United States
Environmental Protection
Agency

Air and Energy Engineering
Research Laboratory
Research Triangle Park NC 27711

Research and Development

EPA/600/S7-90/016 Jan. 1991

EPA

Project Summary

Investigation of Radon Entry and Effectiveness of Mitigation Measures in Seven Houses in New Jersey

C. S. Dudney, L. M. Hubbard, and T. G. Matthews

Little previous work on radon mitigation strategies has involved detailed, continuous monitoring over long periods of time in occupied houses. With permission of the owners, seven houses in New Jersey were studied for 7 to 10 months.

The houses selected all had basements that were partially or completely below grade on all four sides. Premitigation radon levels were between 20 and 200 pCuL.* The principal focus of the project was understanding pressure-driven flows of radon-laden gas into the substructure of basement houses.

During the 7 to 10 months the houses were studied, radon concentrations, temperature, pressure, and weather data were continuously logged, and a variety of experiments were performed to study soil and building dynamics. This report describes the results of these measurements and how they relate to pressure-driven flow of soil gas into and through these residential structures. The report also describes design, implementation, and refinement of radon mitigation systems for these houses.

The principal findings of the study are:

(1) Reversal of the pressure gradient across the basement slab in these houses resulted in a dramatic, rapid decrease in indoor radon levels.

(2) Diagnostic examinations of possible radon reservoirs as well as air flows and pressure gradients resulting from applied depressurization under the basement slab were most important in designing a successful subslab depressurization system for radon mitigation.

(3) Occupant behavior can substantially perturb the forces driving radon entry. The most important factor in this regard is the operation of the fan in the central air handler.

(4) A time series analysis failed to reveal consistent cross correlation between radon in the living area and such factors as radon in the basement, temperature differences, or pressure differentials.

This Project Summary was developed by EPA's Air and Energy Engineering Research Laboratory, Research Triangle Park, NC, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

The discovery of residences with indoor levels of radon far in excess of those equivalent to federal limits for occupational exposure to short-lived progeny of radon have raised public concern for a better understanding of radon entry processes and how best to reduce radon entry. Many epidemiological studies have shown that the incidence of fatal lung cancers among miners in underground uranium mines

* 1 pCi/L = 37 Bq/m^3.

increases according to cumulative exposure to short-lived radon progeny.

Radon has been shown to enter houses by several pathways or mechanisms. The most important pathway for detached, single-family dwellings in most regions of the U.S. is thought to be pressure-driven flow of soil gas into the substructure.

Pressure-driven flow of radon may be influenced by: (a) the rising of warm air through the interior volume of the structure, (b) the impact of wind on the exterior shell of the building which results in high pressure relative to indoor pressure on one side and low pressure on the other three sides, (c) falling atmospheric pressure which may result in a transient condition in which soil pressures exceed pressures above ground or in the house, and (d) heavy rainfall which may act as a piston,compressing soil gas beneath the surface layer in the soil.

Procedure

House screening and final selection were completed by August 1986. A copy of the questionnaire used in the house selection process is given in the report.

An instrument package was developed by the Oak Ridge National Laboratory (ORNL)/Princeton team and calibration of the instrument packages was completed by late October 1986.

Nearly continuous, premitigation baseline monitoring was conducted from mid-October to mid-December 1986. The premitigation diagnostic studies were performed between mid-November and the end of December 1986. These studies included measurements to characterize the entry of radon into structures and potential control measures. Diagnostic measurements were continued in selected houses through the winter and spring of 1987 to improve mitigation efficiency.

The selection and implementation of mitigation measures in the study houses were commonly divided into two major phases: Phase I mitigation measures were installed principally between mid-December 1986 and mid-January 1987, and Phase II mitigation measures were installed and refined over a period of time from January through May 1987.

After installation and refinement of the mitigation system, the performance of the system was studied in several ways. Subslab systems were operated in pressurization, depressurization, and passive modes. Tracer gases were used to evaluate the energy penalties associated with the installed slab depressurization system.

Results and Discussion

The concentration of radon and radon progeny in indoor air depends on generation and transport of radon from radium-bearing materials to the indoor environment and the characteristics of indoor aerosols. The report discusses gamma radiation surveys, geological survey results, radon in well water, radon progeny measurements, and time-weighted-average radon measurements.

The rates at which air moves among the various compartments of a house strongly affects the spatial and temporal distribution of radon. Data discussed in the report include measurements of building leakage using blower doors and measurements of air exchange using active and passive multicompartment systems.

Conclusions

Subslab ventilation is the most positive and effective means for reducing indoor radiation levels in detached, single-family basement houses.

The effectiveness of subslab ventilation is greatly increased by sealing the basement slab to the wall.

The central air handling system significantly affects radon entry into structures.

C. S. Dudney, L. M. Hubbard and T. G. Matthews are with Oak Ridge National Laboratory, Oak Ridge, TN 37831-6285
***David C. Sanchez** is the EPA Project Officer (see below).*
The complete report, entitled "Investigation of Radon Entry and Effectiveness of Mitigation Measures in Seven Houses in New Jersey," (Order No. DE89016676; Cost: $39.00, subject to change) will be available only from:
National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Telephone: 703-487-4650
The EPA Project Officer can be contacted at:
Air and Energy Engineering Research Laboratory
U.S. Environmental Protection Agency
Research Triangle Park, NC 27711

United States
Environmental Protection
Agency

Center for Environmental Research
Information
Cincinnati OH 45268

BULK RATE
POSTAGE & FEES PAID
EPA
PERMIT No. G-35

Official Business
Penalty for Private Use $300

EPA/600/S7-90/016