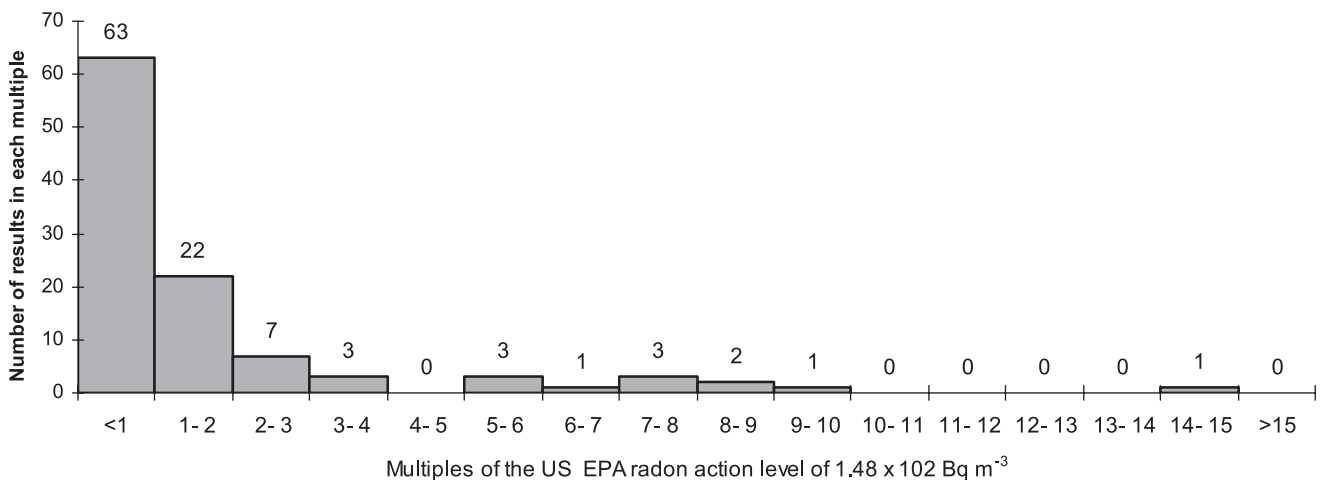


Fig. 1. Results in multiples of the U.S. EPA action level for the 106 wintertime retests of previous summertime negatives in Alabama's known high radon zip codes.

summer dates, the utilization of air-conditioning is almost universal, leaving the interior of the residence cooler than the ambient air. This diminishes the thermal rise stack effect within the house. With little thermal rise pushing hot air into the attic, there is equally little soil gas being pulled in from below.

During the radon testing winter dates, the ambient air temperature is usually predominately less than the constant ground temperature, thus there exists the possibility of a thermal rise within the soil to bring radon up beneath the residences. Further, during the winter dates, the interior of the residences will be warmer, often considerably warmer, than the outside temperature. This results in thermal rise within the house, causing soil gas to be drawn in from below.

January of 2006 was one of warmest Januarys ever recorded in Alabama (Roney 2006), and 72% of the successful winter retests in the known high radon zip codes were conducted that month. Despite being retested in a milder than normal winter, significant seasonal differences were still observed. If the observed seasonal variation is, as the authors believe, associated with relative temperature differences, then the variation would be expected to be greater in winters where temperatures are closer to or below the average for that time of year.

CONCLUSION

The existing practice in real estate transaction-related radon testing of utilizing a test of short duration during the summer provides the homebuyer with a false assurance that the residence will have radon concentrations below the U.S. EPA action level year-round. Alabama's high radon zip codes have an occurrence rate

of approximately one-in-three for elevated wintertime radon in houses that previously had summer tests below the U.S. EPA action level. This is of particular importance to families purchasing a house in a high radon area during the summer and having the house test negative for radon as a part of the real estate transaction and feeling "safe" from radon. Therefore, the Alabama Radon Program recommends that the reports of short-term real estate transaction-related radon tests done in the summer air-conditioning season with results of less than the U.S. EPA action level contain a recommendation that the radon test be repeated during the following heating season.

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