United States
Environmental Protection
Agency

Research and Development

Air and Energy Engineering
Research Laboratory
Research Triangle Park, NC 27711

EPA/600/SR-94/002 March 1994

EPA

Project Summary

Assessment of the Effects of Weatherization on Residential Radon Levels

Timothy M. Dyess

The U. S. Environmental Protection Agency conducts research to determine the factors that influence radon entry into residences. Reducing air leaks in the home has the potential for reducing the pressure-driven flow of radon into the home and has been suggested as a potential radon-reduction technique. However, the reduction of air leaks in a home also reduces the air exchange rate and therefore the dilution rate of radon with outdoor air. Because the underlying physical processes at work can interact in different ways, the relationship between tightening the building envelope and indoor radon levels is not well understood.

Part of a project with the Maryland Weatherization Assistance Program involved weatherizing homes throughout the state of Maryland according to two protocols—a Retro-Tech technique expected to achieve approximately a 10 to 20% reduction in air leakage and an advanced technique expected to reduce air leakage by as much as 50%. For the project that is the subject of this report, time-integrated radon measurements were taken for 30- to 45-day periods both before and after weatherization in 32 Retro-Tech homes, 28 advanced homes, and 16 control homes that were not weatherized during the study period. Air leakage rates before and after weatherization were measured with a blower door, and ambient temperatures and precipitation levels during the monitoring periods for each study home were obtained from local weather stations.

Based on results of blower-door tests, air leakage rates were reduced by an average of 10 to 15% in Retro-Tech homes and by 35 to 40% in advanced homes. The radon concentration data generally suggest that weatherization procedures did not adversely affect indoor radon levels. However, interpretations are clouded by weather factors that may influence radon entry rates changing differentially for the three groups of homes between the two measurement periods.

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 primary factors that influence radon entry include (1) the radon content of the soil gas, (2) the pressure differential between the interior of the home and the soil, (3) the air exchange rate for the home, (4) the moisture content of soil surrounding the home, and (5) the presence and size of entry pathways. The pressure differential between the soil and the interior of the home is influenced by the wind, temperature differential between indoors and outdoors, and the operation of ventilation and combustion equipment. The air exchange rate is also influenced by the same factors. The pressure differential is the primary force driving the radon entry into the building, and the air exchange rate affects the dilution of the radon with outdoor air. Both factors are influenced by the tightness of the building envelope.

Reducing the air leaks in the home has the potential for reducing the pressure-driven flow of radon into the home and has been suggested as a potential radon-reduction technique. However, the reduction of air leaks in a home also reduces the air exchange rate and therefore the dilution rate of radon with outdoor air. Because the underlying physical processes at work can interact in different ways, the relationship between tightening the building envelope and indoor radon levels is not well understood.

Because reducing the air exchange rate in buildings is a very desirable energy conservation measure, it is important to understand how tightening the building envelope affects the indoor radon level. As part of a project with the Maryland Weatherization Assistance Program for low-income households, 72 homes in the state of Maryland were weatherized. Two weatherization protocols were applied in this study: one expected to achieve approximately a 10 to 20% reduction in air leakage, and the other expected to reduce air leakage by as much as 50%. Eighteen homes, used as a control group, were not weatherized.

Objective

The objective of this two-phase effort was to measure the radon levels inside study homes before and after weatherization so that the effect of weatherization on indoor radon could be assessed. Alpha track detectors (ATDs) were used to measure indoor radon levels before and after weatherization, and blower-door tests were used to determine the change in air leakage through the building shell as a result of the applied weatherization techniques. The ATDs used for both phases of the project were manufactured and analyzed by Tech/OPs Landauer (Glenview, IL). A single ATD was placed in the lowest level of each home for 30 to 45 days during both the pre- and post-weatherization periods.

Ninety-two homes were enrolled in the program, most during the latter part of the 1990-1991 heating season. Of these 92 homes, 28 received pre-weatherization radon monitoring under Phase I of this effort; the remainder of the radon monitoring was conducted during Phase II. A site visit was made to each home by a two-person crew who documented the building characteristics, conducted a blower-door test, installed a furnace run-time meter, and placed an ATD. During the 4 to 6 weeks following the site visit, the homeowner was called to collect data on the furnace run-time and indoor temperature. Outdoor temperatures and precipitation levels from the closest weather station were collected. The weather data, energy use, building characteristics and blower-door results for each home were maintained in a project data base. At the end of the radon monitoring period for each home, the ATDs were retrieved and forwarded to the Tech/OPs Laboratory for analysis. The laboratory radon results for each home were added to the data base.

After the 4- to 6-week pre-weatherization data collection period had ended, 74 homes received a weatherization treatment. The type of treatment was pre-determined by the project staff, with the main concept being to pair homes according to (1) the type of home, (2) the fuel used for heating, (3) the geographical location of the home, and (4) the number of occupants. Within a pair, one home was assigned weatherization with the Retro-Tech technique (existing technique used in the state), and the other home was assigned weatherization with the advanced technique (contemplated alternative to Retro-Tech). Other homes with similar characteristics were assigned to the control group. The weatherization procedures are described in the report.

Results

The following measurements from the weatherization project were used to summarize pre- and post-weatherization results for this project: indoor radon concentrations, average outdoor temperatures, average precipitation levels, and blower-door test results. The blower-door results were expressed as absolute air leakage rates, in cubic feet per minute (CFM) at 50 pascals (Pa), and in relation to house volume, in air changes per hour (ACH) at 50 Pa. The weatherization cases were grouped by type of weatherization and analyzed to determine whether any of the changes were statistically significant. The pre- and post-weatherization values, as well as their differences, are summarized in Table 1 and are discussed in the report.

Between the pre- and post-weatherization measurement periods, average indoor radon concentrations decreased with statistical significance for two subgroups of homes—the control group, which received no weatherization, and the Retro-Tech group, for which weatherization reduced air leakage rates by 10 to 15%. For the advanced group of homes, weatherization reduced air leakage rates by 35 to 40% and radon levels rose slightly, but the increase in radon is not statistically significant while air leakage reductions are. Thus, the data generally suggest that weatherization procedures did not adversely affect indoor radon levels. These interpretations related to changes in indoor levels are clouded by weather factors that may influence radon entry rates changing differentially for the three groups of homes between the two measurement periods. More specifically, both outdoor temperature and precipitation levels changed significantly for the control group, only outdoor temperature changed significantly for the advanced group, and neither changed significantly for the Retro-Tech group.

Within the Retro-Tech group, the correlation coefficient between changes in airtightness (CFM at 50 Pa) and changes in indoor radon concentration are statistically significant: the sign of the coefficient ($r = 0.33$) indicates that reduced air leakage was statistically associated with reduced radon concentrations. However, within the advanced group that had greater changes in airtightness, no significant relationship was evident between changes in airtightness and radon.

Based on analysis for the control group, precipitation was the most influential weather factor. The sine of the coefficient ($r = -0.66$) indicated that radon concentrations generally decreased as precipitation levels increased. Such a finding broadly supports the theory that moisture-laden soil suppresses radon migration in all directions.

Table 1. *Summary of Monitoring Results by Type of Weatherization Procedure*

Measurement Parameter[a]	No. of Cases	Pre-Weatherization Value, Avg. ± Std. Dev.	Post Weatherization Value, Avg. ± Std. Dev.	Difference (Post-Pre), Avg. ± Std. Dev.
Advanced Weatherization				
Indoor Radon, pCi/L	28	2.1 ± 3.0	2.5 ± 4.5	0.4 ± 2.4
Precipitation, in.	28	6.5 ± 4.9	5.7 ± 2.1	-0.8 ± 4.9
Outdoor Temperature, °F	28	48.1 ± 4.5	41.4 ± 9.1	-6.7[b] ± 9.8
Airtightness, CFM @ 50 Pa	25	3897 ± 2732	2351 ± 938	-1546[b] ± 2001
Airtightness, ACH @ 50 Pa	25	23.9 ± 12.4	14.8 ± 4.2	-9.1[b] ± 10.0
Retro-Tech Weatherization				
Indoor Radon, pCi/L	32	1.1 ± 0.7	0.8 ± 0.6	-0.3[b] ± 0.5
Precipitation, in.	32	6.2 ± 5.2	5.8 ± 1.2	-0.4 ± 5.6
Outdoor Temperature, °F	32	46.2 ± 4.5	42.4 ± 13.7	-3.8 ± 14.7
Airtightness, CFM @ 50 Pa	29	3422 ± 1464	2984 ± 1248	-438[b] ± 550
Airtightness, ACH @ 50 Pa	29	24.5 ± 12.5	21.7 ± 12.2	2.8[b] ± 3.9
No Weatherization (Controls)				
Indoor Radon, pCi/L	16	2.5 ± 4.1	2.2 ± 3.8	-0.3[b] ± 0.5
Precipitation, in.	16	4.4 ± 3.8	7.3 ± 2.7	2.9[b] ± 4.7
Outdoor Temperature, °F	16	44.5 ± 5.4	38.9 ± 9.1	-5.6[b] ± 9.9
Airtightness, CFM @ 50 Pa	15	3949 ± 3435	3697 ± 2522	-252 ± 2320
Airtightness, ACH @ 50 Pa	15	23.0 ± 14.2	22.5 ± 14.6	-0.5 ± 9.6

[a] 1 in. = 2.54 cm, °F = 9/5 °C + 32, and 1 cfm = 0.000472 cms.
[b] Significantly different from zero ($p < 0.05$).

☆U.S. GOVERNMENT PRINTING OFFICE: 1994 - 550-067/80209

Timothy M. Dyess is the EPA Project Officer (see below).
The complete report, entitled "Assessment of the Effects of Weatherization on Residential Radon Levels," (Order No. PB94-141181; Cost: $19.50; 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

Official Business
Penalty for Private Use
$300

EPA/600/SR-94/002

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