Interview: Radon Research

Dr. Richard Sextro describes efforts to understand radon and to develop effective techniques for keeping it out of the home.

The issue of indoor air quality is becoming increasingly important for those in the field of energy conservation, and recently radon has been stealing all of the headlines. Radon is a colorless, odorless radioactive gas commonly found in rocks and soil. During the past ten to fifteen years, scientists have found that radon levels in the soil can lead to elevated, and often unsafe, levels of radon in some houses. In the Jul/Aug '86 issue, we reported on radon—its sources, health effects and guidelines, and techniques to control or reduce levels in housing. In this issue we interview Dr. Richard Sextro, a scientist involved in research funded by the Department of Energy to determine the optimal radon control techniques and ultimately to transfer this information to the public. Following the interview is an article on the proliferation of companies that test for radon levels in homes.

Dr. Sextro is leader of the Indoor Radon Group at Lawrence Berkeley Laboratory (LBL). He received his Ph.D. in nuclear chemistry from the University of California, Berkeley in 1973. Later he worked on energy policy issues at LBL, and he became involved in radon research at LBL in 1982. In an interview with **EA&R** *managing editor Peter du Pont, Sextro discussed the health effects of radon, the effectiveness of different control measures, and the uncertainties involved in measuring a house to determine the radon level.*

EA&R: *Is radon really a critical health issue?*

Sextro: Yes, radon is a significant indoor pollutant, and the estimates of the health risks due to radon exposure haven't changed all that much in recent times. Even in houses with ordinary levels of radon, you're talking about potential health effects that are in some cases two orders of magnitude greater than other indoor air pollutants.

Our basis for concern about the health effects of radon is more certain than for most chemicals. The EPA estimates that 5,000 to 20,000 people contract lung cancer each year due to average exposures to radon. These figures are based on the health effects observed in populations of uranium miners exposed to radon, some of whom died of lung cancer. The mining situation is different from the indoor home environment, and miners don't necessarily represent the general population both in terms of their smoking habits and their general health. Nevertheless, one is not making huge extrapolations from different species, as is the case with health estimates for many other environmental chemicals; that is, you're not studying rats and extrapolating the health effects to humans. And you're also not making extraordinary extrapolations from very high doses to very low environmental doses. The Canadians, for example, have reported health effects in miners exposed, over a long period of time of course, to radon levels comparable to the levels found in houses with "moderate" radon concentrations.

EA&R: *How did the radon problem sneak up on us?*

Sextro: The problem didn't exactly sneak up on us. Our group at LBL has been studying the indoor radon problem since 1978. But several issues in the early 1980s brought the issue of

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radon to the forefront. One was the discovery in 1984 of the Watras house in Pennsylvania, a super-hot house, with levels of radon 700 times the EPA guideline level. While the neighboring houses did not have as high levels, they were also quite elevated. This event, probably more than any other, focused media attention on the problem.

At about the same time, the National Council on Radiation Protection issued a report discussing the health effects of environmental radon. It was based on cancer rates in populations of uranium miners. Their study came up with an estimate of about 9,000 cases of lung cancers per year in the U.S. population due to exposure to indoor radon.

EA&R: *What do the data show about the effect of weatherization programs on indoor radon concentrations?*

The data are somewhat equivocal. We have data from a study we did in the Pacific Northwest which shows that everything else being equal, the average seems to drop a little. That is, the radon concentration seems to drop a little after weatherization in the aggregate of the houses. Other studies have shown it going up a little bit. I think a lot of it depends on which part of the superstructure you attack. If you seal off the superstructure a little better, you can't have as much gas escaping from the top of the house, therefore you don't have as gas coming into the bottom of the house. So you can see how a weatherization program that eliminates thermal bypasses and convective loops will reduce, in part, the driving force for indoor radon. We have also found that sealing major openings in a floor above a crawlspace reduces interior radon concentrations.

Certainly, you can't take a house that is low in concentration, weatherize it, and discover that you've created a house with a real high indoor radon concentration. This misconception pops up in the popular press with discouraging frequency.

EA&R: *How are the sources of radon different from those of other indoor pollutants?*

Sextro: Unlike a lot of other indoor air pollutants, the primary source of radon is external to the building, in the soil surrounding the building shell. It enters the building, driven by essentially the same forces that drive infiltration: negative pressures set up by the thermal "stack effect", and wind loading on the building shell. Most other indoor air pollutants have their sources indoors, actually located within the building shell.

EA&R: *You and your colleagues at Lawrence Berkeley Laboratory (LBL) have been involved in several studies of radon mitigation. Could you tell us about the current study you are working on in New Jersey? How many houses are you studying, and what are their construction characteristics?*

Sextro: We are studying seven houses located in north-central New Jersey. The field work began in September 1986 and will continue through this September. All of the houses have basements and block-wall construction. In a couple of the houses there is an adjoining slab-on-grade living area and/or a garage. A couple of houses have basements with adjoining unvented crawl spaces, and the rest of the houses have full basements. In six of the houses we installed systems to reduce radon levels and studied their effectiveness. The seventh house was a control house. It had low enough concentrations, about 20-30 picoCuries per liter (pCi/l) in the basement during the year, so that we didn't feel we had to remediate it right away. In July we installed a mitigation system in this house, and now the radon concentrations are down below 2 pCi/l in the basement.

EA&R: *Who funded the study and what are its objectives?*

Sextro: It was a combination of the Department of Energy and the Environmental Protection Agency (EPA), with some initial assistance from the State of New Jersey in locating study homes. The study has two phases. We are involved in seven houses, and a research team from Princeton and Oak Ridge National Lab is studying a second group of seven houses.

The study has three basic objectives. One is to learn more about the fundamentals of radon entry. Because we are continuously monitoring radon levels in the seven houses, we will have a year's worth of continuous data on about 30 parameters in each house. These include radon concentration in the basement and the first floor, measurements below the slab, pressure differences, indoor-outdoor temperature differences, wind speed, and wind direction.

The second aspect of the study is to investigate the operation of some selective mitigation techniques.

The object of our work in New Jersey wasn't to come up with new or different mitigation techniques. We primarily wanted to explore some techniques that have been in use for some time and to examine their effectiveness, particularly over an extended period of time. We wanted to determine what effect changing environmental

variables, such as temperature, wind speed, and barometric pressure, have on the operation of the system.

The third aspect of the study was to develop diagnostic procedures—things that one can do in a house to help pinpoint where radon is entering the substructure—so that one might know where to direct mitigation efforts. How, for example, does one know if it is localized to a specific area of the house or a general problem?

EA&R: *What are the highest radon levels that you have found in your New Jersey study?*

Sextro: The initial concentrations in the basement of one of the houses was about 200 pCi/l. And one of the houses that we studied in Spokane had winter time concentrations of about 250 pCi/l. For the most part the other houses have been in the 50 to 100 pCi/l range.

EA&R: *Have you been able to reduce radon levels in all cases to below EPA's 4 pCi/l guideline?*

Sextro: We've done pretty well. In most cases, we have been able to get it down to 2 or 3 pCi/l. Our experience has been that it is extremely difficult to get it much lower, say down below 1 or 2 pCi/l. We're taking houses that have 50 to 100 pCi/l, or 200 pCi/l at most in the basement and reducing them down to 4 pCi/l, so that's a pretty significant decrease. We had a couple of houses, which were about 50 pCi/l to begin with, that we reduced to well below 4 pCi/l, but basement concentrations have now begun to creep back up.

We use 4 pCi/l as a target. The EPA guideline is for annual average exposure, which really means that you're talking about 4 pCi/l on average in the living space. You have to take into account where people spend most of their time. Most of the basements that we measured are primarily used for storage, although in several of the houses there was an office or a T.V. room in the basement.

EA&R: *What have you found, to date, to be the most successful mitigation techniques?*

Sextro: We have mainly used what are called sub-slab ventilation systems. In five of our houses we have actually set up two separate mitigation systems and gone through the year by cycling the systems on and off during the course of the year. Mitigation system number one will run for a week; we then turn it off and leave mitigation system number two on for a week, and the third week we shut both mitigation systems off. We have seen as the year progressed how the radon concentrations changed with the soil and other characteristics. The main conclusion that we can draw at this point is that sub-slab ventilation systems seem to work as well as or better than most other systems,

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assuming that they can be installed and assuming that the diagnostics point you in that direction.

In a couple of houses where we had reduced the radon levels to below 4 pCi/l, the levels have now crept up to 4 1/2 to 5 pCi/l. We're going to enhance these systems, even though 4 pCi/l (unless you live in the basement) is not a problem. Your target ought to be 4 pCi/l in the generally occupied space, but because this is a research project, we have the luxury of trying to get radon levels in these houses as low as we can. No concentration, strictly speaking, is "safe", so we should try to reduce the concentrations as far below 4 pCi/l as possible.

EA&R: *How effective were the leak-sealing techniques you tried?*

Sextro: There was, perhaps, a slight reduction in radon levels, but we couldn't tell if it was due to the sealing techniques or if it was just other environmental changes. In one house, we had an open drain, a so-called "French drain". This is a common technique in some areas of the country. Apparently, it's more common in block wall construction than in poured [solid] walls. The French drain consists of a gap, the width of a two by four, between the slab floor and the wall. If water comes in through the wall, it drains down the wall and out through the French drain, instead of puddling up on the floor. But the French drain becomes a perfect entry point for radon. The negative pressure difference between the basement and the soil brings radon in through the opening.

We sealed the French drain—actually made a duct out of it, sealed over the whole thing; and radon concentrations dropped nearly 60 percent. The basement concentrations in that house were about 70 pCi/l, and sealing the French drain dropped the concentrations to about 30 pCi/l.

EA&R: *Are you finding that the radon levels are higher during the winter than the summer?*

Sextro: In general, yes. In some houses we have not seen as much seasonal variation as we had expected. In a couple of houses the radon concentrations are more constant during the winter time. In the fall and the spring, radon concentrations seem to be highly variable, with daily swings that take it up to the winter-time basement concentra-

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tion, and then back down to a tenth of that level. That's because as the season changes, the soil characteristics change, and the driving forces are more apparent in the fall and spring. During these seasons, people generally open their houses more during the day. The indoor-outdoor temperature difference is moderate if it exists at all during the day time, then at night you get maybe a 20 to 25°F temperature difference between the inside and outside. The peak radon concentrations occur during the early morning hours; this corresponds with the peak in the indoor-outdoor temperature difference.

EA&R: *How does this variability affect radon tests done for real estate transactions?*

Sextro: One of the homeowners in New Jersey is a realtor, and it's been interesting to talk with her about what we're seeing and doing and about the impression the real estate industry has about radon. The real estate market in places like New Jersey and Pennsylvania has just been driven crazy by radon. They don't know how to measure it. They don't know what the measurements mean. They're happy if a house comes in at less than 4 pCi/l; and if it's more than 4 pCi/l, they don't know whether to stop the sale or what. I gather from some of the local press that there have been cases where the value of real estate in whole areas has gone to hell in a handbasket because of "radon problems." Some of the states are establishing testing or evaluation guidelines for mitigation contractors, for example. New Jersey and Pennsylvania are about to do this if they haven't already.

EA&R: *What is the greatest misconception about radon in the press?*

Sextro: The main one that troubles me is is the use of the 4 pCi/l guideline. It's a dose-related guideline, that is, it's based on estimated health effects due to exposure to radon progeny concentrations. These radon progeny concentrations are then translated into radon concentrations. The EPA recommends that the annual average concentration to which one is exposed ought to be less than 4 pCi/l. The difficulty is that EPA itself, as well as a lot of people associated with state surveys and the real estate industry, uses 4 pCi/l as a benchmark for all sorts of measurements: long-term alpha-track tests, short-term charcoal canister measurements during the winter or summer, and grab samples of radon progeny. [See section on monitors at end of next article.] The EPA did some short-term screening measurements this winter in ten states and compared the number of houses above 4 pCi/l to the number of houses below that level. I think that's misleading because, for one thing, a lot of those measurements were taken in basements. They were performed in the winter when you might expect radon levels to be higher, and charcoal canisters themselves are probably, at best, not more accurate than plus or minus 25 to 30 percent. The accuracy under some field conditions is probably plus or minus 50 or 100 percent.

EA&R: *But EPA's measurement protocols for the radon monitors require accuracy to within 25 percent.*

Sextro: Based on our experience with charcoal canisters, the devices just don't integrate well enough to give you 25 percent accuracy. Yes, they have to be within 25 percent in the EPA test chamber. But, in fact, I have been suggesting to EPA that they vary the concentration in the test chamber. At least up until now, all they've been doing is exposing monitors to a fixed, unknown radon concentration for a certain amount of time. The companies get the canisters or the alpha-track detectors back, process them and then send back their results to EPA. Their result is supposed to be within 25 percent of the actual chamber level.

But the real issue is whether a charcoal canister gives you within 25 percent of what the real-time variation actually is. From what we've seen thus far, the answer is probably no, particularly if there is a big daily swing in radon concentrations. We've seen variations by a factor of five or seven in indoor radon concentrations over the course of 24 or 48 hours.

In the real estate industry right now, a lot of measurements are being made as part of the contingency for selling the house. They'll come in and do a two-day measurement using charcoal. If the test comes out at 3.9 pCi/l, they'll say, "Gee, it looks good to me. This house is safe." Well, perhaps they made the measurements in late spring, summer, or early fall, when radon concentrations might be low. It also depends a lot on the two-day period you happen to pick, because we know the levels vary daily and even weekly. The flip side is if the house measures 4.1 pCi/l; then everyone gets real worried. The buyer may want to back out of the sale, or will put in a contingency to have remedial work done on it. I'm not sure if one should expect the real estate industry to be able to understand that or to be able to sort it all out, but we in the research community and the

EPA simply haven't been providing the right kind of information so that people can make reasonable measurements and understand what they mean. Scientists will tell you that, given a measurement uncertainty of 25 percent, there is no difference between 4.1 and 3.9.

The real question is whether the radon levels in the house measure 20 to 50 or 100 pCi/l in a two-day measurement. If so, you know that you will need to take further action. The first thing you do after that is take another longer-term measurement with an alpha-track detector, over a period of two months or longer. If you can do this measurement during the winter heating season, you'll get a much better handle on the problem.

EA&R: *What developments do you see on the horizon for developing a more accurate way of measuring radon levels?*

Sextro: We've actually been studying the question of whether one can develop some measurement techniques for use in the summer time that would involve a blower door to depressurize the house. We're looking at that now to see whether the levels we measure using these techniques are at all comparable to what one might see during the dead of winter.

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