United States
Environmental Protection
Agency

Air and Energy Engineering
Research Laboratory
Research Triangle Park NC 27711

Research and Development

EPA/600/S9-91/026 Oct. 1991

EPA

Project Summary

Proceedings: The 1990 International Symposium on Radon and Radon Reduction Technology

Ronald B. Mosley, Compiler

The proceedings of the 1990 International Symposium on Radon and Radon Reduction Technology are contained in three volumes. Volumes 1 and 2 contain 47 oral papers and 13 panel papers, while Volume 3 contains 45 poster papers. The presentation of these papers provided an opportunity for and stimulated the exchange of information among participants on a variety of topics relating to indoor radon and its control.

The symposium was jointly sponsored by EPA's Air and Energy Engineering Research Laboratory and its Office of Radiation Programs. The meeting was held in Atlanta, Georgia, on February 19-23, 1990. Participation reached nearly 600 representing federal, state, and local governments, radon measurement companies, radon mitigation companies, research organizations, academia, construction companies, real estate and relocation companies, and school facilities personnel.

This Project Summary was developed by EPA's Air and Energy Engineering Research Laboratory, Research Triangle Park, NC, to highlight the key findings of the symposium. The results of recent research are fully documented in the three volumes of the proceedings by the same title. Information for ordering the full proceedings is at the back of this summary.

Introduction

The papers contained in the proceedings cover a broad range of topics including: government programs, policies, and public information relating to radon, radon-related health studies, radon measurement methods, radon surveys, radon entry dynamics, radon in the natural environment, radon reduction methods, radon prevention in new construction, and radon issues in schools and other large buildings. It was revealed that, in spite of the recommendations by both EPA and the Surgeon General for everyone to test their houses, less than 5% of the homeowners have tested for radon. It was also noted that most of the measurements that are being made are stimulated by real estate transactions. Most people who test do not follow up with mitigation, and frequently those who do mitigate end up with an inferior installation because they elect to go with the lowest bidder. A 1989 study of 473 radon mitigation systems in New Jersey indicated that 56% of the post-mitigation measurements on the lowest floor were below 4 pCi/L, compared to only 36% in a similar 1988 study.

Limited studies of the reliability of mitigation systems indicate that many subslab depressurization systems are operating stably after 2-4 years. One common failure has been the capacitor in the fan. A limited set of studies support the argument that a subslab depressurization system with a passive stack may be a judicious first step for builders in radon-prone areas.

Differences of opinion still abound concerning the best procedures for measuring radon concentrations in schools. However, most commenters favored testing during the school year (as opposed to summertime testing) under closed conditions with the air handlers off. Major school testing programs are underway, and some mitigation is taking place. Increased activity in testing and

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Differences of opinion still abound concerning the best procedures for measuring radon concentrations in schools. However, most commenters favored testing during the school year (as opposed to summertime testing) under closed conditions with the air handlers off. Major school testing programs are underway, and some mitigation is taking place. Increased activity in testing and

mitigating schools is anticipated for the near future.

Participants were welcomed by Georgia State Representative Frank Redding. An invited Lead Talk was presented by Vernon Houk, Assistant Surgeon General from the Centers for Disease Control. Houk discussed implications of radon health risks to the public, and emphasized the importance of reducing these risks. His characterization of health risks was followed by keynote speaker, Richard J. Guimond, Director of EPA's Office of Radiation Programs.

The keynote address challenged participants in three areas: (1) to continue to explore science as a means to improve measurement technology, mitigation technology, and preventive capabilities; (2) to not lose sight of the "big picture" — reducing health risks—and that, if errors are inevitable, they should be made in the interest of protecting the public health rather than excessive scientific conservatism; and (3) to foster cooperation among the many groups (scientists, federal and state governments, educators, measurement and mitigation industries, and the building trades) in order to protect the public interest and the public health.

Volumes 1 and 2 — Papers

Volumes 1 and 2 contain 47 papers (presented orally in the nine sessions listed below) and 13 papers on measurements and measurement methods (presented in panel discussions). The titles, principal authors, and affiliations are listed below for each session. Papers for Sessions I-IV are in Volume 1; those for Sessions V-IX are in Volume 2.

Session I: Government Programs, Policies, and Public Information Relating to Radon

Dennis Wagner, Chairperson EPA-Office of Radiation Programs

EPA's Radon Action Program: Accomplishments and Future Challenges
Margo Oge, EPA-Office of Radiation Programs

Regulation of Radon in Drinking Water
Gregory Helms, EPA-Office of Drinking Water

"Social Marketing" and the Reduction of Indoor Radon
Thomas J. Bierma, Illinois State University

Public Policy Considerations and the Development of a Code for the Control of Radon in Residences
Mike Nuess, Washington Energy Extension Service

Evolution of EPA's National Radon Mitigation Training and Quality Assurance Programs
Jed Harrison, EPA-Office of Radiation Programs

Session II: Radon-Related Health Studies

Christie Ehmann, Chairperson Centers for Disease Control

Lung Cancer Mortality Among Nonsmoking Uranium Miners Exposed to Radon Daughters
Robert J. Roscoe, National Institute for Occupational Safety and Health

Radon and Lung Cancer Among New Jersey Women
Janet Schoenberg, New Jersey State Department of Health

EPA's Approach to Assessment of Radon Risk
Anita Schmidt, EPA-Office of Radiation Programs

Radon Daughter Exposure in Dwellings and Multiple Myeloma
Inge Tell, Lund University, Sweden

Whole Body Counting of Radon Daughters
Robert A. Schlenker, Argonne National Laboratory

High Radon Houses: Questions About Log Normal Distributions and Implications for Epidemiology and Risk Assessment
Robert Goble, Princeton University

Session III: Radon Measurement Methods

Samuel T. Windham Chairperson, EPA-Eastern Environmental Radiation Facility

Time Series Linear Regression of Half-Hourly Radon Levels in a Residence
David A. Hull, Princeton University

Experience with the Wire Screen Unattached Fraction Measurement Technique,
Douglas Van Cleef, EPA-Eastern Environmental Radiation Facility

Panel Discussion on QA/QC of Radon Measurements

Terry Howell, Moderator

Quality Assurance and Quality Control in the Radon Measurement Industry: What is Missing?
Terry Howell, Radon Reduction and Testing, Inc.

Comparison of the Electret-Passive Radon Monitor System with Charcoal Canisters in Controlled Environments
James R. Summers, Analyses Corporation

A Radon Chamber Comparison of Alpha Track Detectors Over a Range of Exposures
William M. Yeager, Research Triangle Institute

A Study of Batch Calibrations on 4" Open Faced Charcoal Absorbers from Four Different Manufacturers and How They Compare to EERF's Published Calibration Curves
Dallas L. Jones, Radon Reduction & Testing, Inc.

Calibration of Alpha-Track Monitors for Measurement of Thoron (Rn-220)
Mark D. Pearson, UNC Geotech

Quality Assurance Procedures for Home Radon Testing
Richard Tucker, Radonics, Inc.

Panel Discussion on Short-/Long-Term Radon Measurements

Richard Sextro, Moderator

Issues in the Use of Short-Term Radon Concentration Measurements for Evaluating Long-Term Exposures
Richard Sextro, Lawrence Berkeley Laboratory

The Relationship Between Winter Screening and Annual Average Radon Concentrations in U. S. Homes
Melinda Ronca-Battista, Scientific and Commercial Systems Corporation

Temporal Patterns of Indoor Radon in North Central Florida and Comparison of Short-Term Monitoring to Long-Term Averages
Charles E. Roessler, University of Florida

Study on the Reliability of Short-Term Measurements to Predict Long-Term Basement Radon Levels in a Residence
T. Agami Reddy, Princeton University

Results of Short-and Long-Term Radon Measurements in Soil and Dwellings by Alpha Track Detectors
L. Tommasino, ENEA-DISP, Rome, Italy

A Statistical Analysis: Predicting Annual ^{222}Rn Concentrations from 2-Day Screening Tests
S. B. White, Research Triangle Institute

Session IV: Radon Surveys

Paul Wagner, Chairperson EPA-Region 4, Office of Radiation

Radon Exposure in Connecticut: Analysis of Three Statewide Surveys of Nearly One Percent of Single Family Homes
Alan J. Siniscalchi, State of Connecticut Department of Health Services

Residential Radon Survey of 25 States
Jacolyn A. Dziuban, EPA-Office of Radiation Programs

Surveys of Radon Levels in Homes by University of Pittsburgh Radon Project
Bernard L. Cohen, University of Pittsburgh

Radon in Norwegian Dwellings
Terje Strand, National Institute of Radiation Hygiene, Norway

Session V: Radon Entry Dynamics

William J. Angell, Chairperson University of Minnesota

A Simplified Modeling Approach and Field Verification of Airflow Dynamics in SSD Radon Mitigation Systems
Kenneth J. Gadsby, Princeton University

The Role of Diffusion in Radon Entry Into Houses
Allan B. Tanner, U. S. Geological Survey

Soil Gas and Radon Entry Potentials for Substructure Surfaces
Bradley Turk, Consultant

Measurements and Modelling of Radon Infiltration Into a Dwelling
P. Stoop, Kernfysisch Versneller Instituut, the Netherlands

Session VI: Radon in the Natural Environment

Bob Fakundiny, Chairperson New York State Geology Department

Benchmark and Application of the RAETRAD Model
Vern C. Rogers, Rogers & Associates Engineering Corp.

Geologic Controls on Radon Occurrence in Georgia
L. T. Gregg, Atlanta Testing and Engineering

Correlations of Soil-Gas and Indoor Radon with Geology in Glacially Derived Soils of the Northern Great Plains
R. Randall Schumann, U.S. Geological Survey

Geologic Factors and House Construction Practices Affecting Indoor Radon in Onondaga County, New York
Charles Laymon, New York State Department of Health

Geologic Controls on Indoor Radon in the Pacific Northwest
James K. Otton, U.S. Geological Survey

Session VII: Radon Reduction Methods

Michael C. Osborne Chairperson EPA-Air and Energy Engineering Research Laboratory

Evaluation of Sub-Slab Ventilation for Indoor Radon Reduction in Slab-on-Grade Houses
D. Bruce Henschel, EPA-Air and Energy Engineering Research Laboratory

Radon Mitigation Experience in Houses with Basements and Adjoining Crawl Spaces
Marc Messing, INFILTEC

Engineering Design Criteria for Sub-Slab Depressurization Systems in Low Permeability Soils
Charles S. Fowler, Southern Research Institute

Radon Mitigation Techniques for Basement Houses with Poor Sub-Slab Communication
Bobby E. Pyle, Southern Research Institute

One-Year Follow-Up Study of Performance of Radon Mitigation Systems Installed in Tennessee Valley Houses
Charles S. Dudney, Oak Ridge National Laboratory

A Cost-Effectiveness Comparison of Private-Sector Radon Remediation with Traditional Radiation Protection Activities
Daniel J. Strom, University of Pittsburgh

The Effectiveness of Radon Reduction in New Jersey
Nick DePierro, New Jersey Department of Environmental Protection

Long-Term Performance and Durability of Active Radon Mitigation Systems in Eastern Pennsylvania Houses
Arthur Scott, American ATCON

Session VIII: Radon Prevention in New Construction

Michael Nuess, Chairperson Washington Energy Extension Services

Evaluation of Radon Resistant New Construction Techniques
Terry Brennan, Camroden Associates

Radon Mitigation Performance of Passive Stacks in Residential New Construction
David Saum, INFILTEC

Sub-Slab Pressure Field Extension Studies on Four Test Slabs Typical of Florida Construction
Richard A. Furman, University of Florida

A Pilot Study to Evaluate Radon Resistance of Films and Sealants Using Perfluorocarbon Tracers
Mark Nowak, NAHB National Research Center

The Use of Coatings and Block Specification to Reduce Radon Inflow Through Block Basement Walls
John S. Ruppersberger, EPA-Air and Energy Engineering Research Laboratory

Session IX: Radon in Schools and Large Buildings

Alfred B. Craig, Chairperson EPA-Air and Energy Engineering Research Laboratory

Radon Measurements in 130 Schools: Results and Implications
R. Thomas Peake, EPA-Office of Radiation Programs

Radon Diagnostics and Mitigation inTwo Public Schools in Nashville, Tennessee
Alfred B. Craig, EPA-Air and Energy Engineering Research Laboratory

The Effects of HVAC System Design and Operation on Radon Entry Into School Buildings
William A. Turner, Harriman Associates

Radon Mitigation Experience in Difficult-to-Mitigate Schools
Kelly W. Leovic, EPA-Air and Energy Engineering Research Laboratory

Air Pressure Distribution and Radon Entry Processes in East Tennessee Schools
Linda D. Sinclair, Oak Ridge National Laboratory

Radon in Schools of Massachusetts
Lee Grodzins, NITON Corporation

Radon Gas Testing in Kentucky Schools: Summer Testing Pragmatic Concerns and Pressure/HVAC Considerations
Patrick S. Holmes, Alpha Spectra of Kentucky, Inc.

Radon Surveys in Large Buildings - The UCF Radon Project
Ralph A. Llewellyn, University of Central Florida

Volume 3 — Papers

This volume contains a lead paper and 45 poster papers that were presented. The titles, principal authors, and affiliations are listed below for each session.

Lead Paper: Reducing the Health Risks of Radon to the Public
Vernon N. Houk, (Invited Speaker)
Assistant Surgeon General
Centers for Disease Control

Session I: Poster Papers

Indoor Radon Levels in Columbus and Franklin County, Ohio, Residences, Commercial Buildings, and Schools
Harry E. Grafton, Columbus, Ohio, Health Department

Model Standards and Techniques for Controlling Radon Levels within New Buildings
David M. Murane, EPA-Office of Radiation Programs

The Florida Radon Research Program: Systematic Development of a Basis for Statewide Standards
David C. Sanchez, EPA - Air and Energy Engineering Research Laboratory

Ten Practical Lessons for an Effective Radon Risk Communication Program (Abstract Only)
Ann Fisher, EPA-Office of Policy, Planning, and Evaluation

Interactive House Investigation and Radon Diagnostics Computer Program
Lynne M. Gillette, EPA-Office of Radiation Programs

Community-Based Radon Education Programs
Joseph Laquatra, Cornell University

Session II: Poster Papers

Radon-Induced Lung Cancer Risk Estimates for the New Jersey Population
Mary Cahill, New Jersey Department of Environmental Protection

Indoor Radon Exposure in Norway and Lung Cancer Risk
Tore Sanner, Institute for Cancer Research, Oslo, Norway

Validity of Various Epidemiological Approaches to Assessing Radon Health Risk
Susan M. Conrath, EPA-Office of Radiation Programs

Assessment of Health Impacts of Radon Exposures in Florida
W. T. Vonstille, University of Central Florida

Realistic Evaluation of Tester Exposure Based on Florida Testing Experience
Richard A. Schrieber, Razman Associates

Session III: Poster Papers

An E-RPISU (Electret Radon Progeny Integrating Sampling Unit): A New Instrument for Measurement of Radon Progeny Concentration in Air
Paul Kotrappa, Rad Elec, Inc.

A Review of the Detection Technology in the At Ease Radon Monitor
William E. Simon, Sun Nuclear Corporation

A Comprehensive Radon Assay System Using Cellulose Nitrate Films
Anders Damkjaer, The Technical University of Denmark

Two-Filter Continuous Monitor for Low Levels of ^{220}Rn and ^{222}Rn
David Grumm, New Mexico Institute of Mining and Technology

Accuracy and Precision of Passive Long-term Radon Detectors as a Function of Concentration and Exposure Time
Robert J. Lyon, EPA-Office of Radiation Programs

The EPA Diffusion Barrier Charcoal Absorber for Radon Measurements in Indoor Air
David J. Gray, EPA-Eastern Environmental Radiation Facility

Session IV: Poster Papers

Survey of Radon 222 in Monroe County, Pennsylvania
Paul N. Houle, East Stroudsburg University

Private Sector Radon Mitigation Survey
John Hoornbeek, EPA-Office of Radiation Programs

Sampling Strategies of Radon Surveys: The Italian Experience
Gloria Campos-Venuti, National Institute of Health, Rome, Italy

First-Phase Study Design for the U. S. Navy Radon Assessment and Mitigation Program (NAVRAMP)
Richard B. Gammage, Oak Ridge National Laboratory

Radon in Water Aeration System Operational Performance
Bruce L. Lamarre, North East Environmental Products, Inc.

National Residential Radon Survey
Frank Marcinowski, EPA-Office of Radiation Programs

Session V: Poster Papers

Sub-Slab Suction System Design for Low Permeability Soils
David Hintenlang, University of Florida

Interpreting the Vacuum Suction Test
Terry Brennan, Camroden Associates

Seasonal Variations of Indoor Radon Concentrations
Benny Majborn, Riso National Laboratory, Denmark

Dynamic Multi-Compartment Modelling: The Transport of Radon and Its Decay Products Indoors
Craig P. Wray, G. K. Yuill and Associates, Inc.

A Data Acquisition System for Monitoring Radon Entry and Distribution
R. P. Sieber, University of Saskatchewan

Session VI: Poster Papers

Determination of Radon-Geologic Provinces in the United States
R. Thomas Peake, EPA - Office of Radiation Programs

Secular Variations of Radon in Metropolitan Vancouver, British Columbia, Canada
Mory M. Ghomshei, Orchard Geothermal, Inc.

Radon in Soils, Caves and Homes of North Central Tennessee
Paul D. Collar, U. S. Geological Survey

A Statistical Summary of Uranium and Radon in Soils from the Coastal Plain of Texas, Alabama and New Jersey
Linda C. S. Gundersen, U. S. Geological Survey

Effects of Regional and Seasonal Variations in Soil Moisture and Temperature on Soil Gas Radon
Arthur W. Rose, Pennsylvania State University

Session VII: Poster Papers

Energy Penalties Associated with the Use of a Sub-Slab Depressurization System
Mike Clarkin, Camroden Associates, Inc.

Long-Term Durability and Performance of Radon Mitigation Subslab Depressurization Systems
David T. Harrje, Princeton University

Radon Abatement System Ancillary Item
Ronald F. Simon, RF Simon Company, Inc.

Laboratory Studies of "Between the Rooms" Radon Decay Product Removal Units
Dade W. Moeller, Harvard School of Public Health

Radon Mitigation Techniques for Norwegian Houses
Bjorn Lind, National Institute of Radiation Hygiene, Norway

Session VIII: Poster Paper

Radon Reduction in Wood Foundation System
Roscoe J. Clark, Permanent Wood Foundation, Inc.

Session IX: Poster Papers

Prediction of Maximum Radon Concentrations in Schools Using Partial Sampling Methods
William E. Belanger, EPA-Region 3

Commercial Mitigation Techniques Used in Remediating a 2200 pCi/L Public Building
James G. Davidson, Radon Detection Services, Inc.

EPA's School Protocol Development Study — Phase II
Anita Schmidt, EPA-Office of Radiation Programs

Radon Levels in Non-Residential Buildings in New Jersey
Karen Tuccillo, New Jersey Department of Environmental Protection

Electret Ion Chambers for Radon Measurements in Schools During Occupied and Unoccupied Periods
Kenneth D. Wiggers, American Radon Services, Ltd.

Measuring Radon in the Workplace
Michael Boyd, EPA-Office of Radiation Programs

The School Evaluation Program
Eugene Fisher, EPA-Office of Radiation Programs

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