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

SAB-RAC-88-009

January 14, 1988

OFFICE OF
THE ADMINISTRATOR

Honorable Lee M. Thomas
Administrator
U.S. Environmental Protection Agency
401 M Street, S.W.
Washington, DC 20460

Dear Mr. Thomas:

The Science Advisory Board's Radiation Advisory Committee has completed its review of the Office of Environmental Engineering and Technology Demonstration's (OEETD) radon mitigation research program. In response to OEETD's request of May 5, 1987, The Radon Mitigation Subcommittee met publically October 13-14, 1987 and reported to the full Committee on October 15-16, 1987.

Overall, the Committee was very favorably impressed with both the quality and quantity of the Agency's research efforts on radon mitigation. The Committee's recommendations are therefore directed towards strengthening the few weaker areas in an otherwise very strong program.

The Committee made several recommendations concerning data collection and presentation which should improve consistency and ease of interpretation.

The Committee would like to highlight two recommendations in the data analysis area. First, the time-series data should be used to determine the optimum time interval for the pre- and postmitigation measurements. Second, the radon mitigation matrix should be consolidated by combining cells with common physical characteristics so that mitigation results can be analyzed within the context of broad physical characteristics. Such analysis will help the Agency generalize from and extrapolate the data to new situations. This recommendation is consistent with that in our previous report to you on the Radon Mitigation Matrix (SAB-RAC-87-016 January 1987).

The Committee supports OEETD's goal of developing cost-effective mitigation techniques rather than low cost techniques because both cost and performance are important for decisions concerning mitigation. The Committee recommends that OEETD expand and refine its working definitions of cost-effectiveness as soon as possible to include other measures of effectiveness. The Committee recommends that the differing needs of mitigators, homeowners, and policy makers be addressed and that total lifetime costs of each mitigation technique be estimated as accurately as possible, and reported as concisely as possible.

The Committee appreciates the opportunity to review this important research program and requests that the Agency formally respond to our scientific advice.

Sincerely,

Norton Nelson, Chairman
Executive Committee
Science Advisory Board

William J. Schull, Chairman
Radiation Advisory Committee
Science Advisory Board

Keith Schiager, Chairman
Radon Mitigation Subcommittee
Radiation Advisory Committee
Science Advisory Board

cc: J. Skinner
S. Meyers

SAB-RAC-88-009

Review of the Radon Mitigation Research Program

A Report of the

Radiation Advisory Committee's

Radon Mitigation Subcommittee

U.S. Environmental Protection Agency
Science Advisory Board
Washington, D.C.

January 1988

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Introduction

The Radon Mitigation Subcommittee of the Radiation Advisory Committee has reviewed the EPA Office of Environmental Engineering and Technology Development's Program Description and Plans, March 9, 1987; the IAB report, Collection of Field Data, September 18, 1987; the technical guidance manual Radon Reduction Techniques for Detached Houses (2nd edition), September 11, 1987; and a report, Data Analysis in EPA's Radon Reduction Technology/Demonstration Program, September 21, 1987.

In response to specific requests by the Agency, the Subcommittee is presenting observations and suggestions on the following topics:

(1) the variables addressed by the mitigation test matrix,

(2) the collection and management of useful, high-quality data,

(3) the strategy and methodologies for data analysis for the two separate data sets, e.g. the mitigation effectiveness data (also referred to as the general data) and the time-series data (also referred to as the detailed data), and

(4) the definition and application of cost-effectiveness as an objective of the mitigation research effort.

The Subcommittee was very favorably impressed with both the quantity and quality of the Agency's efforts in mitigation of indoor radon exposures. The expanding public demands for guidance on needs for mitigation and on techniques, efficacy and costs of meeting those needs, is a challenging task and the Agency is pursuing its share of the task with vigor. The Subcommittee's recommendations are directed toward strengthening the few weaker areas in an otherwise very strong program.

Mitigation Matrix

In 1986 the Office of Environmental Engineering and Technology Demonstration (OEETD) requested comments on the proposed matrix for conducting radon mitigation test projects. The Radiation Advisory Committee in its report (January 1987, SAB-RAC-87-016) recommended that OEETD reduce the number of cells in the matrix on the basis of the physical principles involved. The matrix subsequently described in Program Description and Plans, March 9, 1987, has not been reduced according to those principles. The Radon Mitigation Subcommittee believes that although it may be desirable to collect data according to the existing matrix, analyzing mitigation results within the context of broad physical characteristics could help to generalize and extrapolate the data to new situations. The Subcommittee recommends that the EPA continue its efforts to consolidate the matrix by combining cells with common characteristics. Split-level houses are actually combinations of basement and slab-on-grade construction. As a further example of possible consolidation, it would appear that techniques such as increased ventilation, particulate removal, gas removal, and water treatment could be tested in one or two of the most common substructure types rather than six to ten as indicated in the matrix.

Data Collection and Presentation

EPA must impose certain quality standards for data collection and presentation upon their contractors, or be prepared to reformat and verify the quality of the data prior to public release. Use of a common computer data-base-management system by the various contractors would also be helpful.

With regard to data collection EPA should consider further standardization of the data collected in the several non-data-intensive programs to include comparable before and after radon measurement methods and relevant engineering details such as:

(1) pressure field developed in block wall venting installations (value for each wall is suggested),

(2) pressure field developed in slab venting installations (four values in four separate areas of the slab are suggested),

(3) fan flow (measured),

(4) pressure differential at the fan,

(5) fan power consumption (measured),

(6) percent time fan is "on" if not continuous, and

(7) estimated annual operating cost of system based on measured power consumption.

These seven items, currently not being collected, would require minimal additional effort after the completion of the mitigation effort and be valuable in addressing system performance criteria and cost-effectiveness.

With regard to data presentation, as part of a quality control program, EPA should consider further standardization of measurement, display of uncertainties on graphics, and consistent labeling of graphs and tables. Many of the preliminary graphics presented to the Subcommittee could be improved by more descriptive labeling or by use of different formats. For example, a scatter plot of radon concentration before mitigation (x axis) versus concentration after mitigation (y axis) would provide a simple and direct indication of whether mitigation generally reduced concentration to a uniformly low level or by a relatively consistent fraction of the initial value.

Data Analysis

The Subcommittee reviewed the objectives of the extensive time series data being collected from the group of houses in the Piedmont area, as well as the analytical and modeling methods employed by the Agency. The data consist of 30-minute interval measurements of radon concentrations and several environmental variables such as barometric temperature and wind speed. The Subcommittee agrees that although studies of this type would have little practical application in simply evaluating the effectiveness of mitigation efforts, they may be useful in developing a better understanding of the dynamics of radon concentration in dwellings. For evaluation of effectiveness, comparable pre- and postmitigation measurements integrated over appropriate time intervals are adequate.

The Subcommittee suggests that the time-series data might be used effectively to determine the optimum time interval for the pre- and postmitigation measurements. The Agency staff presented a graph illustrating the correlation between radon measurements integrated over 2 days and 4 days (not derived from the time-series data). The Subcommittee found this correlation to be of limited interest, but felt that the real issue is the relative variance of average radon concentrations determined by measurements integrated over various time intervals, e.g. 2, 4, 8 or 16 days. Such averages could be obtained from the time-series data by an appropriate random-sampling scheme. Identification of the shortest interval that has an acceptably small variance would be an important input to the mitigation testing protocol. These various estimates could also be used to develop uncertainty bounds for reporting the effectiveness of mitigation.

The Subcommittee questions the value of starting the analysis by fitting a full blown auto-regressive integrated moving average (ARIMA) time-series model. More immediately informative might be analyses of serial correlations (correlations over time) among the various variables and the lag time that maximizes the correlations. (A lagged correlation coefficient is one calculated between variable 1 at time t and variable 2 at time t - n, where n is the number of intervals in the time difference.) Autocorrelation of radon concentrations must also be considered in the analysis.

Cross validation is also an analytical area of concern to the Subcommittee. In a typical cross validation, the data are split into two parts. Then the first part is used to fit a model, and the fitted model is used to predict the second part. If the second part-prediction is a success, confidence in the generalizability of the model is increased. In some time-series analyses, the model is cross validated iteratively, i.e., it is fit to half the data, then tested on the other half. If this procedure is a failure, the model is refitted to the original data and retested. After several such iterations, a model which "cross validates" well is obtained. Such exercises are of questionable validity. A discussion of exactly what was done in cross validating the radon time series data would be helpful.

Cost-Effectiveness

One of the issues referred to the Science Advisory Board for comment in Dr. Skinner's memorandum of May 1987, was the Agency's definition of the term "cost-effectiveness."

The Subcommittee believes that the goal adopted by OEETD of developing cost-effective mitigation techniques is preferable to emphasis on development of low cost techniques, since both cost and performance are important for decisions concerning mitigation. In order to accomplish this goal, OEETD should expand and refine its working definitions of cost-effectiveness for radon mitigation as soon as possible. The two measures of mitigation effectiveness currently used by the Agency, i.e. the percentage reduction in the average indoor radon concentration and the final value of the concentration, are appropriate for certain applications of cost-effectiveness, as illustrated later. However, other applications of cost-effectiveness evaluations would benefit from other measures of effectiveness, e.g. the absolute reduction of the radon concentration, which might also be expressed in terms of risk.

As applied by EPA in other situations, cost-effectiveness has been a comparison of the costs of achieving equal results by use of different engineering or equipment elements; or, conversely, a comparison of the magnitude of results by use of different control elements of equal costs. An appropriate measure for radon mitigation, for example, might be performance per dollar of total cost of mitigation. However, the Subcommittee believes that the factors that influence the use of cost-effectiveness data may be at least as important (if not more important) as the specific definition (or units) used for its presentation.

Because mitigation requires decisions by different groups that participate in the mitigation process, three specific definitions may be required for this program, one for the perspective of each of the three primary use groups: (1) mitigators, (2) homeowners, (3) policy makers and analysts (e.g., legislators, risk analysts and managers). Each of these interested groups--mitigators, homeowners, and policy makers--need realistic projections of total costs of mitigation, including diagnostic and verification measurements, equipment and labor for the initial

installation, and lifetime operational and maintenance expenses (including such costs as increased energy consumption). Therefore, the Subcommittee recommends that the total lifetime costs of each mitigation technique be estimated as accurately as possible and reported as concisely as possible. A brief discussion of some other specific suggestions follows.

Mitigators. The mitigator must be able to predict which techniques or combination of techniques are most likely to achieve the reduction desired by the homeowner (client) at minimal or nominal cost. The mitigator also must know the probability of success (or failure) to allow for liability or warranties that may be demanded by the homeowners. As a result, an appropriate measure of cost-effectiveness for the mitigator might be the ratio of expected reduction in radon level to total cost for each radon mitigation technique. However, because the reduction achieved depends not only on the mitigation technique, but also on the initial radon concentration, OEETD should develop a method that somehow accounts for the initial concentration. The simplest approach may be to estimate the cost effectiveness for categories of pre-mitigation concentration (e.g., for 4-20 pCi/L, 20-100 pCi/L, and more than 100 pCi/L).

The use of an expert system, or similar decision tree techniques, to guide the mitigation efforts to those most likely to be cost-effective should be considered. For example, diagnostic costs could be minimized by mitigation guidance based on observed substructure features, and expected performance results. Separate guidance could be provided for homes with, say, more than 20 pCi/L, and those with less than 20 pCi/L. This guidance can be generated from the results of current demonstration programs, and the strategies should then be prioritized.

Homeowners. The homeowner, as the consumer of a service, may be interested in one, or both of two different concepts of effectiveness. In connection with real estate transactions, homeowners are concerned with maintaining the market value and marketability of their homes when elevated radon levels are found. They are most likely to be interested in the effectiveness of mitigation in achieving the EPA-recommended guideline of 4 pCi/L or less. In spite of EPA efforts to emphasize the flexibility of the guideline, it is unfortunately being treated more and more as a boundary between safe and unsafe. Insufficient data at present preclude evaluation of the effect of radon mitigation installations on market value of homes, but a measure of cost-effectiveness could guide selection of mitigation techniques.

Owners of homes, faced with high radon concentrations but not intending to sell a home may be more interested in the effectiveness of mitigation for reducing health risks to family members. These homeowners may be more receptive to concepts of risk than to EPA numerical recommendations. For such homeowners, cost-effectiveness cannot be separated from the concept of cost-benefit, i.e., what health benefit or risk avoidance can be obtained for a given expenditure on mitigation. For such a homeowner to make informed choices, the expected reduction in radon exposure should be expressed in absolute rather than relative values. A useful definition of cost-effectiveness for these homeowners might be the same as that suggested for mitigators. However, to facilitate interpretation by homeowners, this form of cost-effectiveness might be converted to the decrease in risk or expressed in terms of the statistical increase in life expectancy per total dollar invested over the life cycle. In any case, the definition adopted should help homeowners decide what level of mitigation is desirable and how likely various mitigation techniques are apt to be helpful. Allowance needs to be made for differences among homeowners in willingness to take risks and recognizing the difficulty in reducing extremely high concentrations to a prescribed low level (e.g., 4 pCi/L).

Policy Makers and Analysts. Policy makers analyze the total national benefit, or risk reduction, expected for a given level of national (or state) effort toward mitigation. The following are examples of the types of questions related to cost-effectiveness that would involve national policy. If the current distribution of indoor radon concentrations causes 5000 - 20,000 cases of lung cancer per year, how much will this number be reduced by a national effort based on voluntary participation and a 4 pCi/L guideline? How much different would the results be if the guideline was higher or lower? How different would the results be if the current guideline was applied only to new construction and a different guideline was applied to existing housing stock?

To help answer these questions, OEETD should consider developing a method for determining the decrease in total population risk per total dollars spent on mitigation, including costs of research, development and demonstration, diagnostics, installation, and operation of mitigation measures. This definition might be applied to the estimated distribution of radon concentrations in U.S. homes to determine which levels are cost-effective from a societal perspective.