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RADON IN THE UNITED STATES: ACCOMPLISHMENTS AND FUTURE CHALLENGES

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Although radon research and related programs have been operating in the United States (U.S.) for several years, it has only been within the last few years that major research and operational programs have been conducted. This paper describes the key elements of radon research, policy, and program implementation activities. It discusses the accomplishments over the past few years and the future directions of the programs.

INTRODUCTION

Indoor radon is one the most serious environmental health threats addressed by the U.S. government. Radon is the second leading cause of lung cancer in the United States. A recent report by scientific experts within the U.S. Environmental Protection Agency (EPA) ranked radon as presenting the highest cancer risk of any single environmental problem (1).

THE RADON PROBLEM

Radon is one of a few known human carcinogens. The International Agency for Research on Cancer (IARC) has stated that "radon and its decay products are carcinogenic to humans (Group 1)" (2). The risk assessments for radon are based on a wealth of information including extensive animal and human studies. Although every study has some limitations, the data have been sufficiently strong to enable quantitative risk assessments to be developed for exposure to radon. The U.S. EPA principally uses the conclusions and findings of the National Academy of Science's Biological Effects of Ionizing Radiation (BEIR IV) Report and that of the International Commission on Radiological Protection (ICRP 50) to support its quantitative risk assessments on indoor radon and its decay products (3,4). In addition, the U.S. Surgeon General's Office, the

American Medical Association, the American Lung Association, and the World Health Organization have all identified radon as a serious health threat.

Despite the extensive evidence for radon-induced cancer in humans resulting from residential exposure, there are a few investigators who remain unconvinced about the seriousness of the indoor radon problems. These critics base their conclusion that radon does not cause lung cancer on negative correlations from limited ecological investigations which look at population groups rather than individuals. This type of study is not appropriate in assessing radon risks because it is unable to evaluate exposure and disease in the same individual and unable to assess the effects of other significant factors, such as migration and smoking. For example, if all other factors were equal, one would expect to see increased incidence of lung cancer in areas with high radon levels. However, since smoking is the dominant cause of lung cancer, small differences in smoking patterns can mask the effects of radon. For example, if one county has 10 percent more smokers than another, even if the other has twice the radon level, lung cancer incidence in the county with higher smoking rates would more than offset the added lung cancers due to radon in the second county. There are a number of ongoing case-control studies of residential populations which could yield data to allow scientists to refine existing radon risk estimates. In addition, EPA has commissioned the National Academy of Sciences to delineate the relationship between underground miner exposure to radon and exposure in homes. The Academy's findings are expected next year.

RADON DISTRIBUTION THROUGHOUT THE UNITED STATES

Data collected through radon surveys conducted jointly by the EPA and 25 States indicate widespread distribution of elevated indoor radon concentrations in the United States. For the past 3 years, EPA has measured radon levels in 37,313 houses through its State Survey Program. The houses were randomly selected. Radon was measured using charcoal canisters in the lowest level of the house. Alpha track detectors were also placed in about 10 percent of the houses. The purpose of the surveys were to provide the State health personnel with information to help them set priorities for their radon control programs. The results of the surveys have shown that radon is highly variable throughout the country. One in four houses had screening levels above 4 pCi/L, indicating that additional followup is warranted in those houses. Alabama had the lowest percentage of houses with screening levels greater than 4 pCi/L (about 6 percent), whereas Iowa had the highest (about 70 percent). EPA is continuing these residential surveys in nine more States this year. These findings will be reported this fall.

To provide an overall perspective on radon exposure in the United States, EPA is currently conducting a National Residential Radon Survey. The purpose of this survey is to determine the frequency distribution of annual average radon levels in houses across the United States. The survey will help define the relationship between specific housing construction types and indoor radon levels. Information collected on living patterns should assist EPA in refining our radon risk estimates.

THE UNITED STATES APPROACH

The U.S. government initially determined that conventional regulatory approaches would not be the most appropriate means to reduce radon risks. Consequently, the United States approach is primarily based on public education and technical assistance to get

the public and the private sector to make reasonable choices to test for radon and fix buildings with elevated levels. Addressing the radon problem is ultimately the responsibility of the individual building owner. The U.S. program relies on an effective Federal/State partnership to reach its goal of reducing public health risk by motivating the public. Governments at the State and local level play a critical role in effectively assisting the public to take informed action to identify and correct radon problems. A credible measurement and mitigation industry is also essential to sustain these efforts.

There is also a unique and necessary Federal role, particularly in conducting basic and applied research, developing a national assessment of the radon problem, providing technical assistance to States, encouraging the development of State and local government capabilities, and providing national leadership to promote radon awareness and appropriate risk reduction activities.

Several Federal agencies have responsibilities involving radon, however, the EPA has been designated the lead agency. In addition, the Department of Energy has a prominent role in conducting various basic research programs.

The goals of the Department of Energy's basic research programs are as follows (5):

- to describe the sources, distribution, and transport of radon in the environment.
- to understand the transport of radon into and within buildings.
- to understand the physical-chemical interactions of radon progeny in ambient air.
- to determine the relationship between exposure to radon progeny and dose to cells at risk.

The EPA's Radon Action Program is based on four key elements, designed to create a comprehensive approach to radon risk reduction: 1) Problem Assessment - to determine the magnitude and distribution of the radon problem throughout the country; 2) Mitigation and Prevention - to develop cost-effective technologies for controlling radon levels in new and existing buildings; 3) Capability Development - to transfer technologies to State and local governments and the private sector; and 4) Public Information - to communicate radon information to the public.

In 1988, the U.S. Congress enacted the Indoor Radon Abatement Control Act (IRAA)(6). The Act provides several new provisions which guide EPA's efforts to deal with the radon problem in the United States. Later in this paper several of the elements of the Act will be outlined.

COST-EFFECTIVENESS OF RADON RISK REDUCTION

In developing the Radon Action Program, EPA developed a number of key policies. Two of the most important include: 1) An action guideline of 4 pCi/L was established based on consideration of several factors, including health risks, the limits of available mitigation technology, and the availability of qualified contractors to measure and fix radon. 2) The second major policy decision was the recommendation that most homes and all schools be tested for radon. This recommendation was based on the often significant differences in radon levels found in homes or schools in the same areas (i.e., neighborhood, county or State), the difficulty in identifying homes or schools with elevated

radon levels without testing, and the cost-effectiveness of this approach, from a societal perspective.

EPA is currently updating our analysis of the cost-effectiveness of radon measurement and mitigation activities. Preliminary information on the projected health benefits of lives saved per unit cost of radon reduction compare favorably with other environmenal risk reduction programs. The benefits to society of radon reduction in existing homes can be achieved for approximately $400 thousand to $1 million per life saved, compared with a range of benefit values used by other environmental programs of $500 thousand to $7 million per life saved. The costs per life saved for the radon program also compare favorably with costs for other public health programs depending on individual action. For example, for programs such as smoke detectors and seat belts, the cost per life saved ranges from about $250 thousand to $600 thousand.

Moreover, installing radon prevention features in new homes can result in a net financial savings to the public. By using basic foundation sealing and weatherization techniques and installing a post-construction capability for subslab depressurization, we can achieve significant reductions in indoor radon levels at a cost of approximately $300 per home. Since improvements in weatherization also yield an estimated energy savings of $50/year, the initial investment in installation of radon reduction features may actually pay for itself over a fairly short time period, as well as providing important health benefits.

HIGHLIGHTS OF FUTURE DIRECTIONS

Congress, in enacting the 1988 Indoor Radon Abatement Act (IRAA), established a national goal that indoor air be as free from radon as the ambient air outside of buildings.

As a result of analysis of the results of risk communication studies and in an effort to respond to the national goal, a strong national public information campaign, is needed to motivate the public to take informed actions to reduce radon risks.

State and local governments play a key role in reducing radon health risks. One of EPA's highest priorities is the encouragement of the development of effective State radon programs.

Prevention of radon problems in new homes is an important complement to mitigation efforts in existing homes. EPA has provided guidance on preventing radon entry through simple techniques for new residential construction. In FY 1990, EPA is developing new construction standards, as directed by the IRAA. EPA is working with States and national building code organizations to ensure that effective standards are developed, and ultimately adopted by the appropriate regional code organizations or local governments.

Key EPA radon activities are highlighed below:

<u>National Advertising Council Radon Campaign</u>

In FY 1990, EPA and the Advertising Council launched a national public awareness campaign designed to reduce radon public health risks. The campaign was developed in response to the need, identified by the risk communication studies mentioned above, to

provide a clear message to reduce apathy about radon risks and to motivate public action. The campaign messages are strong and unsettling in order to overcome the deep public apathy about radon. The campaign consists of TV, radio, print and outdoor advertising to increase awareness about the radon problem, and to motivate people to call the national hotline (1-800-SOS-RADON), which provides the public with an easy way to get immediately involved in the radon action process. A simple informative brochure to motivate people to test for radon is sent in response to hotline calls. A brochure to motivate people to fix homes with high levels is sent along with radon test results.

The campaign is initially targeted to areas in 29 States where at least 1 in 5 homes or more than 100,000 homes have radon screening levels above the EPA action level. The campaign will leverage approximately $20 million in creative advertising expertise and donated media time each year, and is expected to increase the number of people who complete each stage of the radon action process. The campaign would prevent about 130 lung cancer deaths annually if it motivates an additional 3 million people to test their homes for radon, and if it even marginally increases the percentage who fix homes with high levels.

In addition, the Agency is working with the American Lung Association (ALA) and 22 local affiliates to develop and implement local radon awareness activities in 16 States. These activities will be designed to support the Ad Council campaign and to promote radon testing and mitigation for homes and schools.

Citizen's Guide

EPA issued the first Citizen's Guide to Radon in 1986 (7). The Guide established a three-step process (test/re-test/mitigate) for residential radon reduction, and set an action level of 4 pCi/L, as the most protective action level that could be achieved given existing technology.

In the 1988 IRAA, Congress directed EPA to update the Guide to support progress toward the national goal that indoor air be as free from radon as the air outside buildings. In developing the updated Guide, EPA is to assess the health risks associated with a series of action levels, the effect of radon exposure on sensitive populations such as children, the cost and feasibility of radon reduction in existing and new buildings, and the relationship between the short- and long-term measurement techniques. In revising the Guide, EPA will also take into account improvements in mitigation technology since 1986, the societal costs and benefits of alternative testing strategies and action levels, and the results of risk communication studies indicating the need for more effective and streamlined communication with the public. We expect the revised Guide to be available to the public in the fall of 1990.

Prior to 1988, approximately 600,000 homes had been tested for radon. Following EPA's and the Surgeon General's recommendation in September 1988 that most homes be tested, an estimated 1.2 million additional homes were tested. However, over 80 million U.S. homes need to be tested. Although EPA and several States have developed comprehensive radon programs, the primary result to date has been an increase in public awareness without a corresponding increase in appropriate and effective actions to reduce radon risks. Several risk communication studies have investigated public response to radon information in the Citizen's Guide, and medial public information campaigns. These

studies have shown that people are more likely to take effective action to reduce their radon risks if instructions provide clear and simple directions for action. We have found that homeowners frequently do not follow EPA's current three-step guidelines. Risk communication research also shows that many people who tested and found radon levels significantly higher than EPA's action level of 4 pCi/L are not taking any followup actions.

In revising the Citizen's Guide, EPA faces several challenges and important policy decisions. In developing action levels, we must consider the current mitigation technology. Based on preliminary data, we believe that the majority of homes with elevated radon levels can be reduced to 2 pCi/L. In addition, our current test/re-test/mitigation strategy is very complex, and people are not responding appropriately. We will need to balance scientific integrity, good communications, and cost-benefit considerations as we proceed to develop options for revising the Guide.

Activities to Address Radon in Schools

As with our approach to radon reduction in homes, EPA has developed a nonregulatory program to address radon in schools. We have undertaken activities to identify the magnitude of the radon problem in schools, and have developed educational and technical assistance programs to support radon risk reduction.

Based on an initial study of radon in schools, EPA issued a recommendation in April 1989 that all schools be tested for radon. EPA has developed an Interim Report for Radon Measurements in Schools and is currently conducting Phase II of a school protocol development study (8). The results of the study will be used to refine the interim guidance. However, based on preliminary data from Phase II, we believe that our testing protocols will not be changed significantly and should be followed by schools undertaking testing programs now. We are also undertaking a study to evaluate the use of the interim guidance by States and school districts.

Results of the Phase II protocol development study will also be used in FY 1990 to design a nationwide survey of schools, required by the IRAA, to determine the extent of radon problems. We expect to implement the survey in the fall of 1990, and hope the results will be useful to States in planning radon activities and programs.

In addition to the school survey required by the IRAA, several bills have recently been introduced in Congress which would require local education agencies across the country to test their schools for radon. The Congress plans to consider these bills, introduced by Senator Frank R. Lautenberg (New Jersey), and Representatives Peter H. Kostmayer (Pennsylvania) and Bart Gordon (Tennessee) during the 1990 session.

EPA has also issued interim guidance for radon mitigation in schools. This guidance will be refined based on the results of EPA's new School Evaluation Program (SEP), which will consist of numerous field evaluations of schools across the country to determine effective radon diagnostic techniques and mitigation measures. The goal of SEP is to develop and implement a technology transfer program to provide radon mitgation assistance to school officials and private sector contractors. The results of these evaluations, and the school mitigation work done by EPA's Office of Research and Development, will also be used to develop and deliver training programs on school remediation.

Workplace Activities

EPA is currently developing approaches to radon diagnostics and remediation in large buildings, since there are critical elements such as ventilation systems which make these structures different from homes. As required by the IRAA, EPA is assisting other Federal agencies to assess radon problems in their buildings. We have developed interim guidelines for Federal agencies; these guidelines are available to others interested in radon testing for larger buildings. EPA is currently conducting testing to refine these guidelines.

Based on the results provided by Federal agencies, EPA is required to report to Congress on the extent of the radon problem in the Federal workplace. Information from these Federal surveys will contribute to our understanding of radon in the workplace, and may indicate the extent of radon contamination in larger buildings nationwide.

State Grants

In FY 1990, EPA is making available the first State radon program development grants, as authorized by the IRAA. These grants will provide a boost to State radon program development, and EPA is pleased to be able to support the critical State role in radon risk reduction. In addition, States may share these funds with local governments to further enhance effective support of citizen action.

Forty-eight States, the District of Columbia, Puerto Rico, the Virgin Islands, and Guam are participating in the State Grant Program this year. The majority of these grants will be awarded in spring 1990. EPA intends that these grants result in the development of effective radon programs continuing beyond the lifetime of the grant program, and appreciate to the scope and severity of the radon problem in each State. These programs may consist of core activities in radon problem assessment, problem response, public information and program management in States that have not yet developed radon programs. We also anticipate that the grants will stimulate innovation and expansion in States that have already initiated programs. States with more developed programs are encouraged to develop approaches to consumer protection such as measurement and mitigation certification programs, and to implement activities to promote adoption of the model new construction standards to be published by EPA.

Training

In FY 1989, EPA established three Regional Radon Training Centers, as authorized by the IRAA. The Centers, located at Rutgers University, the University of Minnesota, and Colorado State University, provide training to government officials, professional and private firms, in radon health risks and demonstrated methods of measurement and mitigation. EPA is planning to establish an additional center in FY 1990 in the southern portion of the United States.

EPA's goal, consistent with Congressional intent, is that the Training Centers established in FY 1989 be self-sufficient by FY 1993. We view each of the Centers as playing a critical role in developing and providing training programs tailored to the needs of their particular region, and look forward to working with them to achieve these goals.

Since starting operation in the fall of 1989, the Centers have offered courses to nearly 700 individuals in measurement, mitigation, and diagnostics in residences and schools, and general radon information to the public and to State and local government officials. In addition, the Centers have offered EPA's contractor proficiency exam to nearly 850 individuals. The Centers will soon be offering additional courses in school measurement and mitigation, and quality control for measurement laboratories. In addition, the Centers will be updating existing courses and developing specialized courses such as trouble-shooting diagnostics.

Proficiency Programs

EPA operates two major proficiency programs which provide information to States and the public on proficient radon measurement companies and radon reduction contractors.

The Radon Measurement Proficiency Program (RMP) is a voluntary program that is intended to evaluate the proficiency of radon measurement companies, and to provide technical assistance to States in identifying proficient firms (9). The program is voluntary. Those companies that meet the RMP requirements are included in the annual Cumulative Proficiency Report (CPR), which is made available to the public through State radon agencies.

The RMP has grown significantly in company participation since its inception in 1986, when 35 companies were listed in the CPR. The latest CPR contains 657 primary companies offering a range of measurement services, and 5000 secondary companies. In addition, approximately 10 States have incorporated participation in the RMP as part of State certification requirements.

As the RMP program has grown, EPA has instituted program improvements designed to make information on proficient firms more useful to consumers. In the last test round, EPA initiated a pilot double-blind testing program intended to assess a company's routine day-to-day performance in the field. We are currently working with States and the radon measurement industry to identify a number of additional opportunities for enhancing the effectiveness of this program.

The goal of the Radon Contractor Proficiency Program (RCP) is to support the continued development of a competent radon mitigation industry and to provide information on proficient mitigators to the public. To achieve this goal, the RCP program requires participants to meet several program criteria: 1) pass a comprehensive written examination; 2) follow EPA mitigation guidelines; 3) meet continuing education requirements; 4) meet the program mitigation record-keeping requirements; and 5) pass a re-examination every 2 years. In addition, EPA strongly recommends that mitigation contractors take an EPA-approved training course prior to the first exam. Training and exams are offered through EPA's Regional Radon Training Centers. Successful participants are included in the National Radon Contractor Proficiency List. This list is also made available to the public through State agencies. The first National Radon Contractor Proficiency List will be issued in the spring of 1991, and will contain over 600 contractors.

Model New Construction Standards

As required by the IRAA, EPA is developing model construction standards and techniques for radon resistant new construction. Current information indicates that radon levels in new homes can be routinely lowered to below 2 pCi/L by installing the radon resistant features described in our draft Model Standards and Techniques. We believe that building radon resistance into new homes is a cost-effective way to deal with the radon problem. Initial costs are much lower than post-construction mitigation costs, and there is a potential for having an impact on over a million homes each year by adopting radon resistant techniques into building codes. By adopting these techniques about 100 lung cancer deaths could be averted annually for each million new houses built. The resultant number of lives saved would quickly surpass those currently being saved by a public that has been reluctant to deal with the radon problem in their existing homes. There are several key challenges in developing model standards and techniques: 1) address policy-options for the appropriate radon level for new construction; 2) develop recommended implementation procedures that would take into consideration the differences in radon potential that exist across the United States; and 3) consider how to make the document readily accepted as a model by the building code organizations. Finally, another important component of effective implementation of the model codes is support for adoption of the code changes by the State and local jurisdictions that will ultimately have to enforce the new codes.

EPA has been working closely with the National Institute of Building Sciences and the National Association of Home Builders Research Center to develop these model construction standards and techniques for control of radon in new buildings. We expect to have a draft of these standards available for public review and comment in the spring of 1990, and to publish the completed document in the fall.

EPA encourages model code organizations to use the new standards and techniques in the development of revised building codes. We also urge States, local governments, and the radon industry to actively support our new construction standards and techniques when the document is published, and to work for the adoption of radon resistant features in new construction.

CONCLUSIONS

Although considerable progress has been made in the United States in dealing with the scientific and social aspects of indoor radon, much remains to be done to achieve significant national radon risk reductions. To achieve this goal will require effective radon programs at Federal, State, and local levels and a responsive radon measurement and mitigation industry. The efforts of all of these groups will be critical to meet the challenge of motivating the public to make informed decisions and take prudent actions to protect themselves and their families.

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