UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

December 9, 1991 EPA-SAB-RAC-92-003 OFFICE OF THE ADMINISTRATOR

Mr. William Reilly
Administrator
United States Environmental Protection Agency
Washington, D.C. 20460

Re: Correlation of Short-term and Long-term Tests for Radon

Dear Mr. Reilly:

It is a pleasure to transmit to you the Science Advisory Board's report on the review of the "Correlation of Short-term and Long-term Tests for Indoor Radon".

Radon gas is present in all homes. Approximately 6% (about 5 million) of the homes are estimated to have levels exceeding the EPA guideline of 4 pCi/L annual average radon concentration.

There are a number of relatively inexpensive measurement devices and methods available for assessing the levels of radon gas in homes. These devices or methods can be separated into broad classes, depending upon the sampling time. The short term techniques can generate information in a relatively short period of time, from a few days to a few weeks (e.g. charcoal canisters and short-term alpha track detectors). These methods provide a "snapshot" of conditions in the house (usually with the house closed more tightly than it would be under more typical living conditions). The principal drawback to using such devices or methods arises from the variable nature of indoor radon concentration, which can change significantly over the course of a day, a few days, or from season to season. Long-term devices or methods (e.g. long-term alpha track detectors) provide a better picture of the average conditions in the home throughout the year, but in order to obtain the resulting concentrations, the integration period must be long enough to average over the season-to-season variations. The deployment periods are typically nine months to a year or longer.

The test results should be as accurate as possible, particularly those around the guideline or action level. The goal is to avoid the situation in which a homeowner conducts a measurement that indicates a radon level above (or below)

the action level, when, in fact, the actual radon level is below (or above) the action level; i.e., a "false positive" (or a "false negative"), respectively. For example, if a measurement strategy leads to 50% false positive (or false negative) results, this would mean that half of those who thought they were over (or under) the action level really were not. This situation would result in poorly informed decisions being made by the homeowners.

The Board was asked by the Office of Radiation Programs (ORP) to examine how well the available annual average testing method approximates the "true level" of radon in the home; how well results from available short-term tests correlate with results from long-term tests; and what improvements can be made to increase the likelihood that correct decisions will be made by citizens based upon test results. The Agency prepared an document, "Analysis of the Relationship of Short-Term Measurements to Annual Measurements in Support of the Citizen's Guide Revision" (Analysis), which provided a foundation for the Board's discussion of these issues and for an assessment of the impact of using short-term measurements as the sole basis for remediation decisions.

The Board concluded that the one-year (AATD) radon measurement--taken in the lowest lived-in space--is a good approximation to the "true level" of radon in the home and is the standard against which other measures of radon levels should be judged, even though there are inherent uncertainties in this measurement.

With regard to using a single short-term test as the sole basis for estimating long-term average concentrations--from which individual mitigation decisions might be derived--the Board has two concerns. First, the false positive rate for radon concentrations near 4 pCi/L can be quite high (over 50%), indicating the need for verification with a more definitive long-term test. Second, while results in excess of 10-15 pCi/L have more acceptable false positive rates, even these screening tests should be verified with at least a second short-term test in order to guard against gross errors, such as clerical errors in the lab, and to ensure that the long-term average concentration is above the guideline.

The following steps would increase the likelihood of correct remediation decisions being made: improving the testing method and/or adopting measurement strategies that more accurately estimate the levels to which people are actually exposed.

As to whether there are procedures by which long-term concentrations in the lived-in space may be better estimated--short of performing a long-term measurement--the Board is aware that the Agency is currently analyzing several alternatives as part of the proposed Citizen's Guide revisions. The Board would be pleased to provide a review of this effort at the appropriate time. At the moment, it appears that the Agency's original advice, that of using a short-term

screening measurement as an indicator of whether to perform a long-term measurement, remains the most scientifically defensible position.

We appreciate the opportunity to examine this important issue. We look forward to hearing from you how this report and its conclusions are viewed and utilized by the Agency.

Sincerely,

Raymond C. Lechr

Raymond C. Lechr, Ph.D.
Chair, Executive Committee

Oddvar F. Nygaard. Ph.D.
Chair, Radiation Advisory Committee

Enclosure

EPA United States Environmental Protection Agency

Science Advisory Board (A-101)

EPA-SAB-RAC-92-008
December 1991

AN SAB REPORT: CORRELATION OF SHORT-TERM AND LONG-TERM TEST RESULTS FOR INDOOR RADON

PREPARED BY THE RADIATION ADVISORY COMMITTEE

NOTICE

This report has been written as part of the activities of the Science Advisory Board, a public advisory group providing extramural scientific information and advice to the Administrator and other officials of the U.S. Environmental Protection Agency. The Board is structured to provide a balanced expert assessment of scientific matters related to problems facing the Agency. This report has not been reviewed for approval by the Agency; and, hence, the contents of this report do not necessarily represent the views and policies of the Environmental Protection Agency or other agencies in the Federal Government. Mention of trade names or commercial products does not constitute a recommendation for use.

ABSTRACT

The Radiation Advisory Committee of the Science Advisory Board reviewed the Office of Radiation Program's approach to analyzing the effects of substituting short-term tests for long-term tests in determining the concentration of radon gas in homes.

The Committee endorsed the long-term test in the lowest lived-in space as the standard against which other test results should be judged; noted that the lower the radon level, the less accurately informed the homeowner is likely to be by results obtained with currently available test devices; expressed concern about the false positive and negative rates that are likely to result from short-term tests near an assumed action level of 4 pCi/L; and noted that the long-term test, when properly done, provides a more scientifically appropriate basis for mitigation decisions, particularly in the range of radon levels most commonly found in U.S. homes. The Committee observed that improving the test methods and/or improving the means of estimating actual radon exposure could lead to a greater number of correct mitigation decisions.

Keywords: indoor radon measurement; mitigation; charcoal canister; alpha track detector

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TABLE OF CONTENTS

1. EXECUTIVE SUMMARY

The Office of Radiation Programs (ORP) of the Environmental Protection Agency (EPA) requested that the Radiation Advisory Committee (Committee) of the Science Advisory Board (SAB) review materials being prepared for the revision of "Citizen's Guide to Radon" in order to "assess whether the scientific radon risk assessment information is appropriately summarized in the public information materials." Among the materials was an ORP analysis concerning the possible use of the results of a short-term indoor radon measurement as the sole basis for deciding whether or not to take steps to reduce the radon levels in homes. Currently EPA recommends using the short-term results as a screening test, followed by a longer-term test for more definitive determinations, prior to making a mitigation decision.

The Committee's principal findings and recommendations are the following:

a. The use of a one-year radon measurement is the standard against which other measures are judged because the longer integration period more closely reflects the average annual concentration of radon in the building.

b. Measurements of indoor radon should be made in the lowest lived-in space, rather than the lowest livable space, since this more closely reflects conditions of actual human exposure.

c. Because the error rate increases as radon concentration decreases, the lower the action level chosen, the more frequent false negative and false positive results will be and, therefore, the more frequently mitigation decisions will be made based on inaccurate information.

d. For an action level of 4 pCi/L, the available data indicate that the false positive rate is around 50%, which is quite high. Therefore, for an action level of 4 pCi/L, sole reliance on a single short-term test could result in approximately 10% of all U.S. homes (5-10 million homes, if all homes were tested) being recommended for mitigation even though their "true" radon levels are below the action level.

e. The long-term test, when properly done, provides a scientifically more appropriate basis for mitigation decisions. Therefore, the Agency should continue to use and recommend the use of long-term measurements as the basis for mitigation decisions in the range around 4 pCi/L.

f. Improved testing methods, particularly those that would provide a better estimate of radon exposures actually experienced, will lead to better mitigation decisionmaking.

2. INTRODUCTION

2.1 Background and Process Considerations

The risks posed by radon gas in homes across the country have attracted considerable attention in scientific journals, the news media, and regulatory bodies at the local, state, and national levels. These risks are generally regarded as high when compared to risks posed by other environmental problems (cf., Reducing Risk, USEPA 1990, and Unfinished Business, USEPA, 1987). And yet, questions about regulatory authority and the absence of readily identifiable "responsible parties" have confounded attempts to mount a concerted national response to the problem.

In an effort to clarify the situation, in 1986, EPA's Office of Radiation Programs (ORP) produced the "Citizen's Guide to Radon" (Guide). This booklet was aimed at communicating directly with the public about what the radon problem is, how the individual can assess his/her own situation, and what the individual can do to mitigate exposures that are deemed to be excessive.

In a February 7, 1990 memorandum to the Staff Director of the Science Advisory Board (SAB), the Director of ORP requested that the SAB review technical documents that support an updating and revision of the Guide. At the February 15-16, 1990 meeting of the SAB's Radiation Advisory Committee (Committee), ORP identified two specific issues for SAB attention:

a. The estimate of radon risks to smokers, non-smokers, and children.

b. The correlation of estimates of in-house radon levels obtained from long-term measurement procedures vs short-term procedures.

The first issue was the subject of a separate SAB report (SAB, 1991a) and is also discussed in an SAB report on revised radon risk estimates and associated uncertainties (SAB, 1991b). The second issue is the subject of this SAB report. At its May 17-18, 1990 meeting, the Committee received a detailed briefing on the correlation study approach, as described in ORP's "Analysis of the Relationship of Short-Term Measurements to Annual Measurements in Support of the Citizen's Guide Revision" (Analysis).

As a part of its program of evaluating possible modifications in the recommended testing methods for indoor radon in homes, EPA has analyzed the relationship of short-term to long-term test measurements. Two types of incorrect decisions could be made, based on short-term measurements alone. The first would occur when a short-term measurement result is above the action level, when, in fact, the long-term test result (which more accurately reflects the annual average radon level) is below the action level. In this case, the short-term result would be a "false positive". The second incorrect decision would occur when a

short-term test result is below the action level, when, in fact, the long-term test result is above the action level. In this case, the short-term test result would be a "false negative". In each case, the short-term test result would suggest an inappropriate course of action to the homeowner: in the false positive case, remediation, where none was really needed; and in the false negative case, no action, when remediation might well be the more appropriate course of action.

In the Analysis the Agency examined the relationship between short-term and long-term (i.e., one year) measurements for several different short-term testing strategies and testing devices. The strategies all involved testing on either a lowest lived-in or lowest livable level of the dwelling. The devices used were 2-day open-faced charcoal canisters (CC) and 60- to 90-day alpha track detectors (60-90 ATD). All of the year-long measurements were made with alpha track detectors; i.e., annual alpha track detectors (AATDs). The Analysis includes estimates of the percentage of incorrect remediation decisions as a consequence of false results (false positive or false negative) expected in the testing population when the decision is based solely on short-term measurements.

Additional context for the issue can be found in the following passage from the Analysis:

> *In revising the Citizen's Guide to Radon, Congress has required the Environmental Protection Agency (EPA) to evaluate the relationship of short-term to annual measurements. This relationship is an important consideration in determining any modification in testing methodology for the revised 'Citizen's Guide'. One of the goals of the revision is to streamline the testing process. Therefore, several of the proposed testing methods involve mitigation decision making based on short-term measurement. It is critical to understand the degree of error to be expected in the population (how often homeowners would make wrong decisions concerning mitigation based on short-term measurement).*
>
> *This analysis examines the relationship of wintertime short term measurements to annual measurements for several different testing methods as well as testing devices. It also attempts to define the fraction of incorrect decisions expected in the testing population when the decision to mitigate is based on a short-term measurements.*

After hearing the ORP presentation and discussing the matter, the Committee drafted a report and circulated it for comment. On June 14, 1990, ORP provided supplementary written material on the correlation study approach. This material, a letter from Committee member Dr. Genevieve Matanoski, and a revised draft of the report were distributed to the Committee for further revision on June 25, 1990. Subsequently, the Committee worked on various drafts of the report, refining its conclusions and recommendations, finally approving the report by mail June 24, 1991. The report was approved by the SAB Executive Committee (EC)

at their meeting on July 23, 1191, contingent upon text changes being made to the satisfaction of EC vettors.

2.2 The Charge

The Committee and ORP agreed upon a charge at the May 17, 1990 meeting, to the effect that the Committee would review the Analysis for scientific and technical accuracy, with specific emphasis on the following questions:

a. Is it reasonable to assume that an annual alpha track detector measurement represents the true radon level in the living space?

b. Is the method used by EPA in the Analysis appropriate for determining how often a short-term test (e.g., charcoal canister and 60- to 90-day alpha track detector) would result in a mitigation decision different from that based on a long-term (i.e., annual alpha track detector) test?

c. What can be done to increase the likelihood of a correct mitigation decision being made on both an individual basis and on a national basis?

3. RESPONSES TO THE CHARGE

3.1 Is it reasonable to assume that an annual alpha track detector measurement represents the true radon level in the living space?

Cancer risks posed by indoor radon depend upon the concentration of radon in the home and the extent to which people are exposed to those concentrations. Therefore, the average risk depends upon the average concentration of radon and the activity patterns of people in the home.

The radon concentration in the home varies throughout the year, reflecting changes in the seasons, the weather, household conditions (e.g., forced air heating and air conditioning and open doors/windows), and the like. A longer integration period more closely represents the "true radon level". Since a single short-term radon measurement captures only a "snapshot" of the radon concentration at some point in time, a long-term measurement that averages these long-term fluctuations provides a better estimate of the true average level of radon at the location of the detector.

Therefore, the preferred measurement would be made with AATD placed on the lowest lived-in level, which is the likely site of the greatest radon exposure.

At present, charcoal canisters (CC) and alpha track detectors (ATDs) are the two most widely used methods for measuring radon concentrations in homes. The CC measurements are usually made for shorter periods of time, typically two days for open face canisters and up to 10 days for diffusion barrier charcoal canisters. The ATDs measurements are used for both 60 to 90 day periods (60-90 ATDs) and annual measurements (AATDs). It would be possible to make multiple CC or 60-90 ATD measurements in order to obtain information on variations of the radon concentration throughout the year. These data could then be averaged to estimate an annual average. However, such a procedure would be more expensive and less convenient than use of a single AATD.

Each measurement method has an inherent error associated with it. That error describes how accurately the method measures the radon concentration actually present at the time the measurement was made. If the relative error of the AATD were much higher than that of the CC or 60-90 ATD, then the AATD might not be a good choice despite the advantages of its longer integration period. However, based on the data presented in the Analysis, this does not appear to be the case. Therefore, the integrated AATD measurement is the preferred method for estimating the average annual concentration.

In summary, there is a sound scientific basis for concluding that an AATD measurement represents a good approximation of the true average radon level in the area in which the detector is placed. It should also be remembered, however,

that human risk depends on both the radon concentration and the pattern of human activity that results in exposure to the radon.

3.2 Is the method used by EPA in the Analysis appropriate for determining how often a short-term test (e.g., charcoal canister and 60- to 90-day alpha track detector) would result in a mitigation decision different from that based on a long-term (e.g., annual alpha track detector) test?

EPA's general proposal to use short-term measurements for a radon mitigation decision would be reasonable, if, for the individual homeowner, the use of short-term measurements at a given level can be related to the more robust long-term annual estimates of exposure and if the false positive and false negative rates for those whose short-term test results are near the action level are reasonable. Five factors impacting this question are discussed below.

3.2.1 The errors associated with available short-term radon measurement methods.

In the view of the Committee a relative standard deviation of no more than 25% is usually acceptable for screening tests for most phenomena. The EPA's RRMP tested devices at concentrations greater than 20 pCi/L and obtained a generally acceptable standard error. However, as the radon level is reduced below the 20 pCi/L level into the range more often associated with an "action level" (e.g., 4 pCi/L), the data used in the Analysis show that short-term measurements represent the annual level to within $\pm$ 1-2 pCi/L (i.e., a relative error of 25-50%) roughly 30-50% of the time . However, if ORP in its (Radon Measurement Proficiency Program (RMPP) were to require a mean absolute relative error (MARE) of no more than 25% at radon concentrations comparable to the current action level of 4 pCi/L, then all devices and methods listed by RMPP would be acceptable for short-term measurements. This appears to be a reasonable goal for the RMPP to set. It is the Committee's understanding that the RMPP acceptance criterion is now an MARE of $\leq$ 25%.

3.2.2 The errors associated with available long-term radon measurement methods.

The relative standard deviations of the AATD measurements appeared to be less than the relative standard deviation of the CC and the 60-90 ATD measurements in the range of interest; i.e., around 4 pCi/L, which gives increased confidence in the long-term results.

3.2.3 The distribution of residential radon concentrations.

Radon concentrations vary over a wide range in different homes across the country. Available data indicate that the frequency of these different levels is log-normally distributed, with homes at lower radon concentrations being found more often than homes at the higher concentrations. Although all log-normal curves

generally have the same shape, there can be important differences in the extremes ("tails"). While the nature of this distribution is not relevant to mitigation decisions by individual homeowners, it is important for the national picture.

In the Analysis ORP uses two assumptions regarding the shape of the national annual average distribution. One of these is based on the distribution developed by Dr. Anthony Nero (Nero et al, 1986) and the second is based on a hypothetical "EPA national radon distribution" (based, in turn, on State surveys) that was prepared before the preliminary results of the National Residential Radon Survey (NRRS) became available. A comparison of the preliminary NRRS data (See Figure I) with either distribution used in the Analysis shows no significant differences for the purposes of the present discussion.

The Committee recommends that EPA use a national radon distribution model that represents realistic exposure for occupancy of all lived-in levels in a residence. The NRRS may provide a reasonable approximation to such a model. However, since the NRRS results were not available at the time of the Analysis, ORP has appropriately used estimates of the distribution development Dr. Nero and by EPA.

3.2.4 The effect of the action level on the number of incorrect mitigation decisions.

The Committee considered the relationship between the numerical value of an action level and the number of houses in which an incorrect remediation decision would be made on the basis of short-term measurements.

Clearly, the lower the action level, the greater the number of homes needing remediation. The second most important factor is the actual distribution of homes across the country that have specific radon levels.

The action level and the shape of the national radon concentration distribution curve discussed above (Section 3.2.3) are especially important because the percentage errors for both short-term and long-term measurements for radon are high at the low concentrations most commonly found in houses in the U.S. In fact, the relative measurement error increases as the radon concentration decreases. As a result, the lower the action level selected, the higher the proportion of false positives and false negatives. Therefore, the Committee anticipates that the false positive error rate for short-term tests for radon at levels near an action level of 4 pCi/L could be in excess of 50%. (See Appendix).

3.2.5 The error rate for homes with short-term results greater than the action level

The Analysis used a combination of added percentages of false positive and false negative results to address the mitigation decision. However, the Analysis did not take into account the prevalence of the houses that truly require mitigation;

i.e., the actual number of homes with radon levels above some action level. The impact of relying on short-term measurements alone can be illustrated by a "predictive value". (On June 14, 1990 ORP presented the Committee with analyses based on the predictive value concept, as had been suggested.)

The Committee believes that the ORP Analysis of the error rates does not correctly focus on that part of the testing population for whom the guidance is most relevant, i.e., those houses with short-term measurements near the action level. The data tables prepared by ORP in the Analysis can be used to compute the false positive rate among these houses. The results of this exercise are presented in Table A-I of the Appendix. As can be seen, the false positive rates for various testing procedures are high, ranging from 25 to over 50%. The lowest rates are computed for a hypothetical summertime data set, but the number of false negatives increases significantly, as has been pointed out in the ORP Analysis. The results indicate that for an individual homeowner with a short-term test result just above 4 pCi/L, the probability of inferring whether the long-term average concentration is either above or below 4 pCi/L is roughly 50/50. In absolute numbers, if everyone (about 80 million homeowners) measured their radon concentrations with a short-term technique, approximately 10 to 15 million houses would have results above 4 pCi/L. Of these, roughly 5 to 10 million households will make the wrong inference, based on a single measurement, as to whether their long-term radon concentration is above or below 4 pCi/L. The Committee is concerned about this high error rate.

A recently completed comparison of short-term measurements made in four different seasons with long-term alpha -track data for the first floor shows very similar false positive rates (W. Condon, et al, 1990). The comparison table from that report is presented in Table A-II in the Appendix. The Committee notes that the conclusions that can be drawn from the EPA presentation (Table A-I) are consistent with the conclusions reached by Condon and coworkers; specifically ,

> *However, the high false positive results for all seasons indicate that a single screening measurement above 4 pCi/L is a poor indicator of the annual average radon level. It is also a poor way to determine if a house needs mitigation without further measurements, particularly long-term measurements.* (W. Condon, 1990, p.61)

3.3 What can be done to increase the likelihood of a correct mitigation decision being made on both an individual basis and on a national basis?

The Committee has identified two alternatives that would result in more correct mitigation decisions.

3.3.1 Improve test methods

As noted above, improved accuracy of test methods at low radon concentrations (for both short-term and long-term approaches) would lead to

increased likelihood of a correct mitigation decision. The Committee recognizes that there is substantial variation in performance among existing devices and methods for short-term measurements. Therefore, the Agency should continue its efforts through the RMPP to improve the quality of all measurements, particularly the short-term measurements. As well as improving both types of tests, the Agency should address the comparability of estimates derived from multiple, sequential, short-term tests versus those derived from the more direct long-term tests. This evaluation should include consideration of charcoal canisters fitted with diffusion barriers.

3.3.2 Base decisions on estimates of actual exposure

The more closely the radon measurement approximates the concentrations to which humans are exposed, the better the basis for the mitigation decision. Therefore, measurements made in the lowest lived-in area (rather than lowest livable area) and made over longer periods (preferably one year) will be more useful than other measurements.

In this regard, the data for houses with basements should be analyzed and presented separately from the data for houses without basements. This analysis could lead to different overall policy options if the differences are found to be significant.

In the materials provided on June 14, 1990, ORP included tables on houses in the North and the South as a surrogate for data on "with basements" vs. without basements", respectively. (This judgment was based on the understanding the roughly 85% of the homes in the North have basements, while roughly 85% of the homes in the South do not.) While not an ideal surrogate, this North/South analysis is probably a reasonable interim approximation of the "with basements" vs. "without basements" difference.

3.4 Other matters

Mitigation efforts based on false positive measurements in houses where the concentration were actually below the action level apparently were counted as a benefit in the cost-effectiveness analysis presented to the Committee in May, 1990. Such mitigation should not be counted as a benefit since it is doubtful that it leads to any real reduction in risk. (According to a briefing received on June 25, 1990, ORP has changed the Analysis so that mitigation of homes with radon levels below the action level is no longer counted as a benefit.)

4. REFERENCES

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APPENDIX
ERROR RATE ANALYSIS FROM EPA PRESENTATION AND FROM CONDON, ET AL, 1991

The data summary presented here is based on the matrices presented in Tables 3, 5, 9, 11, 13, 15, 17, and 19 of the "Analysis of the Relationship of Short-Term Measurements to Annual Measurements in Support of the Citizen's Guide Revision" (Analysis). Those Tables are based, according to ORP, on two data sets from several different surveys: 1) two-day charcoal canister (CC) measurements in the basement and first-floor of basement houses; or in the first floor of non-basement houses, and 2) 60-90 day alpha track detectors (60-90 ATDs) similarly deployed in New York state. These Tables were constructed using weighting factors in order to analyze the differences between the different testing procedures: "lowest livable" (i.e., a basement if it exists) vs "lowest living" (i.e., "lived-in") (50 percent of the basements are occupied at least 4 hours per day, according to ORP). The overall long-term concentration distributions were normalized either to the published distribution of Nero et al. (1986), or to an "EPA" distribution which was assembled by the Agency prior to the availability of the early National Residential Radon Survey (NRRS) results. The summary shown in this Appendix is based on the normalization to the Nero distribution for the purpose of analyzing the error rates. The differences in the resulting distributions are minor. Summertime data matrices were also constructed in the Analysis using an overall correction factor applied to the winter-time matrices.

In Table A-I the second column presents the percentage of all screening measurements in the EPA data that were above 4 pCi/L. The third column shows the estimated percentage of false positive results for short-term screening measurements, compared with the Nero et al distribution. The last column is the ratio of columns 2 and 3, expressed as the percentage of all EPA screening positives that are false, again assuming that the actual long-term concentration distribution is represented by the Nero distribution.

A comparison between a) screening measurements conducted with open-face charcoal canisters and b) long-term radon concentration measurements obtained with annual alpha-track detectors (AATD) has recently been reported for approximately 1000 homes in five counties in New York State (W. Condon, et al, 1990. "Survey of Indoor Radon Levels in New York State and Evaluation of U.S. Screening Protocols"). In this case, screening measurements were conducted in both the basement (where one existed) and on the first floor for the four different seasons. The AATD measurements were made for the entire year on the first floor.

Table 35-5 from that report, showing the false positive and false negative rates, is reproduced below in Table A-II. Its features are similar to those shown in Table A-I. While this study was conducted in "volunteer" houses, the Committee believes that this is not likely to affect the analysis of the error rates

in comparing short-term and long-term measurements. The Committee also notes that while the study was conducted in only one state, the house types and climate conditions are not distinctly different from those found in other "Northern tier" states. Different house types and climate regions may affect the comparison between screening and long-term radon concentration measurements, thus the results from New York may not be strictly applicable to different regions of the U.S.

In summary both the EPA and the Condon et al data reveal a false positive rate ranging from 25 - >50% at an action level of 4 Pci/L. These results demonstrate that short-term screening type measurements are poor indicators of the long-term average radon concentrations to which occupants are exposed. For short-term positive (i.e., greater than 4 pCi/L) test results near 4 pCi/L, the decision about whether to mitigate or not, based on these test results along, is not going to be well-informed, since the probabilities are essentially equal as to whether the long-term average concentrations will be above or below the guideline level.

TABLE A-I

Analysis of False Positive Rates Derived from EPA Presentation

Test Procedure	% Positive screening measurements in EPA Analysis (>4 pCi/L)	% False positives from national distribution (Screen >4 Pci/L) (Annual <4 pCi/L)	Inferred false positives as percent of all positives in EPA analysis
Lowest Livable:			
Winter			
CC	20	14	68
60-90 ATD	18	12	66
Summer			
CC	10	4.6	46
60-90 ATD	9.3	4.7	50
Lowest Living:			
Winter			
CC	15	8.4	57
60-90 ATD	12	6.6	53
Summer			
CC	6.0	1.5	25
60-90 ATD	5.4	1.5	28

TABLE A-II

Analysis of Error Rates
From Condon et al, 1990

(where "false negative" implies CC < 4, AATD > 4 pCi/L)
(where "false positive" implies CC > 4, AATD < 4 pCi/L)

Test Procedure	% False Negative	% False Positive
Basement CC data:		
Fall	4.3	59
Winter	4.5	57
Spring	7.4	54
Summer	12	55
First Floor CC data:		
Fall	4.8	41
Winter	3.3	38
Spring	17	27
Summer	20	25

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