DISCLAIMER

Lawrence Berkeley Laboratory
Applied Science Division

NEWSLETTER

FEBRUARY 1984

FEATURED PUBLICATION

Health Physics, Vol. 45, No. 2: 277-288 (1983)

INDOOR RADIATION EXPOSURES FROM ^{222}Rn AND ITS DAUGHTERS: A VIEW OF THE ISSUE

Anthony Nero

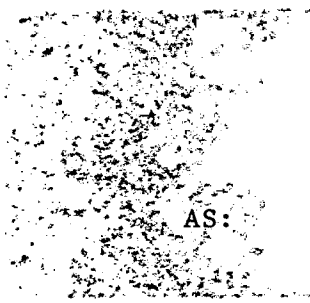
ABSTRACT: Exposure to ^{222}Rn daughters indoors can result in significant risk to the general public, particularly those living in homes with much higher than average concentrations. This paper reviews what is known about indoor concentrations, associated risks, and the effect of measures to save energy by reducing ventilation rates, using U.S. housing as an example. It concludes that, by employing appropriate control measures in homes having unacceptably high concentrations, the average exposure (and therefore risk) of the general public can remain at its present level, or even decrease, despite programs to save energy by tightening homes.

The following is from a discussion with Tony Nero:

AS: You were one of the two guest editors for the "indoor radon" issue of Health Physics (August 1983), and this paper provides an overview of the problem. What was the main reason for this special issue?

Tony: The basic impetus for producing a special issue on the subject of indoor radon was the substantial amount of work taking place on levels of radon and its daughters indoors. We have contacts with 30 or 40 groups around the world which have been performing research in this area, and the special issue was arranged by sending them invitations for contributions. These papers fell into several major areas. Some were rather broad papers reviewing the concentrations that have been found indoors and their probable effects. Others addressed more specific questions: the sources of indoor radon, specific results from surveys of

radon and its daughters indoors, methods for measuring radon and its daughters, and the behavior of the radon daughters themselves which (unlike radon, a noble gas) are chemically active and therefore have a complex behavior. The criterion for acceptance of papers was that they significantly advanced our understanding of these areas. I should note that our group's interest in having such an issue arose initially from the fact that within a relatively short period of time a number of papers reporting our work on radon were approaching completion. We thought that a single issue containing these papers, and perhaps others, would constitute a unique coverage of the question of indoor radon. It was then that I enticed Wayne Lowder to act as my co-editor for the issue, avoiding the obvious difficulties with my handling the review and editing of LBL submissions.



AS: As you have mentioned, several papers in this issue of Health Physics are contributions from the Applied Science Division and, in particular, from your own group. Could you briefly discuss them so that we have a general idea of some of the areas in which you are working?

Tony: The papers contributed by our own group fall into the major categories that I just mentioned. One of them, "View of the Issue", introduces the special issue and attempts to establish a perspective on the concentrations that appear indoors, on their potential significance for the health of occupants, and on the change in exposures that might occur as a result of energy conservation measures. A second paper systematically reviews what is known about indoor radiation. Others are on more specific topics. For example, one examines the emanation of radon from concrete samples collected from around the country. Another reports measurements by our group of radon concentrations and ventilation rates in a selection of houses; work that arose naturally from our interest in examining the connection between indoor pollutant concentrations and energy conservation measures. Other papers report new techniques for measuring the emanation of radon from source materials or the concentrations of radon or its daughters in indoor atmospheres.

AS: Why is the study of radon in indoor atmospheres important? And why do you keep referring to the term "daughters" instead of "sons"?

Tony: Radon indoors is important for several reasons. First, the concentrations of radon and its decay products indoors are high enough to be the dominant contributor to radiation exposures from natural sources: they are as important, or more important, than all of the other contributors together. The irony is that, more often than not, those who refer to "natural background radiation" are thinking specifically of other contributors and are often not aware of the relative importance of radon. Even more important is the fact that the concentrations of radon indoors vary over a very large range, by three orders of magnitude within the U.S. housing stock. The concentrations at the

upper end of the range are presently causing exposures to the occupants at a rate that exceeds occupational limits (the equivalent of 5 rem per year, for those familiar with this dose unit) that apply in nuclear facilities or in underground mines. Such exposures are high by any standard and, in fact, one does not have to make an extrapolation to arrive at risk estimates: the exposures are comparable to those examined in epidemiological studies of miners and other highly-exposed population groups. Concentrations at the top of the range found indoors are expected to expose occupants unknowingly to a risk of lung cancer comparable to that from smoking a pack of cigarettes a day. As to why I keep referring to the decay products as "daughters", this is simply the traditional name for members of a decay series springing from some "parent". There are certain efforts in the U.S., although not internationally, to use the term "progeny"; many of us have not gotten into the habit of doing so.

AS: What are the sources of radon, and what are the major pathways for radon entry into homes?

Tony: The ultimate source of radon (222, the principal isotope) is any earth material that contains radium 226, its parent. There are three major routes for radon entry indoors: (1) The soil or rock underlying houses constitutes the dominant source, as we presently understand it, with radon simply entering houses through their understructures. (2) A second potential source, which can dominate the indoor radon concentration in certain areas, is the domestic water supply derived from underground reservoirs that come into contact with radon sources. For example, in certain granitic areas of the U.S. the water supplies can have radon concentrations that are substantially higher than normal. When water is used indoors, most of the contained radon escapes to the air. (3) A third potential source is building materials that include earth material with radium in it. For example, concrete contains radium in varying amounts. To some degree, this radium constitutes a radon source, but in most circumstances it is not the dominant source indoors.

AS: What is the range of concentration of radon and daughters in U.S. buildings and what would you say are acceptable levels?

Tony: For convenience, let me just refer to concentrations of radon. [In a normal building the concentration of radon decay products (given in radioactivity per unit volume) is, in rough terms, half of that of radon.] In indoor environments in the U.S., radon concentrations range from about 0.1 pCi/l to about 100 pCi/l, with a typical concentration being in the vicinity of 1 pCi/l (assuming a log-normal distribution of the concentrations). When national or international bodies consider (as they have recently) a standard for indoor radon concentrations to which the general public is exposed, numbers in the vicinity of 3 pCi/l to 10 pCi/l are typically discussed. If a linear hypothesis for the relationship between dose and response is

considered to apply, there is, of course, no "safe" level. The issue then is what is an acceptable level, and on this there is no unanimity. People will generally agree that concentrations exceeding, say, 20 or 30 pCi/l deserve substantial and relatively rapid attention. But there is a good deal of disagreement as to what might be done about concentrations that lie below that range. At the level of 20 or 30 pCi/l, the occupants are receiving doses that are approximately at the occupational limit for exposure to radon and its daughters, so there is an existing criterion by which one can judge such exposures.

AS: What are some of the documented toxic effects of radon and daughters?

Tony: The principal health effect of exposure to radon daughters appears to be an increased risk of lung cancer. The evidence for this increased risk arises from several sources, the main one being the exposures of miners in either uranium or other mines. It is very clear from epidemiological studies that exposures to high concentrations of radon decay products for long periods of time cause an increased risk of lung cancer. Most results give a clear indication that for lifetime exposures corresponding to an indoor concentration of, say, 10 or 20 pCi/l or above, there is an observable increased risk of lung cancer. The uncertainty in the risk appears less than that associated with virtually any other ordinary environmental exposure to which we can point (except cigarette smoking). For low concentrations, there is added uncertainty due to the need to presume linearity for the rather modest extrapolation required.

AS: Can efforts to reduce energy losses in buildings also lead to reductions in radon concentration?

Tony: As you probably know, the concern about indoor radon concentrations (and other indoor pollutants) from the point of view of energy conservation arises from the fact that measures to save energy might, in fact, increase pollutant levels. By reducing ventilation rates, one reduces one of the major removal terms for indoor pollutants, and the concentrations may therefore rise with respect to what they might otherwise have been. In the case of radon, there is some potential for reversing this, specifically by sealing the lower part of the house, i.e., the understructure or the floor. This potential for an energy conservation measure to reduce the indoor radon concentration probably does not apply to all housing classes. We have actually observed it in houses that have crawl spaces. Houses built on slabs or with basements probably do not have this potential. A more general possibility is that, in the course of an energy conservation program that inspects houses for potential means to reduce ventilation rates or other energy losses, one could also inspect houses with a view to identifying sources of radon (or other indoor pollutants). One feature of programs to save energy may ultimately be an audit to identify either the potential for high concentrations of indoor pollutants or the means

to reduce those concentrations.

AS: What are some of the problems with the techniques for measuring the concentration of radon and its daughters?

Tony: The basic problems that exist in measurement of radon and its decay products arise in specific applications. In general, there are techniques for measuring whatever we want, but not necessarily over the time period or with the efficiency that we need. For example, a simple integrating device is available for measuring the average radon concentration over a period of months. There is no comparable monitor for the decay products of radon, largely because the chemical reactivity of the daughters precludes design of such a simple device. We do, however, have other means for measuring radon daughters both in aggregate and individually. These techniques are more complex than the radon measurements. Similarly, real-time measurements of radon or its daughters tend to be difficult or imprecise. Their simplification would entail the identification of some new approach to their measurement; right now we have to be satisfied with the approaches that we have already identified.

AS: Surely other indoor pollutants are just as important as radon. Which ones do you consider important and what is known about them?

Tony: There are several other classes of pollutants of substantial importance, although it is not possible to say which of these classes (including radon and its daughters) is most important. One class, for example, is the wide range of combustion emissions indoors, similar to the pollutants that one is often concerned with in the outdoor atmosphere: oxides of carbon, nitrogen, or sulfur; particulates; and more complex chemical species than the simple oxides I have mentioned. A second class consists of chemical substances that arise from a variety of materials and consumer products that are used inside buildings. An example of some importance in this class is formaldehyde, which can arise from wood products such as plywood and particle board and from adhesives and other materials that are used in indoor environments. There are, of course, many other more complex organic chemicals that arise from these same classes of materials. These chemicals can have substantial health significance, although the identity, concentration, and health significance of many members of this class are generally not very well characterized at this time. A final class that I should mention, but which our own program is not investigating, is that of biologically active substances. This includes bacteria and fungi, and, in general, any living substance that can have an effect on the health of building occupants. It is quite clear that the design of a building and the manner in which it is operated can have a substantial effect on the concentrations of each of these classes. Although it is not known which of these classes is most important, it is clear that they all have well-identified or potentially important health effects. Indoor

pollutants have a health significance that can be considered comparable to that of pollutants occurring in other contexts, either outdoors or in occupational settings.

AS: What is the future of your research on radon and its daughters?

Tony: Research on radon and its daughters has two major directions. The first is to understand better the behavior of daughters in an indoor environment. They can attach to walls and to particles, so that their concentration indoors depends on what kinds of devices one has in the building for heating the building and for cleaning the air. In fact, concentrations depend directly on how air moves within the building. The other major direction of work on radon is to understand how radon actually enters buildings, specifically from the soil. Radon entry does not appear to be dominated by simple diffusion. The dominant force driving radon into the house appears to be depressurization of the interior with respect to the outdoors. This depressurization arises from temperature differences between the indoors and outdoors and from wind; the radon enters along with air that flows from the soil into the house. Understanding how this occurs is an important premise (along with understanding the distribution of source materials) for identifying circumstances where high entry rates are likely to occur and for understanding how to reduce these rates. These two major topics for radon are similar to the directions for research on combustion products and organics. Specifically, our interest is in understanding the factors affecting emission of these substances into the indoor environment and the factors that determine indoor concentrations and the fates of these pollutants. We need to know how they react with other substances in the air, how they are removed from walls, or arise from walls, and how this behavior is affected by ventilation and air movement within the structure.

The Featured Publication was selected by Elton Cairns, Don Grether, and Alex Quintanilha from articles published in the refereed, archival literature.

INVITED TALKS AND FOREIGN TRAVEL

- In December, Mary Hunt was in American Samoa working aboard the research vessel S.P. Lee. Her geophysical research activities were part of the U.S. Geological Operation Deep Sweep.

Gleb Verzhbinsky, Chean Hsui, Debbie Wilson, and Joe Huang demonstrating use of the slide rule.

ENERGY ANALYSIS PROJECT RECEIVES PROGRESSIVE ARCHITECTURE AWARD

"Affordable Housing through Energy Conservation", a project which the Residential Group of the Energy Analysis Program at LBL has been working on for two years, recently received an award for applied research from the Progressive Architecture magazine. This project is completing a DOE-sponsored homebuilder's guide to energy conservation for site-built housing throughout the United States. The completed guide, due to be published later this year, will consist of a set of easy-to-use slide rules with accompanying sets of tables, a guidebook, and a technical support document.

LBL's involvement in the project includes doing the technical analysis, developing the slide rules and modifier tables, and writing the technical support document. Steven Winter Associates, an architecture firm in New York, is responsible for the guidebook with construction details and economic worksheets, and the final printing and production of all the materials.

The slide rule has movable tabs that indicate the amount of ceiling, wall, and floor insulation, the estimated amount of air infiltration, the floor and window areas in the building, the efficiency of the equipment, and a location multiplier (provided in an accompanying instruction book). By moving the tabs to various positions and in various combinations, builders can calculate the added costs and annual savings an owner will realize with any given conservation strategy.

The slide rules are the result of several years' work by the Residential Energy Analysis Group, first in developing and analyzing the large data base, and then transforming it into a simplified slide rule format. The group is led by Ron Ritschard, and includes Steve Byrne, Chean Hsui, Joe Huang, Isaac Turiel, Gleb Verzhbinsky, and Debbie Wilson.

APPOINTMENT OF NEW EEB DEPUTY PROGRAM LEADER

On January 30, 1984, Elton Cairns appointed Robert Sonderegger as Deputy Program Leader of the Energy Efficient Buildings Program, succeeding Richard Crenshaw in that position. The Division and the Energy Efficient Buildings Program are grateful to Richard for a job well done during the past three years under the most difficult circumstances of funding uncertainties and personnel changes in Washington. Richard Crenshaw will assume the position of Director for Managed Environments, Inc., in Annapolis, Maryland.

Robert Sonderegger was chosen after a prolonged international search providing candidates from Oxford University, Georgia Tech, Texas A&M, the British Research Establishment, other national laboratories, and corporate research centers. Sonderegger has been at LBL 6-1/2 years, most of the time as Group Leader of the Energy Performance of Buildings Group. He holds a "final diploma" in physics from the Eidgenoessische Technische Hochschule in Zurich, Switzerland, and a Ph.D. in Mechanical Engineering from Princeton University.

HONORS

Chang-Lin Tien, UC Vice Chancellor-Research and Professor of Mechanical Engineering, and ASD faculty scientist, has been named Prince Distinguished Lecturer at Arizona State University. He will give a series of three lectures on "Fire Radiation".

DIVISION NEWS

- Lee Schipper has been named to serve on the Committee on International District Heating and Cooling which was established by the National Academy of Sciences-National Research Council on February 6, 1984. The primary task of this committee is to sponsor, plan, and hold an International Symposium on District Heating and Cooling as a Socio-Technical System at the National Academy of Sciences from June 4-6, 1984.

- At the end of February, Paul Berdahl will present testimony in Washington, D.C. to the Subcommittee on Energy Development and Applications of the House Science and Technology Committee. His statement will be a summary of recommendations of 30 solar and atmospheric research scientists who met in November of last year to address the problems with the current U.S. Solar Resource Assessment Program and provide suggestions for an improved program.

ASD WORD PROCESSING REPORT

The Publications Committee has completed its investigation into word processing needs of the Division and alternative ways of meeting the needs. The committee relied strongly on results of a survey on word processing conducted last November, and carefully reviewed the recommendations of Computer Division staff (December 13, 1983) for expanding Unix at LBL.

The committee belives that Unix run on minicomputers could serve the Division needs very well, but that the quality of service on Unix strongly needs to be upgraded. Additional minicomputer capability is required to increase the number of users served by Unix and to improve the accessibility and reliability of service.

The committee favors the expansion of Unix being carried out by the Computer Division. However, discussions with the Computer Division are necessary to (1) agree on appropriate level of staffing to support an expanded Unix, (2) obtain assurances about billing mechanisms and estimates of future costs of an expanded Unix per unit of use, and (3) reach agreement on appropriate minicomputer configurations and interfaces for an expansion of Unix.

In addition, the Publications Committee also believes that microcomputers have an important role to play in word processing (and other applications) within the Division. "Microcomputers and Unix (run by microcomputers) can and should complement each other, if an interface between the two systems can be accomplished."

You may contact Mark Levine, Chairman of the Publications Committee, for more information on the complete report.

VISITORS

Terry Levinson, Office of Energy Systems Research, Conservation & Renewable Energy, and Richard Silberglitt and John Bornstein, DHR Company, visited LBL on February 3. The following scientists from ASD gave presentations describing new ideas for research projects: Steve Selkowitz and Arlon Hunt, Holographic Coatings and Other Diffractive Microstructures for Advanced Glazing Materials for Windows; Sam Berman, Doubly Efficient Lamp Phosphor; Arlon Hunt, Sol-Gel Processing for the Production of High Temperature Ceramics; and Jud King, Separations of Polar Organics from Aqueous Solutions by Processes Based Upon Reversible Chemical Complexation. The Division has not received definite word as yet on the funding for these new research projects.

Barry Jones, Australian Minister for Science and Technology, visited LBL on Jauary 9 and met with Earl Hyde, Elton Cairns, Don Grether, and the Division's Program Leaders who are involved in conservation and alternative energy.

NEW APPOINTMENTS TO PROFESSIONAL STAFF COMMITTEE

Elton recently appointed Michael Rothkopf and Lester Packer to the Division's Professional Staff Committee (PSC), and would like to thank Frank Asaro and Edward Grens for their many years of service to the Division through their membership on this important committee. The PSC, together with the Division Head, establishes Division policy with respect to the employment and advancement of the scientific staff. The PSC also makes recommendations on Staff Scientist indefinite appointments, Senior Staff appointments, and promotions within the Staff Scientist series. The present membership of the committee is:

Michael Wahlig, Chairperson
Arthur Rosenfeld
John Harte
Frank Robben
Michael Rothkopf
Lester Packer
Elton Cairns (non-voting)
Jan Smith (staff)

ANNUAL REVIEW

The 1984 Annual Review of our Division will take place April 16 and 17. The review will be of the Chemical Process R&D Program and the Combustion part of the Environmental Research Program. The Reviewers are:

Thomas Chapman, University of Wisconsin
Adel Serofim, MIT
Mostafa El-Sayed, UCLA
Richard Alkire, University of Illinois
Arthur Humphrey, Lehigh University
Herbert Kaesz, UCLA
Stanford Penner, UC San Diego

RECENT REFEREED JOURNAL ARTICLES

"Rate of Formation of Toluene from Ethylbenzene," Hubert G. Davis, International Journal of Chemical Kinetics, Vol. 15, 469-474 (1983).

"Direct Liquefaction of Biomass: Results from Operation of Continuous Bench-Scale Unit in Liquefaction of Water Slurries of Douglas Fir Wood," Larry L. Schaleger, Carlos Figueroa, and Hubert G. Davis, Biotechnology and Bioengineering Symp. No. 12, 3-14, John Wiley & Sons, Inc. (1982).

SEARCH FOR A NEW DIVISION ADMINISTRATOR

Mark Alper, the Division's Administrator for the past three years, has accepted the comparable position for CAM (Center for Advanced Materials). Mark will be playing a major role in helping this new division of the Lab get started. Mark's achievements for Applied Science are much appreciated, and we wish him well in this new endeavor. Mark will be making a phased transition over the next couple of months, so he will be available to help with problems that come up.

A search for a new Division Administrator has been started. In addition to the regular posting in Current Job Openings the position will be advertised. The basic information is as follows:

Management I

Reporting to Division Head, responsible for management of all administrative functions in the Laboratory's largest research division; including complete budget cycle (including coordinating research proposal submissions, preparation and monitoring of budgets, administering divisional overhead allocations, providing Laboratory management with regular financial reporting), personnel administration, property management, and sound administrative practices. Supervision of a staff of administrative personnel charged with the above functions.

The Applied Science Division is staffed by approximately 120 research staff, 50 technical support persons, 70 graduate students, and 30 University of California faculty; assisted by an administrative and clerical staff of approximately 50 persons.

The Applied Science Division carries out a broad interdisciplinary program in energy supply and conservation technologies. Research areas include: electrochemical energy storage; fossil and biomass conversion to liquid fuels; solar energy for buildings; energy conservation in buildings with an emphasis on windows and lighting, computer simulation, indoor air quality, and building envelopes; atmospheric processes with an emphasis on atmospheric aerosols and acid rain; combustion of fossil fuels; advanced instrumentation; and energy policy.

This position requires extensive interactions with persons at all levels in the Applied Science Division, the Laboratory, and many within the Department of Energy. The person in this position is required to interpret Laboratory policies and procedures across a wide variety of applications.

Technical background in one of the Division's areas of research, in addition to strong business education and background, will be preferred for this position.

A search committee, headed by Don Grether, is currently being formed. Suggestions for candidates for the Division Administrator position should be brought to the attention of Don or Jan Smith.

PUB-432 2/84-330 This work was supported by the U.S. Department of Energy under Contract Number DE-AC03-76SF00098.
Lawrence Berkeley Laboratory, University of California
Berkeley, California 94720
An Equal Opportunity Employer