

ALASKA LEGISLATURE COMMITTEE FILES 1987-1988 8672

4489

HCRA

HB 519

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a factor of two. For this reason, we recommend that paragraph (1) of Section 44.47.656, Eligibility For Loans, be reworded as follows:

- (1) A measurement of the radon gas concentration in the homeowner's residence exceeds the following:
 - (a) 4 picocuries per liter for a yearlong measurement; or
 - (b) 6 picocuries per liter averaged over a minimum measurement period of three months; or
 - (c) 8 picocuries per liter for a measurement period of less than three months.

In addition, we recommend that the following two paragraphs be added to Section 44.47.656.

- (2) Measurements of radon gas concentration must be made in a living area of the homeowner's residence.
- (3) Measurements must be performed by companies having successfully passed the Radon Measurement Proficiency Program of the EPA.

Paragraph (2) has been added to insure that measurements are not obtained from crawl spaces, root cellars, etc., which may be appreciably higher than those found in other areas of the home. Radon measurements in these areas do not provide information on which to evaluate health risks. The department has had difficulty making evaluations in a number of instances where homeowners have not followed the recommended guidelines to make measurements in living areas. It is very important that this be required. If not, a high percentage of homes will qualify for loans when the concentration of radon gas does not exceed the eligibility level in living areas. Paragraph (3) insures that the radon measurement is made by a company that has demonstrated a capability for accurately measuring radon levels.

Position

With the changes suggested above, the Department of Health and Social Services supports passage of HB 519.

POSITION PAPER/Department of Health & Social Services

Position Paper, HB 519, pg. 3

Recommended by:

Elizabeth Ward
Elizabeth Ward, M.N.
Director
Division of Public Health

Date:

March 3, 1988

Approved by:

Myra M. Munson
Myra M. Munson
Commissioner
Department of Health and
Social Services

Date:

March 7, 1988



STATE OF ALASKA
OFFICE OF THE GOVERNOR
BILL ANALYSIS

15 HB 519
MAR - 4 1988

DEPARTMENT DEC	DIVISION Environmental Quality	BILL NUMBER HB 519	SPONSOR Davis, Koponen, Ulmer
SHORT TITLE OF BILL An act establishing a revolving loan fund for radon mitigation			
DEPARTMENT POSITION The Department supports the intent of the bill.			
PREPARED BY Amy D. Kyle <i>alsykh</i>	DATE 3/2/88	COMMISSIONER'S SIGNATURE <i>[Signature]</i>	DATE 3/4/88

SUMMARY

OTHER AGENCIES AFFECTED BY BILL DCRA	CONSTITUENT GROUP(S) AFFECTED BY BILL
ORGANIZATIONAL SUPPORT FOR BILL	ORGANIZATIONAL OPPOSITION TO BILL

FISCAL IMPACT: NONE FISCAL NOTE ATTACHED

BACKGROUND/LEGISLATIVE INTENT
Radon contamination of homes and public facilities has been documented in Alaska. This can cause high levels of radiation and lead to lung cancer. It is a serious health concern.

ANALYSIS OF BILL/PROGRAM EFFECTS
The bill would provide a mechanism to assist homeowners to fund improvements needed to solve radon contamination problems.
The Department has no position on the issue of funding.

AMENDMENTS PROPOSED

PLEASE ATTACH A SEPARATE SHEET FOR ADDITIONAL COMMENTS OR ANALYSIS.

THE FOLLOWING DOCUMENT(S) MAY NOT FILM
LEGIBLY BECAUSE OF POOR QUALITY OF THE
ORIGINAL.

TELECONFERENCE ON RADON GAS

HB 519 & HB 520

TESTIMONY OF PHILIP LONDON, NORTECH INC.

229 3rd Street (1st Floor)

Fairbanks, Alaska 99701

(907) 451-8378, 456-8378

March 7, 1988

Today I am speaking as a principal of a newly formed engineering and technical services firm named Nortech. Nortech is a direct result of the recent radon findings in the Fairbanks area. Involved in Nortech with myself, is John Langeshier, a professional engineer with experience in civil, chemical and environmental engineering.

Our involvement with radon gas in the Fairbanks area consists of providing testing, analysis and mitigation services for building owners that have been inspected by this substance. We have currently distributed over three hundred activated carbon, short term radon monitors and we maintain the largest private data base of information on the frequency and quantities of radon gas found in Alaska. We also own continuous radon monitoring (CRM) equipment and distribute products dealing with home measurement of radon. We are presently working on our fourteenth mitigation system design.

Our customers have been homeowners and small businesses, though we have provided testing services for governments and institutions. In every case, the impact of finding greatly elevated levels of radon gas

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has proven to be difficult financially, occasionally even debilitating and in some cases mentally debilitating, to those with the misfortune to have discovered it.

We are aware of many households that cannot financially afford any amount of mitigation expense. One client of ours who is blind and dependent upon social security, is confronted daily with living in a radon environment that he cannot financially deal with. He is dependent upon friends and neighbors to remove him from his home that contains levels of radon gas above the mine closure level established by the Nuclear Regulatory Commission. The NRC has established cumulative dosage limits for miners exposed to radon gas during a 40 hour work week. This person remains exposed to radon far more than forty hours a week and desperately needs help in mitigating his problem.

Some of our clients have not taken steps toward mitigating their radon problems because other financial burdens have forced them to expend their savings first. In several cases they and their children live, play and sleep in homes that contain an equivalent lung cancer risk as smoking two and three packs of cigarettes per day (using the EPA AVERAGE risk assessment). This is disconcerting, but the EPA has set the risk... we only measure and inform our clients of the reality of their individual situation and what they may do about it. To what extent they carry out our recommendations is their responsibility.

Human exposure to radon gas is clearly the greatest natural radiation threat to modern man. Where other toxic substances such as dioxin, PCB's, benzene, etc. are considered safe at risk levels of one death

In one million, the AVERAGE U.S. home, not Alaskan home, contains amounts of radon gas at risk levels of around 4,000 deaths per million. I distinguish the difference between the AVERAGE U.S. home and the AVERAGE Alaskan home for very important reasons.

The EPA has defined four conditions that must exist for a building to contain a quantity of radon gas:

- 1) Radium must be present in the soil.
- 2) The soil porosity must facilitate movement of the gas.
- 3) The building must have entry points, cracks and holes.
- 4) A pressure difference must exist between the soil and the building interior.

It is quite apparent that all of these conditions exist with surprising regularity in the Fairbanks area. Without trying to alarm, or create a sensation, I feel compelled to focus your attention on the differences between the EPA risk factors and our Alaskan reality. In reviewing the risk assessment formulas used by the U.S. Environmental Protection Agency (EPA) to determine harm from exposure to radon gas, we find that a lifetime risk requires a 75 per cent exposure rate. This is to say that the AVERAGE individual must be exposed to the substance for seventy-five percent of their lives, from cradle to grave. The significance of this becomes clear when we apply this same exposure rate to the Fairbanks population.

In order to fit the wide and varying soil conditions and lifestyle

factors found across the United States population, the EPA has based their risk calculations on an AVERAGE that does not include our long inhospitable winters. These winters are what cause us to remain inside our homes longer than residents in Iowa, Pennsylvania, or Colorado... or whenever this AVERAGE U.S. climate exists.

Example: In order to limit exposure to household radon gas at the 75% level, one is required to remain away from the home for an average of 42 hours each week over a period of 40 to 70 years (EPA literature calculates exposure to radon for these two exposure periods). While this may happen with some working persons and outdoor lifestyles, if we are to define the AVERAGE Fairbanks resident we must include a wide variety of social profiles among which are homemakers, pre-school and school aged children, the elderly, and the infirm. These are the ones most at risk as they are the least able to access the world outside the home, and they increase considerably the AVERAGE exposure time for the AVERAGE Fairbanks resident.

In fact, many Fairbanks residents are indoors more than 90% of the time, especially during our long and cold winter heating season. Even at this seemingly high percentage of indoor presence an average of 2.4 hours a day must be spent outside the residence, every week, every year.

Not only are Alaskans exposed to indoor environments more on a daily basis because of their cold climate, but their gross exposure is greater due the fact that Alaskan winters are longer in duration than the EPA AVERAGE winter.

Cold weather also affects the entry rate of radon gas and is another reason that we have such highly elevated levels in Fairbanks. As the difference in temperatures between our homes and the outside air become extreme, the pressure driven flow of soil gas containing radon increases accordingly. As the warm moist air leaves our homes at the upper portion of our buildings (hot air rises) it is replaced with cool air coming into the lower portions of the building, some of which is soil gas containing radon.

So, the colder it gets - the greater the soil gas entry rate - the higher the radon levels - the more time we spend inside.

Because of the above mentioned reasons, we feel that the true health risk to residents in the Fairbanks area is likely to be between 15-30% greater than that defined within the EPA radon risk assessment. Unfortunately, at this time no hard data is available or documented such an increased threat.

To define the severity of radon levels being found in the Fairbanks area, I would like to bring attention to the findings of a ten state study performed by the U.S. EPA. In testing many thousands of buildings in ten lower forty-eight states during the winter of 1985-87, the highest level of radon was found to be 180 pCi/l in a house in

- 2) Develop state and federal funding support programs.
- 3) Begin an extensive and intensive research program directed at defining what mitigation systems work best in cold climates.
- 4) Develop a financial support program for residents demonstrating a need for continued assistance in measuring and diagnosis.
- 5) Disseminate useful information to the public with emphasis on the need to know about their exposure.
- 6) Develop citizen confidence in their test results, increase the general awareness about the types of tests and the individuals performing the testing.
 - A) Establish testing protocol.
 - B) Insure Quality Assurance of personnel through a certification program.
 - C) Dispense brochures and informative literature.
 - D) Publicize research and demonstration programs.
 - E) Create procedure documents for arctic applications by delineating what works locally and what doesn't e.g., ventilating a snowbase may not apply to cold climate construction due to freezing of mechanical systems.

March 7, 1988

Nortech Inc.

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PRELIMINARY SUMMARY OF ALASKAN RADON DATA

(Heidersdorf, December, 1987)

Detectors processed	331
Detectors in process	125
Communities sampled	50

Radon	<4 pCi/l.....	270
"	5-8 pCi/l.....	18
"	9-20 pCi/l.....	19
"	>20 pCi/l.....	11

**Percent of detectors
registering radon
concentrations**

exceeding 4 pCi/l:..... $48 \div 331 = 14.5\%$

**DISCLAIMER: Sample base still very small,
with inadequate statewide coverage and early
attention to Fairbanks hotspot.**

CURRENTLY RECOGNIZED ALASKAN HOUSEHOLD RADON HOTSPOTS OR POTENTIAL ANOMALIES

(DGGS and DHSS data
as of December 1987)

Area or District	Range of Radon Concentrations Exceeding 4 pCi/l	
Fairbanks (67)	5-800	(24)
Denali Park- Healy Area (77)	5-125	(24)
- - - - -		
Circle Hot Springs (8)	5-31	(4)
Manley Hot Springs (3)	9-20	(1)
Northway (3)	9-20	(1)
Delta Junction (3)	5-8	(1)
Tok (3)	9-20	(1)
Seward (1)	5-8	(1)
Kodiak (13)	5-8	(1)

Results of EPA 1986-1987 Ten State Indoor Radon Survey

ESTIMATED PERCENT OF HOUSES WITH SCREENING LEVELS GREATER THAN 4pCi/l OF RADON

Colorado.....	39 %
Wisconsin.....	27
Wyoming.....	26
Kansas.....	21
Connecticut.....	19
Rhode Island.....	19
Kentucky.....	17
Tennessee.....	16
Michigan.....	9
Alabama.....	6
Alaska*.....	14

*Not representative sample

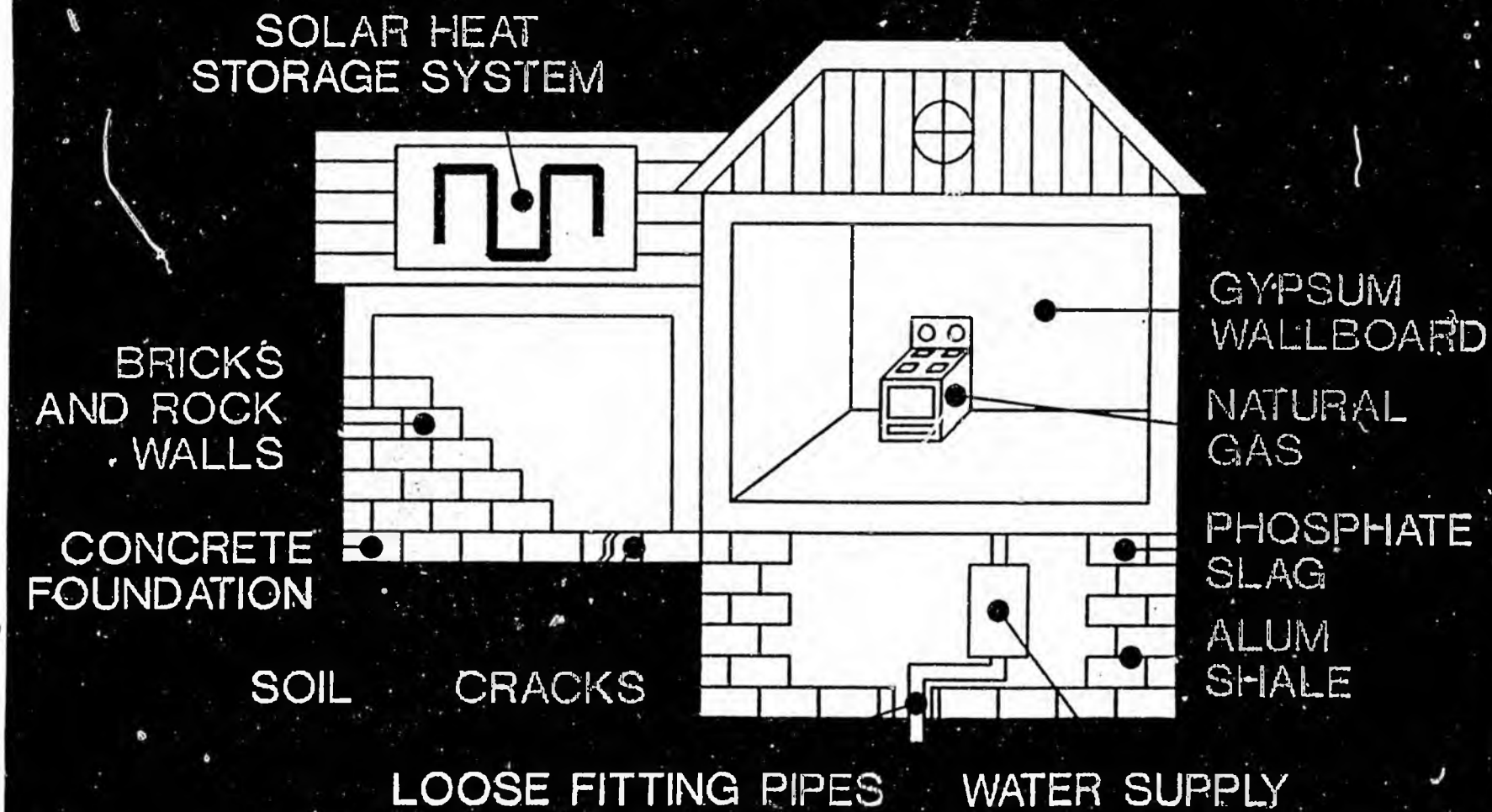
(From Heidersdorf, 1987)

RADON RISK EVALUATION CHART

pCi/l	WL	Estimated number of LUNG CANCER DEATHS due to exposure (out of 1000)	Comparable exposure levels	Comparable risk
200	1	440 - 770	1000 times average outdoor level	More than 60 times non-smoker risk
100	0.5	270 - 630	100 times average outdoor level	4 pack-a-day smoker
40	0.2	120 - 380		20,000 chest x-rays per year
20	0.1	60 - 210	100 times average outdoor level	2 pack-a-day smoker
10	0.05	30 - 120	10 times average outdoor level	1 pack-a-day smoker
4	0.02	13 - 50		5 times non-smoker risk
2	0.01	7 - 30	10 times average outdoor level	200 chest x-rays per year
1	0.005	3 - 13	Average indoor level	Non-smoker risk of dying of lung cancer
0.02	0.001	1 - 3	Average outdoor level	20 chest x-rays per year

(Modified from U.S. EPA Report #OPA-86-004)

Possible Sources of Radon in the Home



RADON IN ALASKAN HOMES

by

Sidney D. Heidersdorf
Radiological Physicist
Division of Public Health
Department of Health and Social Services
September 1, 1987

SUMMARY

This report presents the results of 246 tests for radon in Alaska homes and public facilities. Approximately 70 additional radon detectors are in Alaskan homes at the present time. In addition to the results from the Department of Health and Social Services monitoring program data have been compiled from tests conducted by a number of other State and Federal agencies, and companies providing the service. Seventeen percent of the homes monitored had levels which exceeded the EPA recommended guideline of 4 pCi/l in air. Ten percent of the homes exceeded the remedial action level of 8 pCi/l recommended by the National Council of Radiation Protection and Measurements. The levels ranged from normal background to a high of 383 pCi/l in air. Eight homes exceeded 20 pCi/l. With one exception (Mt. McKinley area) all homes exceeding 20 pCi/l were in the Fairbanks area. Radon in water is not a significant factor in the elevated levels found in the homes in the Fairbanks area.

Overall, the data show a general picture of low radon levels in Southeast Alaska and along the coastline, with higher levels in interior Alaska. In the Fairbanks area, conditions exist for a potentially serious health problem in a small percentage of homes, with 7 of the 54 homes monitored exceeding 20 pCi/l. The problem appears to exist principally for homes in the surrounding hills. The Mt. McKinley area also shows elevated radon concentrations with one home exceeding 20 pCi/l.

It is recommended that individuals living in the Fairbanks and Mt McKinley areas have their homes monitored because of the pattern of elevated radon concentration seen in the two areas.

Recommendations are also given to homeowners following receipt of monitoring results.

RADON IN ALASKAN HOMES

by

Sidney D. Heidersdorf
Radiological Physicist
Division of Public Health
Department of Health and Social Services

September 1, 1987

INTRODUCTION

In recent years, residential exposure to indoor radon has been given considerable attention nationally. Much of the public's interest and concern about radon has been generated by discovery of exceptionally high concentrations of radon gas in homes in an area known as the Reading Prong. This is a uranium rich area that extends through Pennsylvania and into parts of New Jersey and New York. It now appears likely that radon in homes will be one of the nation's most significant radiological health problems to arise in many years.

This report summarizes radon monitoring data for the State of Alaska obtained by the Department of Health & Social Services through its home radon monitoring program. Also included is data compiled from other sources including State and Federal agencies, companies providing monitoring services in Alaska and individuals.

BACKGROUND

Radon is a radioactive gas produced naturally through a series of radioactive transformations originating with uranium 238 which is found in trace quantities throughout the earth's crust. In some areas the uranium deposits are of higher concentrations and consequently produce more radon. Because of the very long radiological half-life of uranium the production of radon within the earth remains essentially constant and may be found in minute concentrations almost everywhere on earth. It is colorless, odorless and chemically inert. Because radon is not chemically reactive it is free to permeate through rock fractures

and underground fissures and eventually emanate from the earth at the surface as soil gas.

Under certain conditions significant amounts of radon can infiltrate and accumulate in homes presenting a health threat to residents. Radon enters homes from several sources. The largest source of indoor radon is directly from the soil. Depending upon where and how the home is built radon can enter as soil gas through dirt floors, cracks in concrete floors and walls, floor drains, sumps, joints and other tiny cracks or pores found in walls. Groundwater is considered the largest of all secondary sources of radon. It enters a home through the domestic water supply and is released into the home when the water is used in the kitchen or bathroom. Other sources of radon are the materials used in the construction of the home, for example stone which contains large quantities of minerals. In general, water and building materials are not considered major sources of indoor radon.

Radon can be found in high concentrations in soil and rocks containing uranium, granite and phosphates. However, this in itself does not mean that the homes in that area will have high levels. In order for a home to have a radon problem at least four conditions must exist: 1) radon must be present in the soil in sufficient quantity, 2) the soil must be permeable, 3) the structure must have openings below ground level and, 4) inside pressure in the home must be less than the outside pressure. It is possible that homes situated away from areas of known concentrations of uranium may have high concentrations of radon because of the geological discontinuities through which radon gas may travel.

While radon source strength is the most important factor, home ventilation has obvious effects. Energy efficient measures in Alaska homes where the number of air exchanges per day is reduced may increase the concentration of radon, since these homes are designed to keep heated air from escaping. It is also known that radon levels in the same home may vary appreciably with time. Studies have documented both diurnal and seasonal variations. Because of the many variables involved it is extremely difficult, if not impossible, to predict which homes will have high concentrations of radon. The only way of knowing what concentration exists in a specific home is to actually measure the level.

Tests normally should be carried out over a period of two to three months in an effort to average the results since health risks are related to the average level, not the peak.

HEALTH EFFECTS

The major known health effect associated with exposure to radon in air is an increased risk of developing lung cancer. The American Cancer Society estimates that approximately 136,000 people will die of lung cancer in 1986. Of that number, it has been estimated by experts in radiation bioeffects that between 5 and 20 thousand of these lung cancer deaths may be attributed to radon. As with other carcinogenic agents there is some uncertainty as to the actual degree of risk involved.

Despite the uncertainties surrounding the risk estimates for radon, it is generally accepted that the greater the exposure to radon the greater the risk for developing cancer at some time in the future. Therefore, the actual risk for an individual developing cancer depends upon the average radon concentration in the individual's home and the length of exposure. Reducing either of these factors will reduce the risk. Also, the time between exposure and the onset of the disease may be many years since lung cancer usually does not occur until people are 45 or older. Lung cancer has other causes and presently lung cancer caused by radon cannot be differentiated from cancer caused by smoking or any other agent. Therefore, it is impossible to attribute a specific case of lung cancer to radon exposure.

The health risks for radon in water include the risk of stomach cancer following ingestion and lung cancer as a result of inhalation of the radon gas which escapes from the water when it is aerated and used in the home. Generally the risk from ingestion of radon in water is small compared to the risk from inhalation, and the primary concern about radon in water is its contribution to the air concentration when water is used in the home.

EXPOSURE GUIDANCE

There are two remedial action levels proposed for general population exposure to radon in air. The U. S. Environmental Protection Agency (EPA) has adopted

a radon concentration level of 4 picocuries per liter (pCi/l) of air as the guidance level above which home owners are advised to give consideration for corrective action. (A picocurie is one trillionth of a curie, a common unit of radioactivity). The National Council on Radiation Protection and Measurements (NCRP) recommends 8 pCi/l as a remedial action level above which steps should be taken to reduce exposure. The NCRP is a nonprofit corporation chartered by Congress in 1964 to develop and disseminate in the public interest information and recommendations about protection against radiation. The difference in the two standards simply reflects the uncertainty of the risk estimates as well as the fact that it is a judgement call. Present departmental policy is to inform homeowners of risk estimates and leave decisions regarding action up to the homeowner. By any standard, a home which exceeds 20 pCi/l of radon in air should be a candidate for remedial action to reduce levels. Those in the range from 4 - 20 pCi/l call for less urgent steps which might include further follow-up evaluation or action within a few years, especially if the levels are at the upper end of this range.

Four picocuries per liter is approximately twenty times the average outdoor level which is a part of our natural radiation background. A remedial action level should not be considered as a division between safe and harmful levels but simply a level which is achievable for residential structures while still not representing an unacceptable risk in view of the incidence of lung cancer to the general population from other causes. According to EPA estimates a 4 pCi/l exposure represents approximately 1 chance in 100 of an individual developing lung cancer for a lifetime of exposure. This is roughly the same as the normal incidence of lung cancer for non-smokers in the general population.

Radon risk estimates for lung cancer are based on epidemiological studies of underground uranium miners. The data for this population group are quite good making it more reliable than those studies which rely solely upon animal data. However, estimates of the health risk for low doses of radiation cannot be obtained directly. They can only be estimated statistically from cancer data observed at high doses by extrapolation down into the low dose region where cancer data are not available. In this process it is assumed that the risks associated with low doses are proportional to those observed at high doses. In development of the risk estimates for the general population it is assumed

that an individual is exposed to a given concentration of radon over a lifetime of seventy years while spending approximately 75% of the time in the home.

There are no State, Federal or NCRP guidelines for radon concentrations in domestic water supplies similar to the EPA recommended guide for radon in ambient air. The EPA is presently considering the establishment of a level for radon in water but has not yet done so. With regard to risk estimates for radon in water per lifetime of exposure, it is estimated that there is one chance in 1,000 for a health effect at a concentration level of 10,000 pCi/l of radon in water, and one chance in 10,000 for a concentration of 1,000 pCi/l. This can be compared to the EPA risk level of one chance in 100 of getting lung cancer for a lifetime exposure (70 years) at a 4 pCi/l concentration of radon in air. In general, levels of radon in the air in a home are much more critical than the levels found in the domestic water supply.

In considering the data presented here, it is very important that the guidelines for air not be confused with levels found in water. As a rule of thumb, for normal water usage and household characteristics, one can assume that it will take about 10,000 pCi/l of radon in water to result in an air concentration of one pCi/l.

ALASKA RADON MONITORING

In the fall of 1985 the Department placed radon detectors in a few selected homes in various locations throughout the State. In 1986 this was repeated in additional homes. This effort included 17 homes in 11 locations. Radon concentrations in five homes exceeded the EPA guideline of 4 pCi/l, with a maximum level detected of 18 pCi/l. Beginning in late 1986 the Department began to offer a state-wide home radon monitoring service using the alpha-track method of detection. The detectors were provided to residents upon request for a fee of \$30.00. The recommended monitoring period for the detectors was 3 months. In addition to the results reported here the Department has approximately 70 alpha-track detectors in Alaskan homes at the present time.

Data presented in this report came from a number of other sources as well. Within the past two years, the Department of Transportation and Public Facilities

(DOT/PF) and the Arctic Environmental Information Data Center also conducted small scale studies. In addition, the DOT/PF sponsored an evaluation of 37 public facilities through studies of a graduate student at the University of Alaska, Fairbanks. More recently additional air data has been gathered through the efforts of DOT/PF research staff, the Department of Natural Resources, the Cooperative Extension Service and other University of Alaska personnel. The results of a separate study by the National Park Service of housing at Mt. McKinley are also included. Finally, some radon in air data have been obtained directly from companies providing a monitoring service to homeowners. The total number of radon results from all sources listed above is 246.

In addition to the air monitoring, this report includes results of monitoring radon in water for 26 homes in the Fairbanks area. This effort was undertaken because of a concern over the possibility that radon in water was significantly contributing to elevated air concentrations found in some Fairbanks homes. At the request of the Department of Health and Social Services these samples were collected by personnel from the Departments of Environmental Conservation and Natural Resources. Many of the samples came from homes with high radon in air concentrations.

RESULTS

Table 1 summarizes the 246 radon in air results by detector type and four concentration ranges. This is a compilation from all sources listed above. Activated charcoal method of measurement represents monitoring periods of a few days to one week. The alpha-track method in most cases represents a monitoring period of 3 months. No differentiation is made between the winter or summer months, however there is reason to believe that the winter months represent conditions promoting the highest levels.

RADON IN AIR OF FAIRBANKS HOMES (results by detector type)					
Detector Type	Total Number	pCi/l			
		4 or less	5 - 8	9 - 20	21+
Charcoal	105	77	13	11	4
Alpha-track	141	127	3	7	4
TOTALS	246	204	16	18	8
% of TOTAL:		83	7	7	3

(From Heidersdorf, 1987)

The above data includes the alpha-track results from a DOT/PF sponsored study of 37 public facilities across the State. For more detail Appendix 1 summarizes all data by location, number of results and concentration range. Monitoring results have been rounded to the nearest whole number for grouping into ranges. For example: 4.4 pCi/l has been reported to the 4 or less column, whereas 4.6 pCi/l would be reported in the 5 - 8 column.

The highest level for a public facility was a school at 5.2 pCi/l. All other results for public facilities were 4 or below. Results for the 209 homes ranged from background levels to a high of 383 pCi/l of air. Three homes had levels above 100 pCi/l. They were all in the Fairbanks area with levels of 383, 200 and 112 pCi/l. Approximately 10% of the homes exceeded the NCRP action level of 8 pCi/l. Seventeen % exceed the EPA guideline of 4 pCi/l. With only two exceptions, (one home each in Homer and Anchorage) all homes exceeding the 8 pCi/l limit are in Interior Alaska. For comparison purposes, Appendix II presents the results of the EPA 1986 - 1987 ten state indoor radon survey with the estimated percent of homes with levels greater than 4 pCi/l. The reader is cautioned that the results for Alaska presented here cannot be considered as representative of all Alaska homes in general.

Overall, the data show a general picture of low radon levels in Southeast Alaska and along the coastline, with higher levels in interior Alaska. It appears that interior Alaska deserves special attention. For example, in the Fairbanks area, conditions exist for a potentially serious health problem in a small percentage of homes, with 7 of the 54 homes monitored exceeding 20 pCi/l. The problem appears to exist principally for homes in the surrounding hills. The Mt. McKinley area also shows elevated radon concentrations with one home exceeding 20 pCi/l.

Table 2 summarizes the results for water samples from 26 homes in the Fairbanks area. Many of these homes were selected because of higher than normal radon in air concentrations.

Radon Concentration in Water (pCi/l)
(26 Fairbanks Homes)

pCi/l	Number
< 1,000	2
1,000 - 2,000	7
2,000 - 4,000	9
3,000 - 4,000	3
4,000 - 5,000	3
5,000 - 6,000	1
6,000 - 7,000	1
(From Heidersdorf, 1987)	TOTAL 26

Results range from a low of 200 pCi/l to the highest level reported of 6476 pCi/l of radon in water. The water results show no correlation with radon in air levels measured in the homes thereby verifying that radon in water does not contribute significantly to the elevated air levels found in Fairbanks homes. This is not unexpected since a level of 10,000 pCi/l of radon in water is needed to produce a 1 pCi/l radon concentration in air.

There is nothing unusual about the levels found in the 26 homes in the Fairbanks area. Results from radon surveys nationally show that approximately 40% of the public water supplies in the U. S. have radon concentrations of 500 pCi/l, 10% have radon concentrations of 1,000 pCi/l, and 10% have levels of 5,000 pCi/l.

The Fairbanks air and water data are not necessarily representative of the typical home in the Fairbanks area since they were not randomly selected. Many were selected because of their locations in the surrounding hills. In addition it is important to remember that levels in one home cannot be used to predict levels in adjacent homes. However it is not unreasonable to suspect that areas which have yielded high results offer the greatest potential for neighboring houses with high levels. Also, one cannot assume that areas which have only low levels reported to date do not have outliers or neighborhood pockets with high radon concentrations. Only the actual measurement of the levels in a specific home can determine that.

RECOMMENDATIONS

Individuals living in interior Alaska, especially those in the Mt. McKinley and Fairbanks areas should have their homes monitored. In the Fairbanks area the potential for high radon appears to be greatest in the surrounding hills. This recommendation is directed specifically toward the Fairbanks and the Mt. McKinley areas because of the high levels observed in these two locations. It does not mean such levels could not be found elsewhere.

Recommendations for other areas may be forthcoming as additional data becomes available which indicates the need for expanding the scope of monitoring. The above recommendation is not intended to discourage homeowners in other areas of the State from having their homes monitored, since sporadic elevated levels have been detected in other interior Alaska locations such as Circle Hot Springs, Delta Junction, Manley Hot Springs, Northway, Tok and Palmer.

The following is recommended for individuals who have obtained monitoring results for their home:

- 1) Individuals with results of 20 pCi/l or higher based on charcoal analysis should carry out a 3-month evaluation of their home using the alpha-track detector.
- 2) Individuals with levels of 20 pCi/l and above using the alpha-track detector should take steps to reduce the levels in their homes. Follow-up monitoring should be conducted to verify effectiveness of reduction methods.
- 3) Individuals with alpha-track results ranging from 4 to 20 pCi/l should give serious consideration to reducing their levels to the extent possible, especially if the levels are at the upper end of the range.
- 4) Individuals with charcoal or alpha-track results below 4 pCi/l need take no action if the measurement was made with the house closed up prior to and during the testing period.

ALASKA RADON RESULTS
(All data through 8/20/87)

Location	Number	Concentration of radon, picocuries per liter of air (pCi/l)			
		4 or less	5-8	9-20	20 +
1 Anchorage	39	38		1	
2 Arctic Circle H.S.	1		1		
3 Barrow	1	1			
4 Bethel	1	1			
5 Bettles	1	1			
6 Craig	1	1			
7 Deadhorse	1	1			
8 Delta Junction	3	2	1		
9 Dillingham	1	1			
10 Douglas	3	3			
11 Eagle	1	1			
12 Eagle River	10	10			
13 Fairbanks	54	33	7	7	7
14 Fort Yukon	1	1			
15 Galena	1	1			
16 Glenallen	1	1			
17 Haines	5	5			
18 Healy	1	1			
19 Homer	4	3		1	
20 Hope	1	1			
21 Juneau	23	23			
22 Kasilof	1	1			
23 Kenai	1	1			
24 Ketchikan	4	4			
25 King Salmon	1	1			
26 Klawock	1	1			
27 Kodiak	3	3			
28 Kotzebue	2	2			
29 Manley Hot Springs	3	2		1	
30 McGrath	1	1			
31 McKinley Park	41	29	6	5	1
32 Nenana	1	1			
33 Nome	1	1			
34 North Pole	2	2			
35 Northway	3	2		1	
36 Palmer	6	5		1	
37 Pedro Bay	1	1			
38 St. Mary's	1	1			
39 Seward	1		1		
40 Skagway	1	1			
41 Soldotna	4	4			
42 Sterling	1	1			
43 Tanacross	1	1			
44 Tok	2	1		1	
45 Unakleet	1	1			
46 Valdez	2	2			
47 Wales	1	1			
48 Wasilla	5	5			
TOTALS	246	204	16	18	8

(From Heidersdorf, 1987)

Results of EPA 1986-1987 Ten State Indoor Radon Survey

ESTIMATED PERCENT OF HOUSES WITH SCREENING
LEVELS GREATER THAN 4 pCi/l OF RADON

Colorado	39%
Wisconsin	27
Wyoming	26
Kansas	21
Connecticut	19
Rhode Island	19
Kentucky	17
Tennessee	16
Michigan	9
Alabama	6
Alaska (not representative sample)	17

(From Heidersdorff, 1987)

Handwritten mark

RADON INFORMATION PACKET
PROVIDED BY
COOPERATIVE EXTENSION SERVICE
ENERGY AND BUILDING SPECIALIST
NOVEMBER 1987

**Alaskans
Meeting
Economic
Challenge**



IN CONTROL



RICHARD SEIFERT
EXTENSION ENERGY SPECIALIST

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Fairbanks, Alaska 99775-5200
U.S.A.

Phone (907) 474-7201

Radon Tests for Alaska
by Richard Selfert

In an effort to speed up radon research, New Shelter magazine, in conjunction with Air-Chek and Alpha Energy Labs, has agreed to coordinate a national radon survey. The goal is to create a national database on radon levels in homes and at the same time offer homeowners a discount on radon testers. This provides a chance for the average homeowner to test the radon levels in his home for a minimum cost and still contribute to a national study.

Test kits, normally \$20 each, will cost survey participants \$11.95. A questionnaire in the test kit will help to compile data on tested homes and locations. All names and addresses will be kept in the strictest confidence, which of course they should be if you must pay to participate! Please note that it has taken me more than two weeks to receive my kit, but I am told by the Air-Chek people that they will accept phone orders and ship them the same day for an additional \$3 fee. Their phone number is (704) 891-5892. They also advise shipping the kits back to them first class--special handling at a minimum--because they have about a 12-day lifetime before analysis once the four-day exposure time is completed. If too much time elapses before the test is complete, the devices are difficult to read, so they must be sent back promptly.

To join in the testing and the survey, send your name, address and check of \$11.95 to Air-Chek, P.O. Box 2000-NS, Penrose, NC 28766. After receiving the testing device, it is kept in the home for four days, and then returned to Air-Chek in the envelope provided. They'll process the results and advise the participant of the radon level in the home within 10 days. The survey findings will be published in a future issue of New Shelter magazine.

Do the first (\$12) test initially. If this test shows greater than 10 pCi/l, we recommend a three month test, which is available from CES. The following press release gives the details on this test!

Press Release

**RADON TEST KITS NOW AVAILABLE THROUGH
COOPERATIVE EXTENSION SERVICE, UAF**

As a result of the recent concerns about radon levels in some of the areas in Fairbanks, the Cooperative Extension Service has entered into an agreement with the State Health Radiologists office in Juneau to make 3-month radon test kits available at the Fairbanks office of the Cooperative Extension Service.

These badges are a second-tier test. That means you should test first with a \$12 three-day test kit to find out if you have a problem. The next step if you have a problem would be to buy one of these three-month test kits from the Cooperative Extension Service in Fairbanks. They cost \$30, the same as they cost from the Juneau office.

It was felt that it would be useful to have them in Fairbanks since a larger part of the radon problems happen to be in the Fairbanks area. For information in obtaining one of these badges, please call Rich Selfert at the Cooperative Extension Service office 474-7201 weekdays 9 a.m. to 5 p.m.

RADON PROOFING IN NEW CONSTRUCTION

The best protection against the event of high radon levels in a home which has normal soil contact is to build it with radon-proof construction techniques. These include:

- a. A sub-pad vapor barrier below the basement pad, sealed to all perforations of the pad with watertight seals, and tabbed around the perimeter of the pad to enable easy attachment to a wall vapor barrier.
- b. Use of glass-clad dense fiberglass below grade insulation around the walls of the basement. This allows air movement and therefore radon escapement along the walls.
- c. Use of a layer of below-pad gravel which is vented by perforated pipe around the perimeter and placed in the gravel. This allows for escape of radon from below the pad, and the system could even be negatively pressurized if necessary to remove radon from beneath the pad.
- d. The supply of fresh air to the basement with an air-to-air heat recovery ventilation system is a normal requirement of an ACHP home which can be used to provide the basement ventilation.
- e. Certification of the radon levels in the house can be provided through testing and subsequent disclosure of the test results in the sales agreement of the ACHP home.

Also available is a publication from the US EPA entitled "Radon Reduction in New Construction -- An Interim Guide," which is free for the asking at CES (474-7201).

A Citizen's Guide To Radon

What It Is And What To Do About It



PHONE # 1-800-AIR-CHEK
or # 1-800-CK-RADON



Insertion of the above logo & phone number DOES NOT
INFER endorsement by any of the above agencies.

This is a reprint of the EPA's Booklet furnished com-
pliments of Air Chek. (Because of space limitations ap-
proximately 5% of the original material has been deleted.)

What is radon?

Radon is a radioactive gas which occurs in nature. You cannot see it, smell it, or taste it.

Where does radon come from?

Radon comes from the natural breakdown (radioactive decay) of uranium. Radon can be found in high concentrations in soils and rocks containing uranium, granite, shale, phosphate and pitchblende. Radon may also be found in soils contaminated with certain types of industrial wastes, such as the byproducts from uranium or phosphate mining.

In outdoor air, radon is diluted to such low concentrations that it is usually nothing to worry about. However, once inside an enclosed space (such as a home) radon can accumulate. Indoor levels depend both on a building's construction and the concentration of radon in the underlying soil.

How does radon affect me?

The only known health effect associated with exposure to elevated levels of radon is an increased risk of developing lung cancer. Not everyone exposed to elevated levels of radon will develop lung cancer, and the time between exposure and the onset of the disease may be many years.

Scientists estimate that from about 5,000 to about 20,000 lung cancer deaths a year in the United States may be attributed to radon. (The American Cancer Society expects that about 130,000 people will die of lung cancer in 1988. The Surgeon General attributes around 85 percent of all lung cancer deaths to smoking.)

Your risk of developing lung cancer from exposure to radon depends upon the concentration of radon and the length of time you are exposed. Exposure to a slightly elevated radon level for a long time may present a greater risk of developing lung cancer than exposure to a significantly elevated level for a short time. In general, your risk increases as the level of radon and the length of exposure increase.

How certain are scientists of the risks?

With exposure to radon, as with other pollutants, there is some uncertainty about the amount of health risk. Radon risk estimates are based on scientific studies of miners exposed to varying levels of radon in their work underground. Consequently, scientists are considerably more certain of the risk estimates for radon than they are of those risk estimates which rely solely on studies of animals.

To account for the uncertainty in the risk estimates for radon, scientists generally express the risks associated with exposure to a particular level as a range of numbers. (The risk estimates given in this booklet are based on the advice of EPA's Science Advisory Board, an independent group of scientists established to advise EPA on various scientific matters.)

Despite some uncertainty in the risk estimates for radon, it is widely believed that the greater your exposure to radon, the greater your risk of developing lung cancer.

*How does radon cause lung cancer?

Radon, itself, naturally breaks down and forms radioactive decay products. As you breathe, the radon decay products can become trapped in your lungs. As these decay products break down further, they release small bursts of energy which can damage lung tissue and lead to lung cancer.

How is radon detected?

Since you cannot see or smell radon, special equipment is needed to detect it. The two most popular, passive commercially-available radon detectors are the charcoal canister and the more expensive, slower, alpha track detector. Both of these devices are exposed to the air in your home for a specified period of time and sent to a laboratory for analysis.



Charcoal Canisters
Test Period: 1 to 4 days

How can I get a radon detector?

Homeowners in some areas are being provided with detectors by their state or local government. In many areas, private firms offer radon testing. Your state radiation protection office may be able to provide you with information on the availability of detection devices or services.

* Other ongoing studies may show a more conclusive relationship between Radon 220 (Thoron) and cancer in other body tissue.

How should radon detectors be used?

Obtaining a useful estimate of the radon level in your home may require that several detectors be used to make measurements in different areas. Following the steps below should provide the information needed as you decide whether or not further action is advisable. (In making radon measurements, you should be sure to follow the instructions of the manufacturer as to the proper exposure period for the particular device you are using.)

Step One: The screening measurement

The first step you should take is to have a short-term "screening" measurement made to give you an idea of the highest radon level in your home. Thus, you can find out quickly and inexpensively whether or not you have a potential radon problem.

The screening measurement should be made in the lowest livable area of your home (the basement, if you have one). All windows and doors should be closed for at least 12 hours prior to the start of the test, and kept closed as much as possible throughout the testing period. This is necessary to keep the radon level relatively constant throughout the testing period. Because of the need to keep the windows closed as much as possible, we recommend that you make short-term radon measurements during the cool months of the year.

Step Two: Determining the need for further measurements

In most cases, one screening measurement is not a reliable measure of the average radon level to which you and your family are exposed. Since radon levels can vary greatly from season to season as well as from room to room, the screening measurement only serves to indicate the potential for a radon problem. Depending upon the result of your screening measurement, you may need to have follow-up measurements made to give you a better idea of the average radon level in your home.

The following guidance may be useful to you in determining the urgency of your need for follow-up measurements.

If your screening measurement result is greater than about 1.0 WL or greater than about 200 pCi/l, you should perform follow-up measurements as soon as possible. Expose the detectors for no more than one week. Doors and windows should be closed as much as possible during testing. You should also consider taking actions (see page 13) to immediately reduce the radon levels in your home.

If your screening measurement result is about 0.1 WL to about 1.0 WL or about 20 pCi/l to about 200 pCi/l, perform follow-up measurements. Expose detectors for no more than three months. Doors and windows should be closed as much as possible during testing.

If your screening measurement result is about 0.02 WL to about 0.1 WL or about 4 pCi/l to about 20 pCi/l, perform follow-up measurements. Expose detectors for one year, or make measurements of no more than one week duration during each of the four seasons.

If your screening measurement result is less than about 0.02 WL or less than about 4 pCi/l, follow-up measurements are probably not required. If the screening measurement was made with the house closed up prior to and during the testing period, there is relatively little chance that the radon concentration in your home will be greater than 0.02 WL or 4 pCi/l as an annual average.

Step Three: The follow-up measurement

Follow-up measurements will provide you with a relatively good estimate of the average radon concentration to which you and your family are exposed. We strongly recommend that you make follow-up measurements before you make any final decisions about whether to undertake major efforts to permanently correct the problem.

Follow-up measurements should be made in at least two lived-in areas of your home. If your home has lived-in areas on more than one floor, you should make measurements in a room on each of the floors. An example is to take a measurement in the living room on the first floor and another in a second-floor bedroom. The results of the follow-up measurements should be averaged together.

What do my test results mean?

The results of your follow-up measurements provide you with an idea of the average concentration throughout your home. The actual risk you face depends upon the amount of time you are exposed to this concentration.

The figures on the facing page illustrate the number of lung cancer deaths, out of a group of 100 people, that scientists would attribute to exposure to specific levels of indoor radon. The first three figures assume that these 100 individuals spent 75 percent of their time in the dwelling for 70 years. The numbers below each picture indicate what scientists consider to be a reasonable range of estimates of lung cancer deaths that could be attributed to the radon exposure. This is in addition to the number of lung cancer deaths attributed to other causes. (On average, about four people out of a hundred die of lung cancer from all causes combined.) The pictures represent the midpoint of the ranges.

How quickly should I take action?

In considering whether and how quickly to take action based on your test results, you may find the following guidelines useful. EPA believes that you should try to permanently reduce your radon levels as much as possible. Based on currently available information, EPA believes that levels in most homes can be reduced to about 0.02 WL (4 pCi/l).

If your results are about 1.0 WL or higher, or about 200 pCi/l or higher:

Exposures in this range are among the highest observed in homes. Residents should undertake action to reduce levels as far below 1.0 WL (200 pCi/l) as possible. We recommend that you take action within several weeks. If this is not possible, you should determine, in consultation with appropriate state or local health or radiation protection officials, if temporary relocation is appropriate until the levels can be reduced.

If your results are about 0.1 to about 1.0 WL, or about 20 to about 200 pCi/l:

Exposures in this range are considered greatly above average for residential structures. You should undertake action to reduce levels as far below 0.1 WL (20 pCi/l) as possible. We recommend that you take action within several months.

If your results are about 0.02 to about 0.1 WL, or about 4 pCi/l to about 20 pCi/l:

Exposures in this range are considered above average for residential structures. You should undertake action to lower levels to about 0.02 WL (4 pCi/l) or below. We recommend that you take action within a few years, sooner if levels are at the upper end of this range.

If your results are about 0.02 WL or lower, or about 4 pCi/l or lower:

Exposures in this range are considered average or slightly above average for residential structures. Although exposures in this range do present some risk of lung cancer, reductions of levels this low may be difficult, and sometimes impossible, to achieve.

Remember: There is increasing urgency for action at higher concentrations of radon. The higher the radon level in your home, the faster you should take action to reduce your exposure. If you find elevated radon concentrations in your home, you should take the relatively easy, short-term actions described on the back page. See: How can I reduce my risk to Radon?

Are there other factors I should consider?

Most of the risk information given in this pamphlet, as well as the recommendations for taking corrective action, are based on the general case. Your individual living patterns could influence your assessment of your risk and your decisions about the need for further action. Your answers to the following questions may help you evaluate your personal risk.

- Does anyone smoke in your home? Scientific evidence indicates that smoking may increase the risk of exposure to radon. In addition, smoking significantly increases your overall risk of lung cancer.

- Do you have children living at home? Although there are no studies of children exposed to radon to determine whether they are more sensitive than adults, some scientific studies of other types of radiation exposure indicate that children may be more sensitive. Consequently, children could be more at risk than adults from exposure to radon.

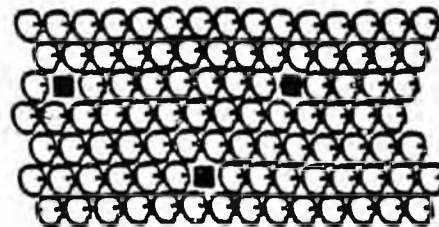
- How much time does any family member spend at home? The risk estimates given in this pamphlet assume that 75 percent of a person's time is spent at home. If you or your family spend more or less time at home, you should take this into consideration.

- Does anyone sleep in your basement? Since radon concentrations tend to be greater on the lower levels of a home, a person who sleeps in the basement is likely to face a greater risk than a person who sleeps in a second-floor bedroom.

- How long will you live in your home? The risk estimates in this booklet are based on the assumption that you will be exposed to the radon level found in your home for roughly 70 years. As you evaluate your potential risk, therefore, you might consider the total amount of time you expect to live in your home. But remember: other houses you have lived in—or will live in—may have the same or higher radon levels.

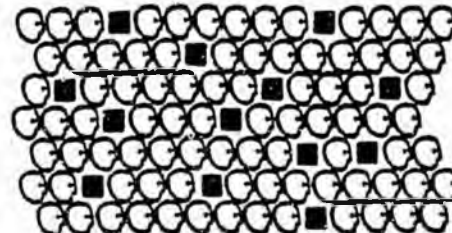
Lung Cancer Deaths Associated With Exposure To Various Radon Levels Over 70 Years

WL = 0.02
pCi/l = 4



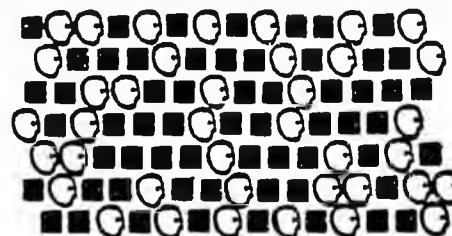
Between 1 and 5 out of 100

WL = 0.1
pCi/l = 20



Between 6 and 21 out of 100

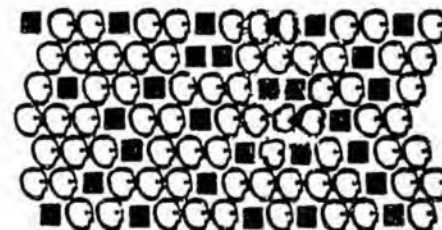
WL = 1.0
pCi/l = 200



Between 44 and 77 out of 100

If these same 100 individuals had lived only 10 years (instead of 70) in houses with radon levels of about 1.0 WL, the number of lung cancer deaths expected would be:

WL = 1.0
pCi/l = 200



Between 14 and 42 out of 100



How does radon get into a home?

Radon is a gas which can move through small spaces in the soil and rock on which a house is built. Radon can seep into a home through dirt floors, cracks in concrete floors and walls, floor drains, sumps, joints, and tiny cracks or pores in hollow-block walls.

Radon also can enter water within private wells and be released into a home when the water is used. Usually, radon is not a problem with large community water supplies, where it would likely be released into the outside air before the water reaches a home. (For more information concerning radon in water, contact your state's radiation protection office.)

In some unusual situations, radon may be released from the materials used in the construction of a home. For example, this may be a problem if a house has a large stone fireplace or has a solar heating system in which heat is stored in large beds of stone. In general, however, building materials are not a major source of indoor radon.

How can I reduce my risk from radon?

Your risk of lung cancer from exposure to radon depends upon the amount of radon entering your home and the length of time it remains in your living areas. Listed below are some actions you might take to immediately reduce your risk from radon. These actions can be done quickly and with minimum expense in most cases.

- Stop smoking and discourage smoking in your home. By doing so, you should reduce your family's overall chance of developing lung cancer, as well as reducing your family's risk from radon exposure.
- Spend less time in areas with higher concentrations of radon, such as the basement.
- Whenever practical, open all windows and turn on fans to increase the air flow into and through the house. This is especially important in the basement.
- If your home has a crawl space beneath, keep the crawl-space vents on all sides of the house fully open all year.

While the above actions will help reduce your risk from radon, they generally do not offer a long-term solution. You can find more information about permanent, cost-effective solutions to a radon problem in the EPA publication, *Radon Reduction Methods: A Homeowner's Guide*. A copy of this booklet may be obtained from your state radiation protection office or from your EPA regional office. (AIR CHEK has a limited supply of reprints of this booklet.)

When did radon become a problem?

Radon has always been present in the air. Concern about elevated indoor concentrations first arose in the late 1960's when homes were found in the West that had been built with materials contaminated by waste from uranium mines. Since then, cases of high indoor radon levels resulting from industrial activities have been found in many parts of the country. We have only recently become aware, however, that houses in various parts of the U.S. may have high indoor radon levels caused by natural deposits of uranium in the soil on which they are built.

Does every home have a problem?

No, most houses in this country are not likely to have a radon problem; but relatively few houses do have highly elevated levels. *The dilemma is that, right now, no one knows which houses have a problem and which do not.* You may wish to call your state radiation protection office to find out if any high levels have been discovered in your area.

Many states, as well as the federal government, are sponsoring work to identify areas of the community which are likely to have indoor problems. *However, early results from this work are inconclusive. If you are concerned that you may have an indoor radon problem, you should consider having your home tested.*

Radon Risk Evaluation Chart

pCi/l	WL	Estimated number of lung cancer deaths due to radon exposure (out of 1000)	Comparable exposure levels	Comparable risk
200	L	440-770	1000 times average outdoor level	More than 60 times non-smoker risk 4 pack-a-day smoker
100	0.5	270-630	100 times average indoor level	20,000 chest x-rays per year
40	0.2	110-380	100 times average outdoor level	2 pack-a-day smoker
20	0.1	60-210	10 times average indoor level	1 pack-a-day smoker
10	0.05	30-120	10 times average outdoor level	5 times non-smoker risk
4	0.02	13-50	Average indoor level	200 chest x-rays per year
2	0.01	7-30	Average outdoor level	Non-smoker risk of dying from lung cancer
1	0.005	3-13	Average indoor level	20 chest x-rays per year
0.2	0.001	1-3	Average outdoor level	

Sources of Information

If you would like further information or explanation on any of the points mentioned in this booklet, you should contact your state radiation protection office.

If you have difficulty locating this office, you may call your EPA regional office listed to the right. They will be happy to provide you with the name, address, and telephone number for your appropriate state contact.

EPA Regional Offices

EPA Region 1
Room 2203
JFK Federal Building
Boston, MA 02203
(617) 223-4645

EPA Region 2
26 Federal Plaza
New York, NY 10278
(212) 264-2515

EPA Region 3
841 Chestnut Street
Philadelphia, PA 19107
(215) 597-8320

EPA Region 4
345 Courtland Street, NE
Atlanta, GA 30365
(404) 881-3776

EPA Region 5
230 South Dearborn Street
Chicago, IL 60604
(312) 353-2205

EPA Region 6
1201 Elm Street
Dallas, TX 75270
(214) 767-2630

EPA Region 7
726 Minnesota Avenue
Kansas City, KS 66101
(913) 236-2603

EPA Region 8
Suite 1300
One Denver Place
999 18th Street
Denver, CO 80202
(303) 283-1710

EPA Region 9
215 Fremont Street
San Francisco, CA 94103
(415) 974-6076

EPA Region 10
1200 Sixth Avenue
Seattle, WA 98101
(206) 442-7660

For more information about Air Chek's available services and industry leading low pricing please call 1-800-AIR-CHEK or 1-800-CK-RADON or 1-704-891-5892.

Or Write: Air Chek, P.O. Box 2000, Penrose, N.C. 28786

RADON CONCERNS IN ALASKA

by R.D. Seifert

I chose the title of this article very carefully because I am trying very hard not to be an alarmist. The reasons for this will become evident as I describe what radon is and how it affects the indoor environment in Alaska. Radon is a colorless, odorless gas which is a natural by-product of uranium decay in most soils. It can be found in especially high concentrations in soils and rocks containing uranium such as uranium mine tailings, granite, shales, phosphate or pitchblende. Radon can also be found in certain soils contaminated with industrial wastes such as the by-products from uranium mining or phosphate mining.

Normally, in outdoor air, radon is diluted to such a low concentration that it is nothing to worry about. It's the indoor, enclosed spaces that can accumulate radon which are of concern. Indoor levels depend both on the construction of the building and the concentration of radon in the underlying soil. Because I am the energy and building specialist with Cooperative Extension at the University of Alaska-Fairbanks, I have investigated the presence and movement of radon in Alaskan buildings.

Back in mid-1986, I tried to encourage people to test for radon in buildings by participating in a national radon survey. This survey was organized through Rodale's New Shelter magazine. People were encouraged to buy a test kit for approximately \$12, expose it in their homes, and then send it to a laboratory for analysis. They would be informed of the radon level in their house.

Broad awareness that radon could pose a health problem only developed recently. Actually, radon has been an indoor air quality issue for 20 or 30 years, and it has been affecting our lives for millennia. However, attention to radon emerged from studying energy efficient homes, and was first thought to be a problem because buildings were becoming more tight. Therefore, any pollutants which entered the indoor building environment probably remained longer, and possibly posed a greater risk to the occupants of the building. However, this has generally been debunked by a paper from the buildings group at the University of California-Berkeley. Headed by Doctor Nero, this group generally characterized the sources and environmental influences on radon

transport, and found that really the most important factor for determining radon concentration in buildings was the source of the emissions in the soil beneath the building.

This was also brought home by the striking and sensational reporting of a radon problem by the U.S. press. The little community of Boyertown, Pennsylvania, became famous for its high radon concentrations when one of its citizens, who worked at the Limerick Nuclear Power Plant in Pennsylvania, suddenly came into work several days in a row with his badge exposed and hotter (in a radiation sense) than when he left the plant. This was of great concern to the radiation physicists working here, and they eventually determined that his house was extremely radon-rich: several thousand times the recommended limit for exposure.

As a result of that incident and much attention to the problem of radon in the indoor environment, many subsequent events have occurred. The Environmental Protection Agency has issued a publication entitled Citizen's Guide to Radon, describing what radon is and what to do about it. They also published an additional pamphlet called Radon Reduction Methods, a homeowner's guide to what to do as a result of high radon levels in the home. (In the public interest, I might add that I have copies of these two publications in my office. Most of the items I refer to in this article are available for public perusal. They can be obtained by calling my office in Fairbanks, Alaska, (907) 474-7201.)

The radon problem has become important enough in Pennsylvania that it is now law that when a property is sold through a real estate agent, that agent must have the owner sign a disclosure statement on radon. This disclosure statement poses the question, "Have you ever had the building tested for radon?" If you have, you must state when the test was done and what the results were. On the contrary side, if you have not tested, you must say so and sign a statement saying that you do not know what the radon level is in the home. Obviously, this is intended to discourage people from unloading radon "problem" houses onto unsuspecting purchasers in Pennsylvania. It is worth noting this particular bit of law, because I predict that in 5 years this necessity to dis-

Richard D. Seifert is the energy and building specialist with the Cooperative Extension Service at the University of Alaska-Fairbanks.

close the radon levels in the home will be the law nationwide, including Alaska.

In Alaska, we have now had two simultaneous radon surveys proceeding for about eight months, since I first made public the radon tests from both Alaska and the National Radon Survey. Generally, the results have not been alarming. In most cases, the houses are below four picoCuries/liter, which is the recommended limit for long-term exposure given by the Environmental Protection Agency. This is an acceptable level of radiation exposure, but it is often difficult to reduce levels below this amount. However, there have been several houses, notably in the Fairbanks area, where high levels (20-50 picoCuries/liter) have been encountered over the winter period. There does not seem to be any pattern or predictability to these yet, because there are only about three or four instances where high levels of radon have been detected. However, there have been enough instances to cause me to conduct further research into the problem.

My first research effort was to review the geology of the Fairbanks area. I wanted to find out whether, in fact, we have any suspect geologies that might increase radon levels in homes. Paul Metz of the University's mining and engineering department was my first contact. Metz is experienced in the bedrock geology of the Fairbanks area and, in fact, showed me research indicating that there was a very slight enrichment of uranium in the mineralized areas north of Fairbanks, in the Cleary sequence and in the areas around Gilmore Dome. This is interesting but not conclusive in any way. However, there is enough uranium to provide a source of radon in the area.

Taking this research further, I encountered an excellent paper by a professor from the University of North Carolina, Harry E. LeGrande. His paper is entitled, "Radon and Radium Emanations from Fractured Crystalline Rocks - A Conceptual Hydrogeological Model." LeGrande discusses the movement, transport and generation of radon from soil to air and to buildings in a very lucid and detailed presentation. He gives the following conditions which could lead to high radon concentrations.

1. Granite and associated rocks with normal or above-normal amounts of uranium.
2. Normal interconnecting fracture patterns of weathered rock.
3. A thin mantle of relatively impermeable clay soil.

4. Repeated cycles of recharge of a fluctuating water table in the fracture zone or in the overlying weathered rock.

5. Indentation of buildings into soil and rock materials.

6. Building construction allowing relatively easy inflow of air from the subsoil and rock.

Just a casual assessment of the buildings and geology in the Fairbanks area easily identified five of these six factors. The only one we are not certain of is number 4. However, repeated cycles of recharge of a fluctuating water table in the fracture zone may not be an issue for that portion of the radon emanation of soils which is airborne.

LeGrande's paper also makes this point: there is a key factor in how deeply the soil is penetrated, and what elements of the soil and rock are penetrated by a basement which could lead to a radon problem. The factor that needs to be understood about underground airborne radon is its mobilization from what is normally a mineral (uranium) to a gas. It is the gas phase of radon which makes it a problem. As soon as radon is formed in the decay of radium (which itself has decayed from uranium), it suddenly has the ability to become airborne. The amount of air entrapped in the pockets and zones of porous soil above bedrock is very critical to the amount of radon which becomes released in the air.

We believe the following happens. There is a characteristic soil regime in the Fairbanks area which results from aeolian silt deposits. The silts are normally deep (60 feet) near the base of a hill. As one moves up the slope of the hill, the silts and topsoil get shallower and shallower until--at the top of the slope, near the crest of the hill--there is almost no soil at all, and fractured bedrock reaches the surface. This suggests that the construction of a basement on a hillside, where soil and fractured bedrock are intercepted in the excavation for the basement, may lead to a very high probability of radon penetration into a building. At least the availability of radon should be suspected at these sites.

Postulation of how radon moves in the soil is an interesting issue. It may be seasonally affected by the additional overlying layer of frozen soil which could make the permeability of the frozen layer very minimal, leading one to hypothesize that great seasonal variations in the concentration of radon in basements at certain elevations and under certain conditions could occur. Seasonal frost at the soil surface may enhance winter

transport of radon into buildings because the soil surface is impermeable, leaving basements as the easiest exit point of radon to the atmosphere. In fact, most of the known sites where high radon concentrations exist are, indeed, sites that have these characteristics. The homes have basements that intercept the soil bedrock, and penetrate the fractured bedrock area and the overlying soil, and they are near the crest of hills. So indications are that this hypothetical mechanism for the release of radon to buildings is, in fact, a good candidate for understanding why some houses have radon and others nearby may not.

Perhaps the most important thing we can say at this time about radon is that there are very easy and relatively inexpensive methods to prevent radon penetration into a newly constructed building. Because radon has to come in through leaks in the basement and pretty much through that mechanism alone, sealing the basement is the key to solving the problem. I have, through my work, developed a list of radon-proofing building techniques for new construction.

1. If a concrete pad is to be used, as in a typical basement, then it is recommended that a subpad polyethylene vapor barrier be placed below the basement pad, sealed to all perforations of the pad with a watertight seal. Allow a tab around the perimeter of the pad to enable easy attachment to a wall vapor barrier. The tab around the perimeter of the pad should be at least 6 inches above the expansion joint at the base of the pad next to the concrete footing of the basement to allow for easy attachment to the wall vapor barrier.

2. Use of Glas-Clad dense fiberglass below grade insulation around the walls of your basement can allow air movement and, therefore, radon escapement along the outside walls. Unfortunately, this product is not readily available in the Fairbanks area and, to my knowledge, is not available elsewhere in Alaska. It is available in Canada and is used quite frequently there. We need to bring it into our market.

3. Use of a layer of below-pad gravel which is vented by a perforated pipe around the perimeter. This allows radon to escape from below the pad. The system could even be negatively pressurized by pumping it, if necessary, to remove radon from beneath the pad. This is not absolutely essential, but it is good building practice. Such a system provides a very good stop-gap method for areas where there is cause for concern about eventual radon problems.

4. The supply of fresh air to the basement with an air-to-air heat recovery ventilation system is a normal requirement of a well-built home today, and it can also be used to provide the basement ventilation after sealing against radon.

These recommendations, by the way, have been made an integral part of the new Alaskan Craftsman Home specifications, which the Cooperative Extension Service is also promoting at this time.

So far I have talked a great deal about where radon comes from, what it does, what it is and how to prevent it from being a health problem. The only known health affect associated with exposure to elevated levels of radon is an increased risk of developing lung cancer. Of course, not everyone exposed to elevated levels of radon will develop lung cancer. The time between exposure and the onset of the disease may be many years. According to the EPA publication, "A Citizen's Guide to Radon," scientists estimate that from about 5,000 to 20,000 lung cancer deaths a year in the United States may be attributed to radon. The American Cancer Society, on the other hand, estimates that about 130,000 people died of lung cancer in 1986, but about 85% of these lung cancer deaths relate to smoking. There is also some evidence of a synergistic effect of smoking and radon. Risk increases with the level of radon and the number of cigarettes smoked, but risk increases geometrically. Thus, the risk associated with both smoking and radon is more than twice the sum of the two separate risks.

Radon risk estimates are based upon scientific studies of uranium miners exposed to varying levels of radon in their work underground. Consequently, scientists are considerably more certain of risk estimates for radon than they are of the risk estimates which rely solely on studies of animals. Despite some uncertainty in the risk estimates for radon, it is widely believed that increased exposure to radon increases the risk of developing lung cancer. As with many problems in health, air pollution and naturally occurring environmental factors, we never know enough about these problems early on to make accurate predictions of their effects on people. Because of this, I, along with several other associates at the Institute of Northern Engineering, University of Alaska-Fairbanks, have proposed research on radon, especially the transport mechanisms and sources of radon in the northern environment.

There have also been tests conducted by the Alaska Department of Transportation and Public Facilities to detect radon in public buildings. They have found that

an overwhelming majority of the public buildings had very low radon levels (less than 1 picoCurie/liter) in 50 out of 56 buildings tested. However, it should be noted that most of the buildings they tested have very high levels of air exchange and ventilation. Therefore, such buildings would normally be expected to have diluted levels of radon. It is not the large, well-ventilated public buildings where most of the exposure will occur. It will be in home environments which are unsuspectingly built on sites where the potential exists for radon penetration.

Much of the research that needs to be done still remains. I would encourage everyone who reads this article to test their own home if they have reason to suspect their site. Let me give two danger signs of a potential radon problem in the home:

1. A full basement that was not built with an exterior polyethylene vapor barrier under the pad.

2. Basement excavation encountered weathered rock and/or bedrock under the existing basement. This is especially the case with homes built on hillsides at higher elevations in the Tanana Valley.

As I indicated earlier, the jury is still out and we need to know more about this problem. Hopefully, research will soon examine radon transport in Alaska. I would

suggest all readers who are interested in testing to contact me for a packet of information on radon safety and health, and for information on where to obtain test kits for radon.

The following publications were used in this paper.

Radon Reduction Methods, a Homeowner's Guide, U.S. Environmental Protection Agency, Seattle, WA. Publication No. OPA-86-005. 1986.

Citizen's Guide to Radon, U.S. Environmental Protection Agency, Seattle, WA. Publication No. OPA-86-004. 1986.

LeGrande, Harry E. Radon and Radium Emanations from Fractured Crystalline Rocks - A Conceptual Hydrogeological Model. Vol. 25, No. 1, Groundwater, January-February 1987. pp. 59-69.

Nero, A.V., Jr., R.G. Sextro, S.M. Doyle, B.A. Moed, W.W. Nazaroff, K.L. Revzan, and M.B. Schwer. 1985. Characterizing the sources, ranges and environmental influences of radon 222 and its decay products. Science of the Environment, Elsevier Science Publishers, B.V. Amsterdam. 45:233-244.

② HB 519



Alaska State Legislature

Representative Mike Davis

District 19

P.O. Box V
Juneau, Alaska 99811
(907) 456-4930/4941

Interim Office:
P.O. Box 81435
Fairbanks, Alaska 99708
(907) 456-8161

TO: Rep. Heinrich Springer
Chairman, House Community & Regional Affairs
FROM: Rep. Mike Davis
DATE: February 17, 1988
RE: HB 519 and HB 520

I would like to request early scheduling of HB 519 and HB 520, establishing a revolving loan fund for radon mitigation.

While radon exposure is poses a serious threat to public health, many Alaskans cannot afford to install mitigation systems in their homes. HB 519 and HB 520 would provide loans of up to \$10,000 to home owners to install air-to-air heat exchangers, vapor barriers and other mitigation mechanisms.

INCREMENT/DECREMENT DESCRIPTION:

Provide operating funds to initiate a statewide Radon Screening Survey in conjunction with expected matching funds with DOE and EPA.

AGENCY CONTACT/PHONE NUMBER:

Robert B. Forbes

479-7625

DESCRIBE WHY THIS INCREMENT/DECREMENT IS NEEDED AND WHAT IT PURCHASES:

Radon (Rn^{222}) gas accumulation has long been known to be a serious health hazard in the uranium and phosphate mining industries and has resulted in significantly elevated incidence of lung cancer in miners. Since 1984, radon has assumed additional significance as a potentially serious health problem in residences and public buildings in some regions of the United States. EPA and public health officials postulate that radon may be the leading source of human exposure to naturally occurring background radiation. It may also be the leading cause of nonsmoking-related lung cancer that may account for from 5,000 to 20,000 cancer-related deaths per year in the United States.

At this time, more than 30 states throughout the U.S. have initiated programs to identify areas with high radon hazard potential and to deal with the complex health and legal aspects of the problem. DOE and EPA have established offices for the coordination of state radon-assistance programs.

Recent spot surveys by several state agencies (DOTPF, UAF, AEIDC, DHSS, DGCS) show that excessive radon concentrations occur in some Alaskan homes. Most recently, DGCS investigators recorded extremely high radon concentrations in several Fairbanks residences in hillside subdivisions; these concentrations rank among the highest yet measured in the United States (greater than 800 picocuries per liter). Considering that the EPA recommended maximum exposure level is 4 pCi/l, these concentrations indicate that household radon may be a serious health problem in Alaska and that a statewide radon survey program should be initiated as soon as possible.

The magnitude of the problem can be determined using careful and systematic orientation and screening surveys and correlating the results with meaningful geologic parameters. Through the development of geologic models for radon prediction, workers in other states have identified areas where the need for high-density household monitoring is greatest, thereby making the most efficient use of limited funding.

- - - Continued on following page - - -

CODE	EXPENDITURE BY OBJECT	AGENCY REQ.	GOV'S REQ.
100	Personal Services		
200	Travel		
300	Contractual Services	100.0	
400	Supplies		
500	Equipment		
600	Lands, Buildings, Etc.		
700	Grants, Claims, Etc.		
800	Miscellaneous		
TOTAL		100.0	- 0 -
I-A Transfer (NON-ADD)			
1002	Federal Receipts		
1003	General Fund Match		
1004	General Fund	100.0	
1005	Program Receipts/GF		
1007	I-A Receipts		
POSITION INFORMATION		PFT	
		PPT	
		Non Permanent	
		Staff Months	0

Enhance Existing Service

Compared to FY 88

New Service Compared to FY 88

Continuation of FY 88 Service Level

Formula Program

IMPACT FROM CAPITAL PROJECT (NAME)

Chapter _____ SLA _____ Page/Line _____

AGENCY Natural Resources

BRU Geological Management

COMPONENT Land and Public Safety

PROJECT Radon Screening

C5 INCREMENT/DECREMENT REQUEST

Agency Priority _____ of _____

3137

Page 1 of 2

Revised Date _____

FY 89

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④ AB 519

Currently, Alaska is one of the few states for which EPA has little or no information pertaining to radon potential or actual data from radon surveys of homes or public buildings. Limited data have been or are currently being gathered in local surveys of selected areas of the state. As yet, however, we do not have enough data to estimate the magnitude of the statewide radon problem. Presentation and discussions at a recent radon workshop in Reston, Virginia, dealt with geologic conditions that favor radon emanation and concentration in other regions of the United States. A comparison of those conditions to Alaskan geology makes it clear that it would be prudent to develop a multidisciplinary statewide survey program to determine the radon hazard potential throughout Alaska.

C5
ADDITIONAL
EXPLANATION
FORM

Radon Screening Survey

AGENCY Natural Resources

BRU Geologic Management

COMPONENT Land and Public Safety

Page 2 of 2

Revised Date

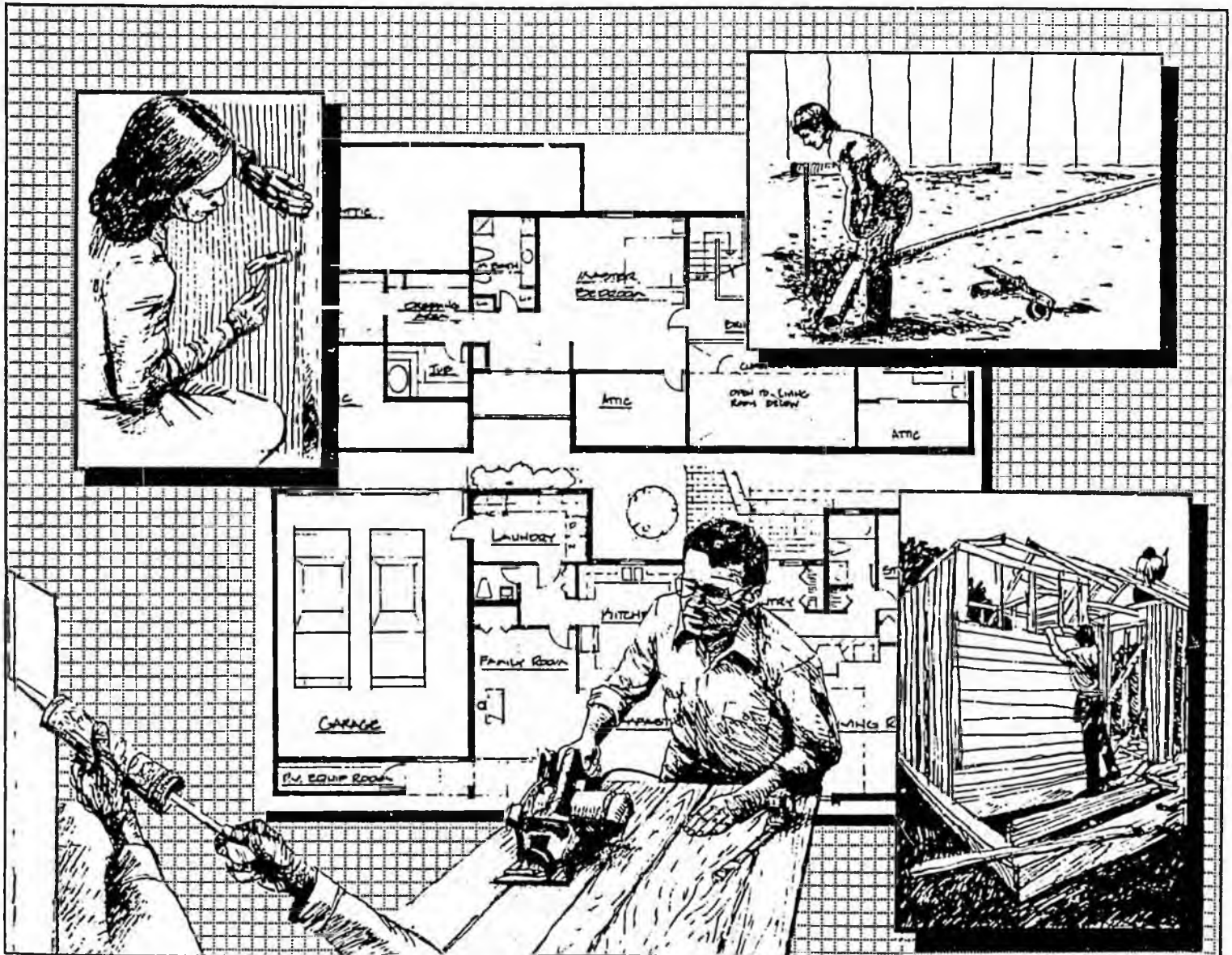
FY 89

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Radon Reduction in New Construction

An Interim Guide



Introduction

The U.S. Environmental Protection Agency (EPA) is concerned about the increased risk of developing lung cancer faced by persons exposed to radon in their homes. Because many families already face the problem, early emphasis was placed on identifying the danger in existing homes and developing cost-effective methods to make such housing safer. Based on this early research, EPA published three documents in 1986: *A Citizen's Guide to Radon: What It Is and What To Do About It*, *Radon Reduction Methods: A Homeowner's Guide*, and a more detailed manual, *Radon Reduction Techniques for Detached Houses: Technical Guidance*. These documents were designed to help homeowners determine if they have a radon problem and to present information on how to reduce elevated radon levels in their homes.

This pamphlet is the next step in attempting to reduce the radon hazard in homes. It is designed to provide radon information for those involved in new construction and to introduce methods that can be used during construction to minimize radon entry and facilitate its removal after construction is complete. If there is concern about the potential for elevated indoor radon levels, it may be prudent to use these construction techniques in new homes. The "Techniques for Site Evaluation" section of this pamphlet outlines several methods for assessing the potential for elevated indoor radon levels. The decision to incorporate these construction techniques rests solely with the builder or homeowner.

In addition to extensive internal EPA review, this pamphlet has been developed in coordination with the National Association of Home Builders Research Foundation, Inc. (NAHB-RF) a not for profit organization, and other federal agencies including the Department of Energy (DOE), Housing and Urban Development (HUD), United States Geological Survey (USGS), and the National Bureau of Standards (NBS). It also reflects comments solicited from a broad spectrum of individual experts in home construction and related industries.

It is potentially more cost-effective to build a home that resists radon

entry than to remedy a radon problem after construction. The construction methods suggested in this pamphlet represent current knowledge and experience gained primarily from radon reduction tests and demonstrations on existing homes. Field tests are underway to develop and refine the most cost-effective new-home construction techniques. After completion of these field tests, a more detailed "Technical Guidance" manual will be published to expand and revise, as necessary, the interim guidance presented in this pamphlet. Accordingly, this *Interim Guide should not be referenced in codes and standards documents.*

Radon Facts

Radon is a colorless, odorless, tasteless, radioactive gas that occurs naturally in soil gas, underground water, and outdoor air. It exists at various levels throughout the United States. Prolonged exposure to elevated concentrations of radon decay products has been associated with increases in the risk of lung cancer. An elevated concentration is defined as being at or above the EPA suggested guidelines of 4 pCi/l or 0.02 WL average annual exposure.* Although exposures below this level do present some risk of lung cancer, reductions to lower levels may be difficult, and sometimes impossible to achieve.

Soil gas entering homes through exposed soil in crawl spaces, through cracks and openings in slab-on-grade floors, and through below-grade walls and floors is the primary source of elevated radon levels (Figure 1). Radon in outside air is diluted to such low concentrations that it does not present a health hazard. In some small public and private well-water supplies, radon is a hazard primarily to the extent that it contributes to indoor radon gas concentrations. When water is heated and agitated (aerated), as in a shower or washing machine, it will give off small** quantities of radon.

Radon moves through the small spaces that exist in all soils. The speed of movement depends on the permeability of the soil and the presence of a driving force caused when the pressure inside a home is lower than the pressure outside or in

the surrounding and underlying soil. A lower pressure inside a home may result from:

- Heated air rising, which causes a stack effect.
 - Wind blowing past a home, which causes a down-wind draft or Venturi effect.
 - Air being used by fireplaces and wood stoves, which causes a vacuum effect.
 - Air being vented to the outside by clothes dryers and exhaust fans in bathrooms, kitchens, or attics, which also causes a vacuum effect.
- In homes, where a partial vacuum exists, outdoor air and soil gas are driven into the home.

New Construction Principles

The facts just discussed form the basis for the following new-construction principles:

- Homes should be designed and constructed to minimize pathways for soil gas to enter.
- Homes should be designed and built to maintain a neutral pressure differential between indoors and outdoors.
- Features can also be incorporated during construction that will facilitate radon removal after completion of the home if prevention techniques prove to be inadequate.

The following techniques for site evaluation and construction are based on these principles.

Techniques for Site Evaluation

The first step in building new radon-resistant homes is to determine, to the degree possible, the potential for radon problems at the building site. At this time, there are no standard soil tests or specific

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standards for correlating the results of soil tests at a building site with subsequent indoor radon levels. The variety of geological conditions in the United States will probably continue to preclude establishment of any all-inclusive, nationwide standards for such correlation. We can, however, estimate the radon potential at a building site based on factors other than soil tests. If the answer to any of the following questions is yes, radon problems might be anticipated and radon reduction features should be considered for inclusion in construction plans.

- Have existing homes in the same geologic area experienced elevated radon levels? ("Same geologic area" is defined as an area having similar rock and soil composition characteristics.) State or regional EPA offices may be able to assist in obtaining this information.

- What are the general characteristics of the soil? State and local geological or agricultural offices can normally help in providing answers to the following questions on soil:

—Is the soil derived from underlying rock that normally contains above-average concentrations of uranium or radium, e.g., some granites, black shales, phosphates or phosphate limestones?

—Is the permeability of the soil and underlying rock conducive to the flow of radon gas? Note that soil permeability (influenced by grain size, porosity, and moisture content) and the degree to which underlying and adjacent rock structures are stable or fractured can significantly affect the amount of radon that can flow toward and into a home.

- If the source of water to the site is going to be a local or onsite well, have excessive levels of radon been detected in other wells within the same geologic area? (Levels measured above 40,000 pCi/l of water could alone produce indoor radon concentrations of about 4 pCi/l or above. Such levels are considered excessive.) State or local health agencies, departments of natural resources, or environmental protection offices may be able to assist in providing this information. Testing well water for radon before the home is built could provide an additional indication of a potential radon problem. If excessive radon levels are confirmed, a granular activated-carbon

filtration system or an aeration system might be designed into the plumbing plan.

Construction Techniques

Some of the radon prevention techniques discussed below are common building practices in many areas and, in any case, are less costly if accomplished during construction. Costs to retrofit existing homes with the same features would be significantly higher. Although these construction techniques do not require any fundamental changes in building design, there is a continuing need for quality control, supervision, and more careful attention to certain construction details. Construction techniques for minimizing radon entry can be grouped into two basic categories:

- Methods to reduce pathways for radon entry.

- Methods to reduce the vacuum effect of a home on surrounding and underlying soil.

Typically, the techniques in both categories are used in conjunction with each other.

Methods to Reduce Pathways for Radon Entry (Figure 2)

In Basement and Slab-on-Grade Construction:

- Place a 6-mil polyethylene vapor barrier under the slab. Overlap joints in the barrier 12 inches. Penetrations of the barrier by plumbing should be sealed or taped, and care should be taken to avoid puncturing the barrier when pouring the slab.

- To minimize shrinkage and cracks in slabs, use recommended water content in concrete mix and keep the slab covered and damp for several days after the pour.

- To help reduce major floor cracks, ensure that steel reinforcing mesh, if used, is imbedded in (and not under) the slab. Reducing major cracks in footings, block foundation, and poured-concrete walls will reduce the rate of radon entry. Radon can, however, enter homes through even the smallest of cracks in concrete slabs and walls if a driving pressure is applied to those surfaces.

- The most common radon-entry pathways are inside perimeter

floor/wall joints and any control joints between separately poured slab sections. To reduce radon entry through these joints, install a common flexible expansion joint material around the perimeter of the slab and between any slab sections. After the slab has cured for several days, remove or depress the top 1/2 inch or so of this material and fill the gap with a good quality, non-cracking polyurethane or similar caulk. Similar techniques for sealing these joints may also be used.

- In some areas, basement slabs are poured with a French Drain channel around the slab perimeter. To be effective, this moisture control technique requires that the floor/wall joint be open to permit water to seep out into the sub-slab area. To reduce radon entry through such open joints, it may be necessary to install a perforated drain pipe loop under the slab, adjacent to the footing and imbedded in aggregate, and to tie this pipe into a sub-slab ventilation system to draw radon gas away from the French Drain joint (Figure 4). For additional information on water control techniques, refer to National Association of Home Builders (NAHB) publication *Basement Water Leakage: Causes, Prevention, and Correction*.

- When building slab-on-grade homes in warm climates, pour the foundation and slab as a single (monolithic) unit. If properly insulated below grade-level, shallow foundations and slabs can also be poured as a single unit in cold climates.

- Remove all grade stakes and screed boards and fill the holes as the slab is being finished. This will prevent future radon pathways through the slab, which might otherwise be created as imbedded wood eventually deteriorates.

- Carefully seal around all pipes and wires penetrating the slab, paying particular attention to bathtub, shower, and toilet openings around traps.

- Floor drains, if installed, should drain to daylight, a sewer, or to a sump with pump discharge. Floor drains should not be drained into a sump if such a pit will be used as part of a sub-slab ventilation system. Suction on the sump could be defeated by an open line to the floor drain.

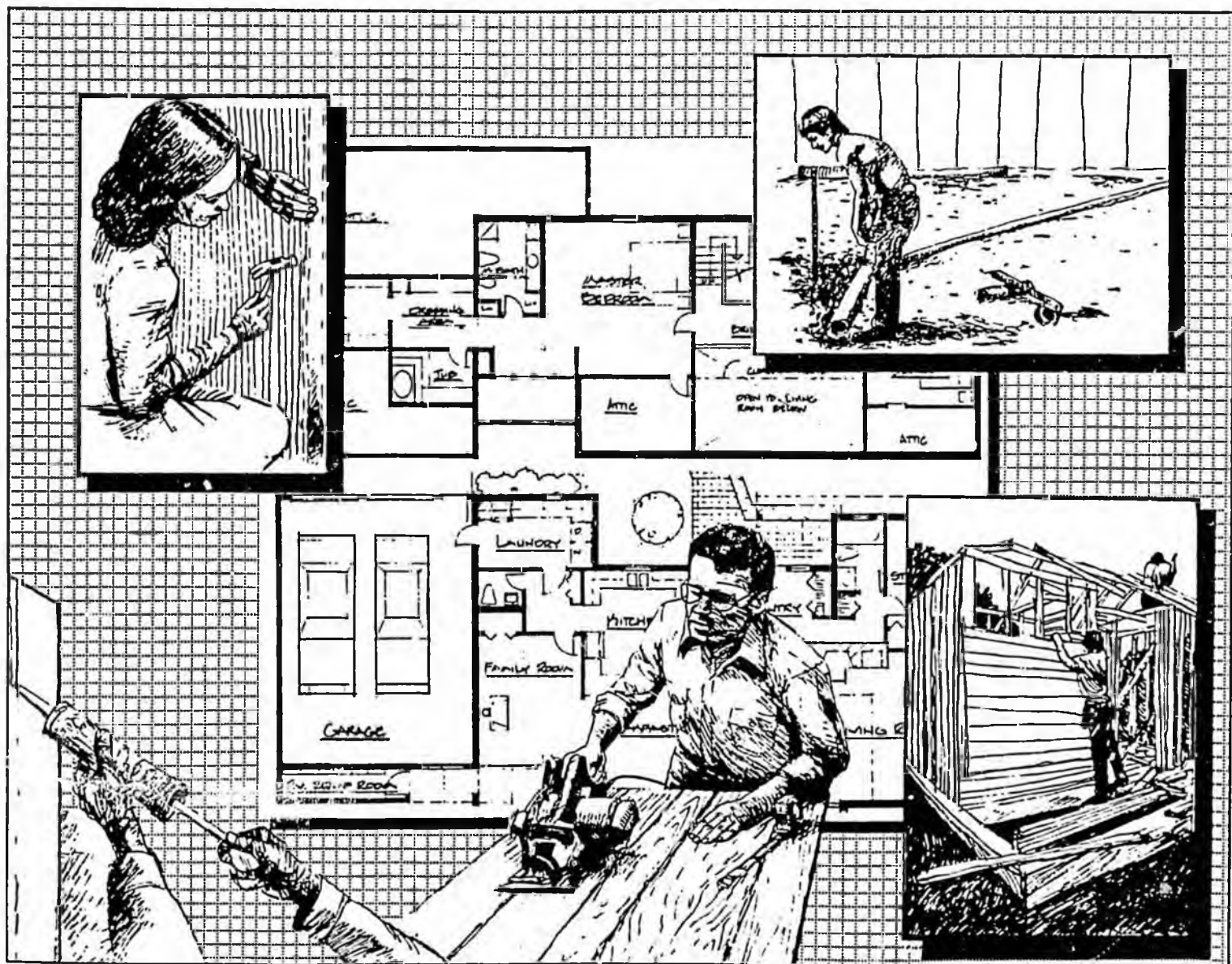
- Sumps should be sealed at the top. In closed sumps used for sub-slab

**THIS DOCUMENT
HAS BEEN REPHOTOGRAPHED
TO ASSURE LEGIBILITY**



Radon Reduction in New Construction

An Interim Guide



*Comments on the information in this booklet should be addressed to:
Radon Division (ANR-464)
Office of Radiation Programs
U.S. Environmental Protection Agency
Washington, D.C. 20460*

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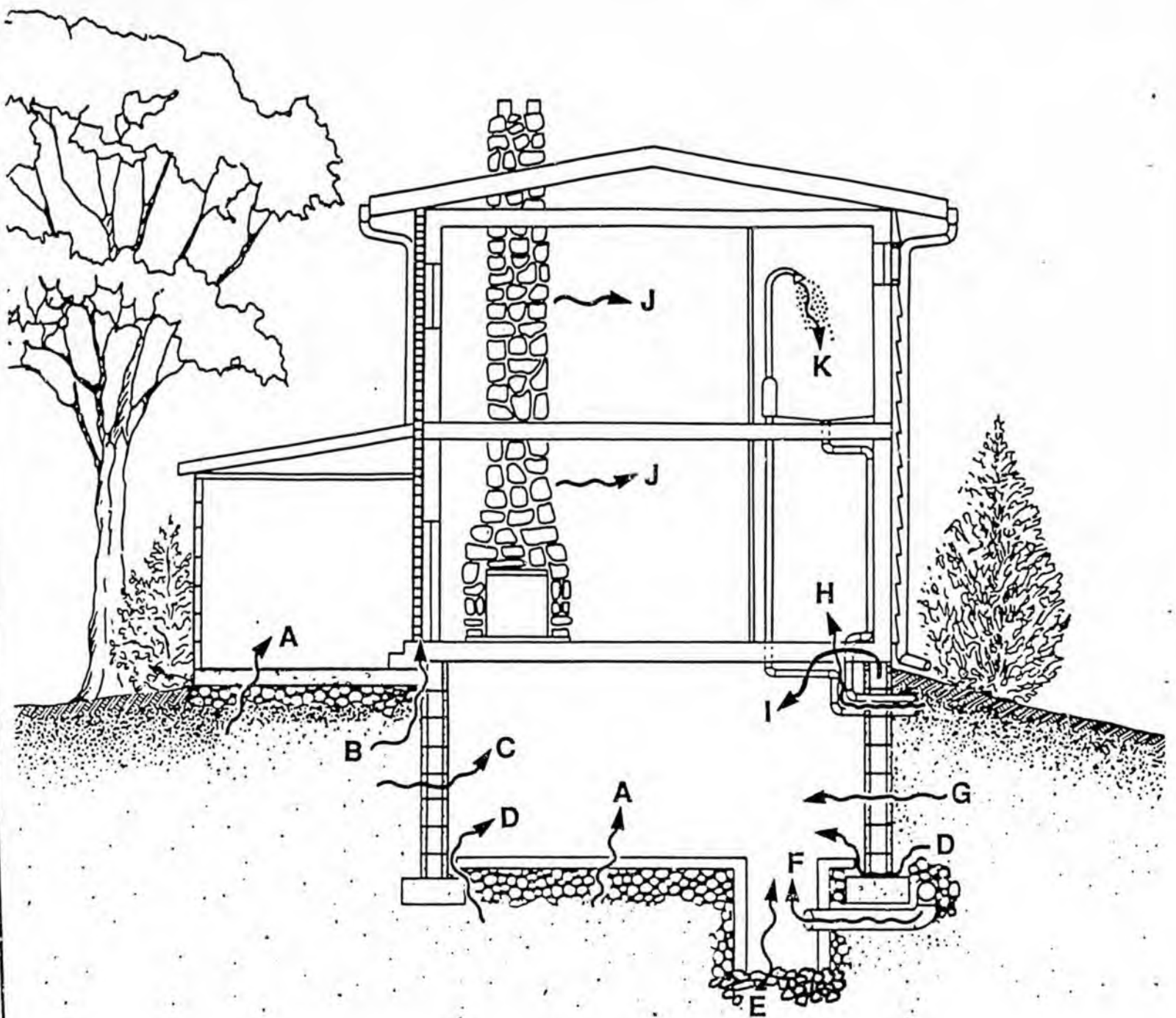
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MAJOR RADON ENTRY ROUTES

- A. Cracks in concrete slabs
- B. Spaces behind brick veneer walls that rest on uncapped hollow-block foundation
- C. Pores and cracks in concrete blocks
- D. Floor-wall joints
- E. Exposed soil, as in a sump
- F. Weeping (drain) tile, if drained to open sump
- G. Mortar joints
- H. Loose fitting pipe penetrations
- I. Open tops of block walls
- J. Building materials such as some rock
- K. Water (from some wells)

Figure 1

standards for correlating the results of soil tests at a building site with subsequent indoor radon levels. The variety of geological conditions in the United States will probably continue to preclude establishment of any all-inclusive, nationwide standards for such correlation. We can, however, estimate the radon potential at a building site based on factors other than soil tests. If the answer to any of the following questions is yes, radon problems might be anticipated and radon reduction features should be considered for inclusion in construction plans.

- Have existing homes in the same geologic area experienced elevated radon levels? ("Same geologic area" is defined as an area having similar rock and soil composition characteristics.) State or regional EPA offices may be able to assist in obtaining this information.

- What are the general characteristics of the soil? State and local geological or agricultural offices can normally help in providing answers to the following questions on soil:

—Is the soil derived from underlying rock that normally contains above-average concentrations of uranium or radium, e.g., some granites, black shales, phosphates or phosphate limestones?

—Is the permeability of the soil and underlying rock conducive to the flow of radon gas? Note that soil permeability (influenced by grain size, porosity, and moisture content) and the degree to which underlying and adjacent rock structures are stable or fractured can significantly affect the amount of radon that can flow toward and into a home.

- If the source of water to the site is going to be a local or onsite well, have excessive levels of radon been detected in other wells within the same geologic area? (Levels measured above 40,000 pCi/l of water could alone produce indoor radon concentrations of about 4 pCi/l or above. Such levels are considered excessive.) State or local health agencies, departments of natural resources, or environmental protection offices may be able to assist in providing this information. Testing well water for radon before the home is built could provide an additional indication of a potential radon problem. If excessive radon levels are confirmed, a granular activated-carbon

filtration system or an aeration system might be designed into the plumbing plan.

Construction Techniques

Some of the radon prevention techniques discussed below are common building practices in many areas and, in any case, are less costly if accomplished during construction. Costs to retrofit existing homes with the same features would be significantly higher. Although these construction techniques do not require any fundamental changes in building design, there is a continuing need for quality control, supervision, and more careful attention to certain construction details. Construction techniques for minimizing radon entry can be grouped into two basic categories:

- Methods to reduce pathways for radon entry.
- Methods to reduce the vacuum effect of a home on surrounding and underlying soil.

Typically, the techniques in both categories are used in conjunction with each other.

Methods to Reduce Pathways for Radon Entry (Figure 2)

In Basement and Slab-on-Grade Construction:

- Place a 6-mil polyethylene vapor barrier under the slab. Overlap joints in the barrier 12 inches. Penetrations of the barrier by plumbing should be sealed or taped, and care should be taken to avoid puncturing the barrier when pouring the slab.
- To minimize shrinkage and cracks in slabs, use recommended water content in concrete mix and keep the slab covered and damp for several days after the pour.
- To help reduce major floor cracks, ensure that steel reinforcing mesh, if used, is imbedded in (and not under) the slab. Reducing major cracks in footings, block foundation, and poured-concrete walls will reduce the rate of radon entry. Radon can, however, enter homes through even the smallest of cracks in concrete slabs and walls if a driving pressure is applied to those surfaces.
- The most common radon-entry pathways are inside perimeter

floor/wall joints and any control joints between separately poured slab sections. To reduce radon entry through these joints, install a common flexible expansion joint material around the perimeter of the slab and between any slab sections. After the slab has cured for several days, remove or depress the top 1/2 inch or so of this material and fill the gap with a good quality, non-cracking polyurethane or similar caulk. Similar techniques for sealing these joints may also be used.

- In some areas, basement slabs are poured with a French Drain channel around the slab perimeter. To be effective, this moisture control technique requires that the floor/wall joint be open to permit water to seep out into the sub-slab area. To reduce radon entry through such open joints, it may be necessary to install a perforated drain pipe loop under the slab, adjacent to the footing and imbedded in aggregate, and to tie this pipe into a sub-slab ventilation system to draw radon gas away from the French Drain joint (Figure 4). For additional information on water control techniques, refer to National Association of Home Builders (NAHB) publication *Basement Water Leakage: Causes, Prevention, and Correction*.
- When building slab-on-grade homes in warm climates, pour the foundation and slab as a single (monolithic) unit. If properly insulated below grade-level, shallow foundations and slabs can also be poured as a single unit in cold climates.
- Remove all grade stakes and screed boards and fill the holes as the slab is being finished. This will prevent future radon pathways through the slab, which might otherwise be created as imbedded wood eventually deteriorates.
- Carefully seal around all pipes and wires penetrating the slab, paying particular attention to bathtub, shower, and toilet openings around traps.
- Floor drains, if installed, should drain to daylight, a sewer, or to a sump with pump discharge. Floor drains should not be drained into a sump if such a pit will be used as part of a sub-slab ventilation system. Suction on the sump could be defeated by an open line to the floor drain.
- Sumps should be sealed at the top. In closed sumps used for sub-slab

ventilation systems, the continuous flow of moist air through the sump can cause rapid corrosion of exposed sump pump motors. For this reason, submersible-type sump pumps are recommended for closed-sump applications.

In Basement and Crawl space Construction:

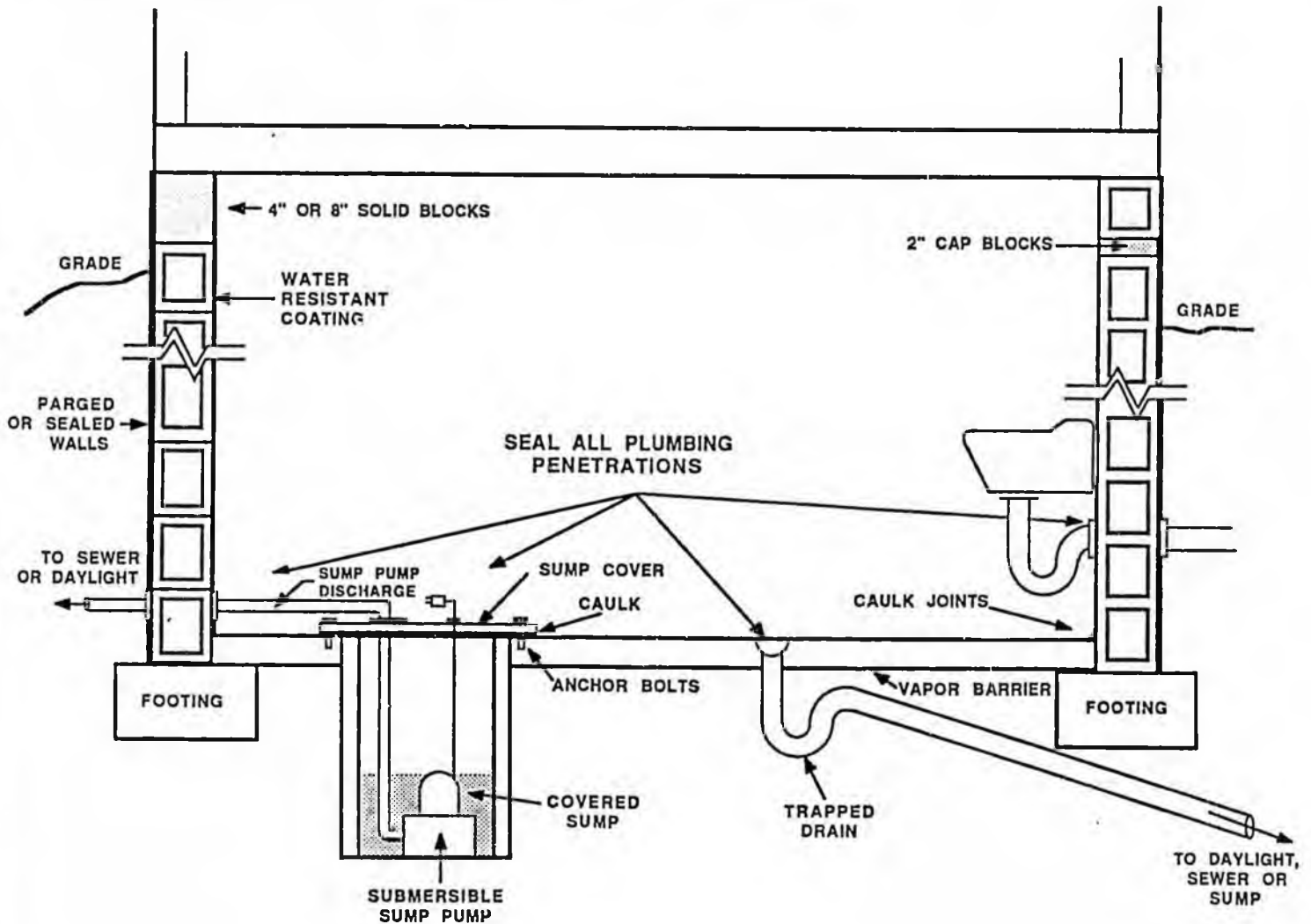
- Seal or cap the tops of hollow-block foundation walls using one of the techniques shown in Figure 2.
- Carefully seal around any pipe or wire penetrations of below-grade walls.
- Exterior block walls should be parged and coated with high-quality vapor/water sealants or polyethylene films. For additional information on wall sealing, refer to NAHB

publication *Basement Water Leakage: Causes, Prevention, and Correction*. Several new products for use on exterior walls are designed to provide an airway for soil gas to reach the surface outside the wall rather than being drawn through the wall. Similar materials may also be used in sub-slab ventilation applications.

- Interior surfaces of masonry foundations may be covered with a high-quality, water-resistant coating.
- Heating or air-conditioning ductwork that must be routed through a crawl space or beneath a slab should be properly taped or sealed. This is particularly important for return air ducting, which is under negative pressure. Due to difficulty in achieving permanent sealing of such

ductwork, it may be advisable to redesign heating and ventilating systems to avoid ducting through sub-slab or crawl space areas, particularly in areas where elevated soil radon levels have been confirmed.

- Install air-tight seals on any doors or other openings between basements and adjoining crawl spaces.
- Seal around any ducting, pipe, or wire penetrations of walls between basements and adjoining crawl spaces, and close any openings between floor joists over the dividing wall.
- Place a 6-mil polyethylene vapor barrier on the soil in the crawl space. Use a 12-inch overlap and seal the seams between barrier sections. Seal edges to foundation walls.



METHODS TO REDUCE PATHWAYS FOR RADON ENTRY

Figure 2

Methods to Reduce the Vacuum Effect (Figure 3)

- Ensure that vents are installed in crawl space walls and are sized and located in accordance with local building practices. Adequate ventilation of crawl spaces is the best defense against radon entry in crawl space-type homes.
- Reduce air flow from the crawl space into living areas by closing and sealing any openings and penetrations of the floor over the crawlspace.
- To reduce the stack effect, close thermal bypasses such as spaces around chimney flues and plumbing chases. Attic access stairs should also be closed and sealed. (Note: Because of potential heat buildup, most codes prohibit insulating around recessed ceiling lights. Such lights should therefore be avoided in top-floor ceilings. As an alternative, use recessed ceiling lights designed to permit insulation or "hi-hat" covers and seal to minimize air leakage.)
- Install ducting to provide an external air supply for fireplace combustion.
- In areas frequently exposed to above-average winds, install extra weather sealing above the soil line to reduce depressurization caused by the Venturi effect. Such sealing will also save energy and reduce the stack effect.
- Air-to-air heat exchange systems are designed to increase ventilation and improve indoor air quality. They may also be adjusted to help neutralize any imbalance between indoor and outdoor air pressure and thus reduce the stack effect of the home. They should not, however, be relied upon as a stand-alone solution to radon reduction in new construction. (A slightly positive pressure, in the basement, may contribute to reducing radon flow into a home.)

Construction Methods That Will Facilitate Post-Construction Radon Removal (Figure 4)

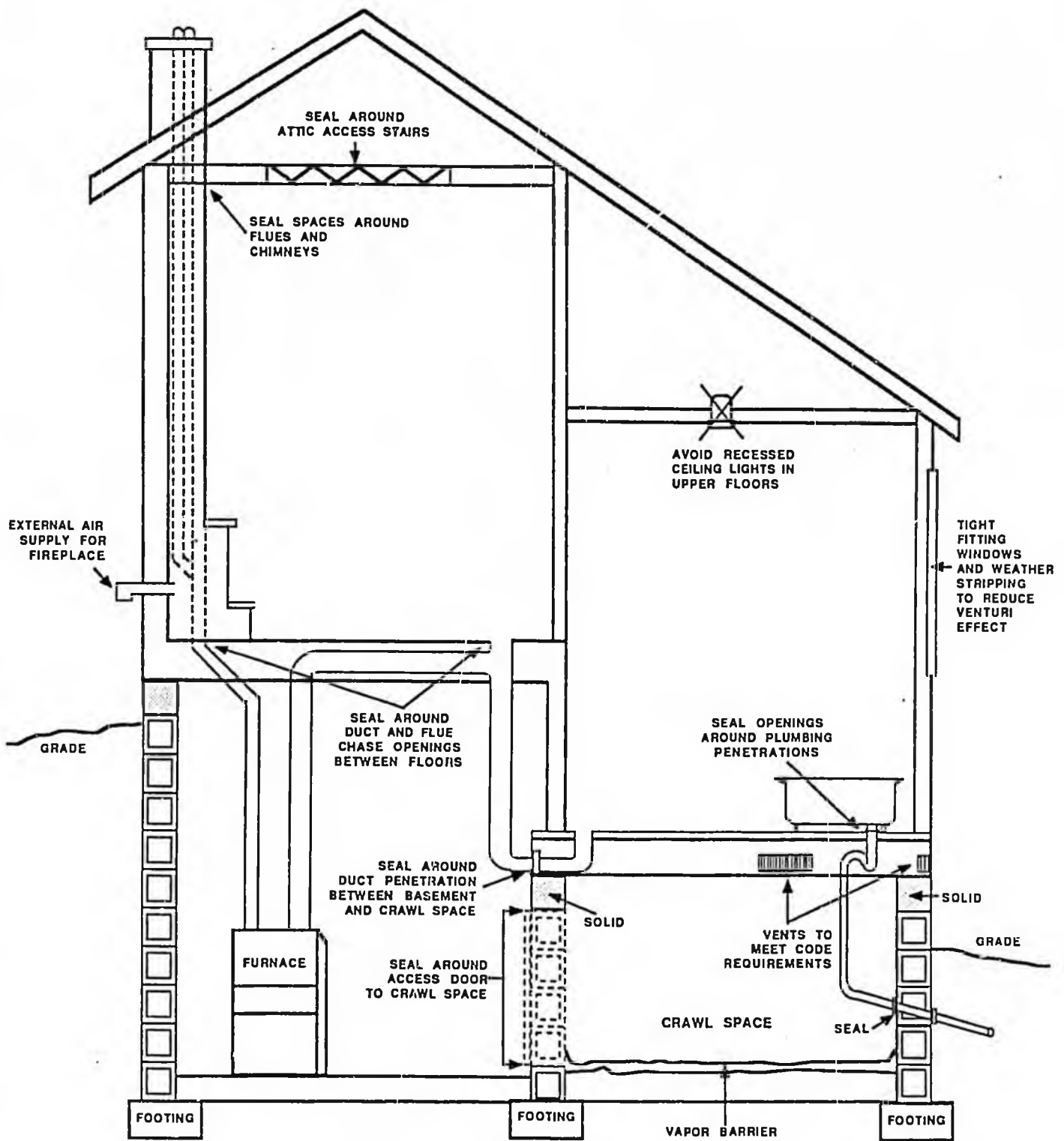
Recognizing that radon prevention techniques may not always result in radon levels below the suggested guideline of 4 pCi/l average annual exposure, there are several additional construction techniques that can be used to facilitate any post-construction radon removal that may be required.

- Before pouring a slab, fill the entire sub-floor area with a layer (4 inches thick) of pea gravel or larger, clean aggregate to facilitate installation of a sub-slab ventilation system.
- Lay a continuous loop of perforated 4-inch diameter drain pipe around the inside perimeter of the foundation footing. Run the vent from this loop into the side of a closed sump that can, if necessary, be equipped with a fan-driven vent to the outside. In this configuration, the drain pipe loop can aid in water seepage control as well as radon reduction.
- As an alternative to the vented interior drain pipe loop, a similarly vented exterior loop can be laid outside the foundation footing.
- In areas where water seepage into below-grade spaces is not a problem and sump pumps are not installed, exterior or interior drain pipe loops can be stubbed-up outside the home or through the slab and can be available for use as sub-slab ventilation points if needed.
- The soil beneath a slab can also be ventilated using the following technique: Prior to pouring the slab, insert (in a vertical position) one or more short (12-inch) lengths of 4-inch minimum diameter PVC pipe into the sub-slab aggregate and cap the top end. After construction is complete, these standpipes can, if necessary, be uncapped and connected to one or

more convection stacks or fan-driven vent pipes. When positioning these standpipes, choose locations permitting venting to the roof through already planned flue or plumbing chases, interior walls, or closets. In homes where flue or other chases are restricted in size or not easily accessible, it may be less expensive to go ahead—during the framing and rough-in plumbing/electric phase of construction—and complete the vent pipe hookup, temporarily terminating the vent in the attic along with an electric outlet for future fan installation. Experience has shown that in homes with higher radon levels—above 20 pCi/l—convection (passive) venting may not produce acceptable radon reductions. If lower radon levels are expected and passive venting is attempted, performance is improved by using a 6-inch diameter vent routed straight from the floor through the roof, with minimum bends.

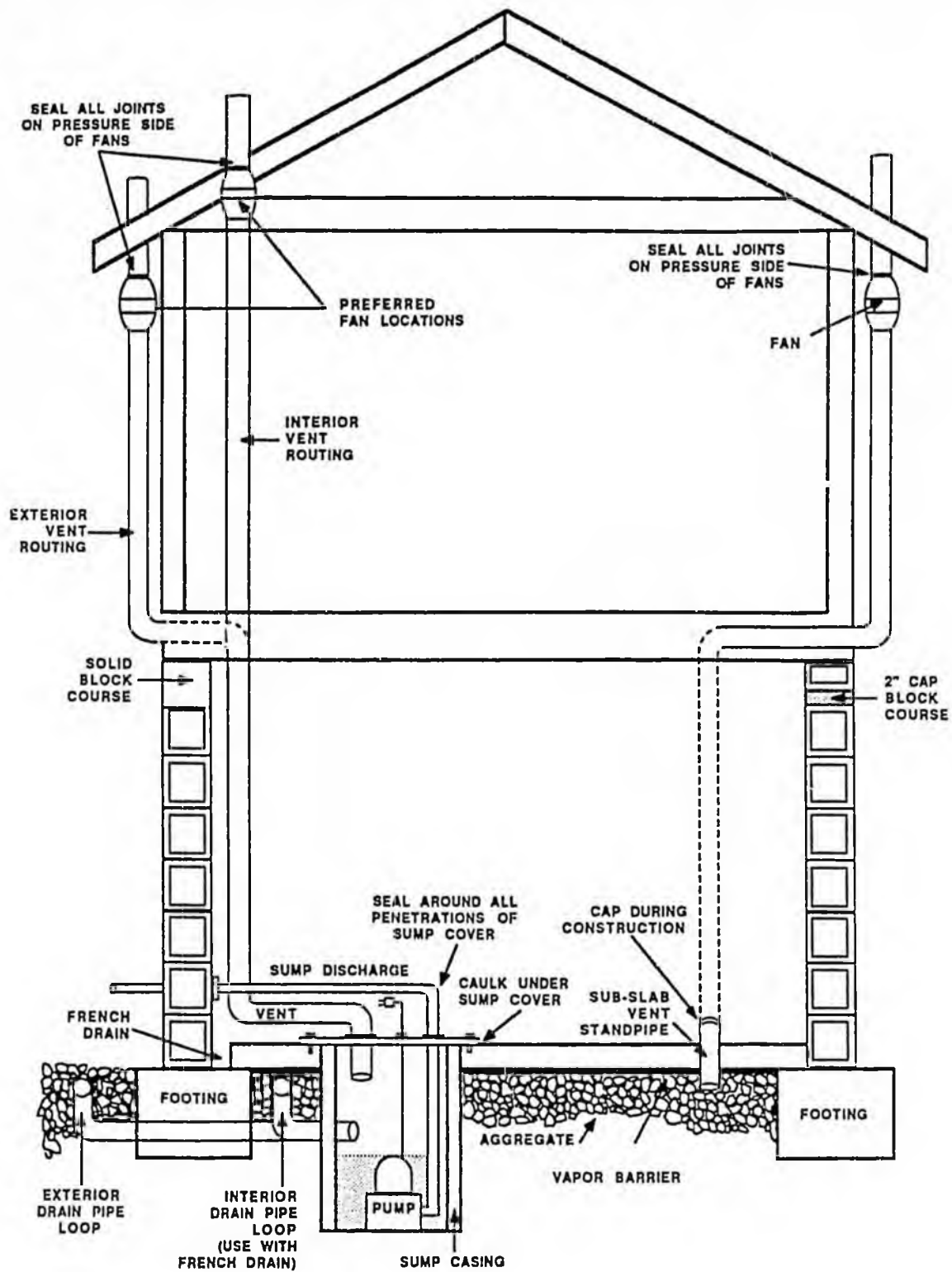
Drilling 4-inch holes through finished slabs for insertion of vent pipes is an alternative to this technique.

- To create the necessary convection flow, radon prevention techniques that involve passive venting normally require stacks that pass through the floors and roof. When active (fan-driven) systems are installed, venting through to the roof is still preferred. Recognizing, however, that active systems can be vented through the band joist or below-grade walls to the outside, it is considered advisable in such active systems to position the exit point of the vent pipe at or above the eave line of the roof and away from any doors or windows. This will preclude any possible recirculation of air containing concentrated radon gas back into the house.
- In homes where an active (fan-driven) sub-slab ventilation system has been installed, it may be necessary to provide make-up air to avoid back drafting.



METHODS TO REDUCE THE VACUUM EFFECT

Figure 3



METHODS TO FACILITATE POST-CONSTRUCTION RADON REMOVAL

Figure 4

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Source of Information

If you would like further information or explanation on any of the points mentioned in this booklet, you should contact your State radiation protection office or home builders association.

If you have difficulty locating these offices, you may call your EPA regional office listed below. They will be happy to provide you with the name, address, and telephone number of these contacts.

STATE-EPA REGION

Alabama-4	Idaho-10	Oklahoma-6	Kentucky-4
Alaska-10	Illinois-5	Oregon-10	New Jersey-2
Arizona-9	Indiana-5	Ohio-5	Texas-6
Arkansas-6	Maryland-3	Pennsylvania-3	Louisiana-6
California-9	Massachusetts-1	Rhode Island-1	New Mexico-6
Colorado-8	Michigan-5	Nebraska-7	Utah-8
Connecticut-1	Minnesota-5	South Carolina-4	North Carolina-4
Delaware-3	Mississippi-4	Iowa-7	Virginia-3
District of Columbia-3	Missouri-7	Nevada-9	West Virginia-3
Florida-4	Montana-8	South Dakota-8	Washington-10
Georgia-4	Maine-1	Kansas-7	Wisconsin-5
Hawaii-9	New York-2	New Hampshire-1	Wyoming-8
	North Dakota-8	Tennessee-4	Vermont-1

EPA REGIONAL OFFICES

EPA Region 1
Room 2203
JFK Federal Building
Boston, MA 02203
(617) 565-3234

EPA Region 2
26 Federal Plaza
New York, NY 10278
(212) 264-4418

EPA Region 3
841 Chestnut Street
Philadelphia, PA 19107
(215) 597-4084

EPA Region 4
345 Courtland Street, NE
Atlanta, GA 30365
(404) 347-2904

EPA Region 5
230 South Dearborne Street
Chicago, IL 60604
(312) 886-6175

EPA Region 6
1201 Elm Street
Dallas, TX 75270
(214) 655-7208

EPA Region 7
726 Minnesota Avenue
Kansas City, KS 66101
(913) 236-2893

EPA Region 8
Suite 1300
One Denver Place
999 18th Street
Denver, CO 80202
(303) 293-1648

EPA Region 9
215 Fremont Street
San Francisco, CA 94105
(415) 974-8378

EPA Region 10
1200 Sixth Avenue
Seattle, WA 98101
(206) 442-7660



⑥ HB 519

United States
Environmental Protection
Agency

September 1987
OPA-87-010

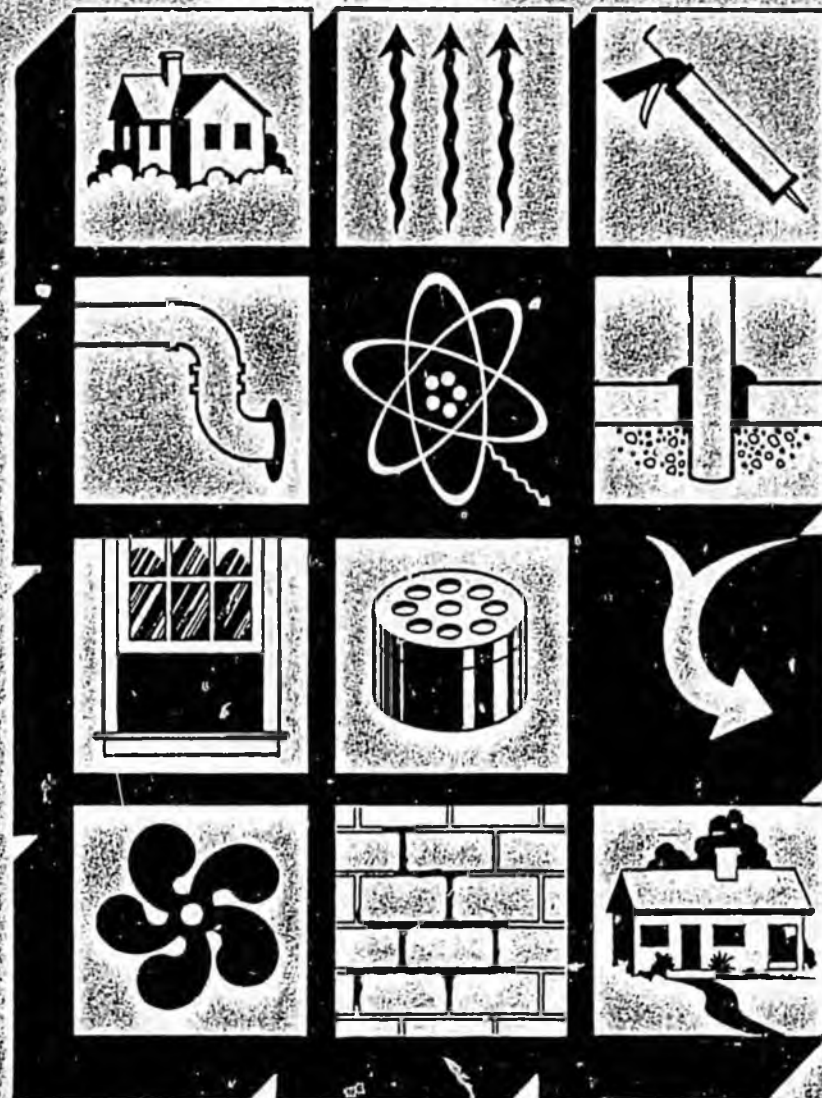
Research and Development



Radon Reduction Methods

A Homeowner's
Guide

(Second Edition)



EPA Study

The U.S. Environmental Protection Agency (EPA) is studying the effectiveness of various ways to reduce high concentrations of radon in houses. While our work is far from complete, we have gained some information which may be of immediate use to homeowners. We are publishing this booklet to share what we have learned with those whose radon problems demand prompt action.

The booklet describes methods that have been tested successfully—by EPA and/or other research groups—on houses with high indoor radon levels. The information presented here is concerned primarily with radon which enters a house from the underlying soil. Additional information will be published as it becomes available.

Unique Problems

The first lesson to learn about radon reduction is this: No two houses are alike. Even houses that look the same have small differences in existing conditions that can affect radon entry and the design and effectiveness of reduction techniques. Underlying soils also vary greatly, even among houses which sit close together. These differences will affect the results obtainable from using the radon reduction methods described here.

General Information

This booklet is intended primarily for homeowners who already have had their homes tested for radon and have decided that they need to take some action to reduce radon levels. If you are uncertain of the meaning of such test results, or if you need general information about radon in houses, read the EPA booklet, *A Citizen's Guide to Radon: What It Is And What To Do About It* (OPA-86-004). To get a copy, contact your state radon program office (see list at the end of this booklet).

Performing screening and follow-up measurements prior to a decision to mitigate (that is, to reduce radon

levels), is strongly encouraged. The results of follow-up measurements will enable the homeowner to make a well-informed decision about health risks and the need for remedial action. As mitigation often entails spending a significant amount of money, follow-up measurements should be reliable estimators of the actual maximum potential exposures of the occupants.

Using Contractors

Many radon remedies require the skilled services of a professional contractor who is experienced in radon reduction procedures. (EPA and the states are currently working to increase the number of experienced contractors.) Due to the skills required, do-it-yourself efforts are recommended only for homeowners with these special skills.

This booklet does not attempt to give the homeowner detailed instructions for corrective action. But, the information here should help you make informed decisions on what type of remedy is needed, and may assist you in evaluating proposals from contractors.

We cannot overemphasize the importance of carefully selecting a contractor and reviewing any proposal for radon reduction work at your house. Asking for business references and checking with your local Better Business Bureau or Chamber of Commerce will help you ensure that a contractor is reputable. Many states will provide lists of contractors doing radon mitigation work, and some states have certification programs for radon measurement and mitigation.

Getting a second opinion from another contractor or from one of your state's radiological health officials can help you decide if a proposal is reasonable. You should be certain to get a written estimate of costs which stipulates the work to be done. Because radon reduction work is so new, most contractors will not guarantee a reduction in radon levels.

A few contractors may be willing to guarantee a radon concentration of less than 4 pCi/L (picocuries per liter);

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however, for a contractor to make this promise he should first thoroughly evaluate the potential for radon reduction methods to work in your home.

Technical Information

Those homeowners who are confident they have the tools, equipment, and skills to do the job themselves may want to read EPA's more detailed manual, *Radon Reduction Techniques for Detached Houses: Technical Guidance* [EPA/625/5-86/019]. Single copies can be obtained by writing:

U.S. EPA
Center for Environmental Research
Information
26 West St. Clair Street
Cincinnati, Ohio 45268

Methods

This booklet describes various methods which may reduce the level of radon in your house—either by preventing its entry or by replacing contaminated indoor air. Some of the methods are simple, some are complex, and some are much more expensive than others.

The effectiveness of any one method will depend upon the unique characteristics of each house, the level of radon, the routes of radon entry, and how thoroughly a job is done. No one can guarantee that these methods will work as they did in the test houses.

Sometimes a single method may be sufficient, but often—especially where levels are high—several methods will need to be combined to achieve acceptable results.

Mitigation Follow-up

Once an action (or combination of actions) has been performed, it is important that you have further testing done to determine the level to which radon levels have been reduced. Some states provide this service. If the radon levels have not been satisfactorily lowered, additional mitigation steps may be taken, and the testing process repeated. All tests should be performed in

exactly the same manner as the test which confirmed the high radon levels in your house.

Due to the many factors affecting the performance of any reduction technique, a trial-and-error approach often will be necessary to achieve lasting radon reductions. If short-term testing indicates that radon has been reduced to an acceptable level, you may wish to test on a long-term basis.

Before Choosing a Radon Reduction Method

The selection of appropriate and cost-effective radon reduction techniques for a specific house depends on how well the source of the indoor radon problem is understood, how house characteristics affect radon entry rates, and how candidate radon reduction systems influence the radon entry process. Definition of these factors is possible through a series of diagnostic observations and measurements made before, during, and after radon reduction systems are installed.

Diagnostics begin with a house survey. This involves visual inspection to identify possible radon entry routes and any construction features which could influence the design of later radon reduction techniques. Diagnostics should also include an evaluation of the ease of soil gas movement underneath the concrete slab if sub-slab soil ventilation is a potential control option. If ventilation techniques are to be considered, the natural air infiltration rate also should be measured. The measurement of radon levels in well water is a good way to learn whether water is an important contributor to the airborne radon level. Similarly, measuring gamma levels inside and outside the house can help identify the possibility of building materials as a radon source.

As with radon reduction techniques, the skills needed to perform radon diagnostics are beyond the capabilities of most homeowners. Diagnostic methods are mentioned here only as supplemental information to assist

homeowners when working with radon diagnosticians and mitigators.

New Construction

If you are planning to build a new home and are concerned about the potential for elevated indoor radon levels, you should consider measures to prevent radon entry into the house. It is typically less expensive to build a home that resists radon entry than to reduce a radon problem after construction.

A recent EPA document, *Radon Reduction in New Construction: An Interim Guide* (OPA-87-009), is available to assist home builders and others interested in potential radon prevention alternatives in new construction. The suggestions contained in this guide represent current knowledge and experience gained primarily from radon reduction tests and demonstrations on existing houses.

Until some of these techniques have actually been applied during the construction of new homes, the applicability, cost-effectiveness, radon-prevention effectiveness, and durability of the techniques cannot be fairly assessed. Ongoing EPA-sponsored field testing of radon prevention techniques in new construction should provide a better evaluation of radon prevention alternatives. The results of these studies will be published in future technical guidance documents.

Radon in Water

The potential concern with radon in water is the airborne radon released when water is used. The amount of

radon that is given off from water depends on the amount in the water initially. The amount given off will increase as the temperature of the water increases and as the surface area exposed to air increases.

In the home, activities and appliances that spray or agitate heated water (showers, dishwashers, and clothes washers) create the largest release of waterborne radon. However, the level of radon in household water must be very high to significantly influence the overall level in the air within a house. As a rule of thumb, 10,000 pCi/L of radon in the incoming household water is equivalent to 1 pCi/L of radon in the indoor air.

In some areas, especially in the northeast and west, water from private wells or small community water systems can contain sufficient radon to contribute significantly to elevated levels within a house. Water from large community water supplies releases most of its radon before it reaches individual houses.

Two techniques can be considered to remove radon from water. The first requires either spraying water into a contained air space, introducing air bubbles into the water, or storing water in a tank until the radon has decayed. The second uses granular activated carbon (GAC) to remove radon from the water. The GAC method has been more widely tested and is more commonly used in individual homes. Radiation buildup in the unit itself may cause exposure and disposal problems.

For more detailed information on radon in water see the recent EPA booklet, *Removal of Radon From Household Water* (OPA-87-011).

Air Cleaners

The radon reduction methods discussed in this booklet concentrate on methods of removing radon gas or preventing radon gas from even entering the house. Since the radon health hazard is associated with the products of radon decay (which are chemically active), and not the radon itself (which is an inert gas), it is appropriate to ask whether it is feasible to remove the radon decay products without removing the radon gas itself.

Air cleaners are devices which either filter or electrostatically remove particles—such as dust or radon decay products—from the air. Air cleaners are commonly used to condition indoor air for a variety of health and comfort reasons, and there have been attempts to market air cleaners to reduce radon decay products. At this time, EPA does not endorse the use of air cleaners as a method of reducing radon decay products in indoor air because this technology has not been demonstrated to be effective in reducing the health risks associated with radon.

Although air cleaners will remove some of the radon decay products, many questions remain concerning the relative health effects of the decay products that are not removed and the potential impacts of the undiminished source of radon decay products. Until more is known, EPA believes that the available data do not warrant discontinuing the use of air cleaners already installed, nor can we suggest installing air cleaners to reduce your risk of exposure to radon and its decay products.

Some people also ask whether the radon gas itself can be removed from the indoor air. While some limited research has been done on using charcoal to filter the air, it appears that extremely large quantities of charcoal would be required. This is not yet a demonstrated or even clearly feasible approach.

Method

Natural Ventilation

How It Works

Replaces radon-laden indoor air with outdoor air and neutralizes pressure. This is most often achieved by opening windows.

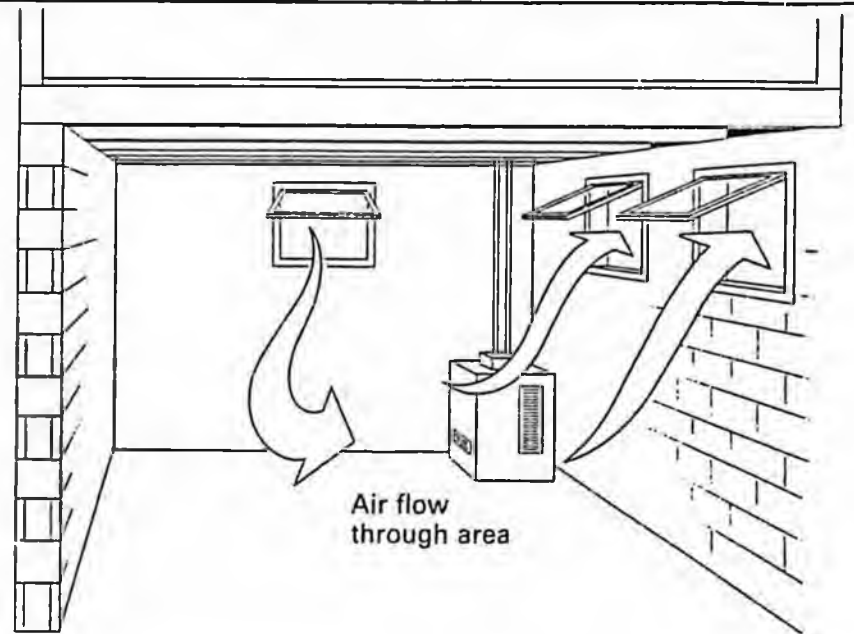
Some natural ventilation occurs in every house as air is drawn through tiny cracks and openings by temperature and pressure differences between indoor and outdoor air. In the average American house, outside air infiltrates about once every hour. In technical terms, this is called 1.0 ach (air changes per hour). Newer houses, which are generally "tighter," may have air exchange rates as low as 0.1 ach (one-tenth that of the average house). The rate in older houses, on the other hand, may be more than twice the average (2.0 ach).

Cost

There are no installation costs unless devices must be purchased to hold windows or vents in an open position, or to detect or prevent unauthorized entry through these openings.

Use of natural ventilation in cold weather will increase your heating costs substantially. For example, if you were to increase the air exchange rate to eight times its normal level in your basement and still maintain comfortable temperatures there, your annual house heating bill could be as much as three times greater than normal.

If you normally run an air conditioner in hot weather, your cooling costs will be similarly greater.



Reductions

The opening of windows, doors, and vents is a very effective, universally applicable radon reduction technique that can be readily implemented by the homeowner. If done properly, natural ventilation is consistently capable of high reductions, probably above 90 percent if a sufficient number of windows and vents is opened. High reductions result because natural ventilation both reduces the flow of soil gas into the house, by neutralizing the pressure difference between indoors and out, and dilutes any radon in the indoor air with outdoor air.

Limitations

The primary shortcoming of natural ventilation is that extreme weather makes this technique impractical year-round in most parts of the country, due to discomfort and/or increased heating and cooling costs. Open windows can also compromise the security of the house.

Procedure

You should ventilate the lowest level of your house, where it is in direct contact with the primary source of radon: the soil. If you have a basement or crawl space, that is the area to ventilate. (If you ventilate your basement, you may find it more economical or comfortable to close it off and limit its use.) If your house sits on a concrete slab, then your only choice is to ventilate the living area. Opening windows around all levels of your house (including the main living area) is recommended whenever outdoor conditions permit.

As noted earlier, radon is drawn into your house when the air pressure in the basement or lowest level is less than the air pressure in the surrounding soil. Therefore, it is imperative that any ventilation system does not further reduce the air pressure within your house and increase this "pull." To guard against this, be certain to open vents or windows equally on all sides of the house. Also, avoid the use of exhaust fans.

When ventilating unheated areas, be sure to take precautions to prevent pipes from freezing.

Method

Forced Ventilation

How It Works

Replaces radon-laden indoor air with outdoor air and neutralizes pressure if the fan is big enough. Uses fans to maintain a desired air exchange rate independent of weather conditions. (Much of the information in the preceding section on "Natural Ventilation" is applicable to "Forced Ventilation" as well.)

Rather than relying on natural air movement, forced air fans can be used to provide a controlled amount of forced ventilation. For example, a fan could be installed to continuously blow fresh air into the house through the existing central forced-air heating, ducting, and supply registers with windows and doors remaining closed. Alternatively, fans could blow air into the house through protected intakes through the sides of the house, or could be mounted in windows. A fan could also be installed to blow outdoor air into a crawl space.

Cost

The installation costs for forced-air systems ranging from simple window fans to elaborate heating, ventilation, and air conditioning (HVAC) systems will range from \$25 to as much as \$1,000.

The additional cost of electricity for forced-air systems will vary depending upon the size of the fans, the number of fans used, and the amount of use. A single window fan can have electricity costs as low as \$20 per year, while a central furnace fan may cost \$275 a year to operate.

Use of forced ventilation throughout cold weather will substantially increase your heating costs. As with natural ventilation, if you were to increase the air exchange rate to eight times its normal level in your basement while maintaining comfortable temperatures there, your annual house heating bill could be as much as three times greater than normal.

If you normally have an air conditioner running in hot weather, your cooling costs will be similarly greater.

Reductions

As pointed out in the preceding section, "tight" houses with low air exchange rates are likely to benefit more from ventilation increases than are houses with high exchange rates. In a typical house, to achieve a 90-percent reduction of radon you will probably need a 500 to 1,000 cfm (cubic feet per minute) fan.

Limitations

Forced ventilation, like natural ventilation, can be employed in most houses, but, in many cases, the trade-off in decreased comfort and/or excessive heating or cooling costs may prove unacceptable. This approach may be useful as an interim measure with very high radon levels.

Procedure

You should ventilate the lowest level of your house. (Closing off and not using a basement may also be advisable.) Ventilating all levels is recommended whenever outdoor conditions permit. Air should be blown into the house and allowed to exit through windows or vents on adjacent or opposite sides. In many homes, blowing air in through an existing central furnace is quite practical. The use of an exhaust fan to pull air out of the house may decrease the interior air pressure and draw more radon inside. The use of whole-house fans is not recommended because they typically operate in the exhaust mode.

Air distribution and ventilation rates can be controlled by the sizing and location of fans and the use of louvered air deflectors. EPA's experience suggests that you should install two or three fans rated at twice the air moving capacity calculated to be needed for the desired increased ventilation.

When ventilating unheated areas, be sure to take precautions to prevent pipes from freezing.

Method

Heat Recovery Ventilation (HRV)

How It works

Replaces radon-laden indoor air with outdoor air.

A device called a "heat recovery ventilator" (sometimes referred to as an "air-to-air heat exchanger") uses the heat in the air being exhausted to warm the incoming air. In an air-conditioned house in warm weather, the process is reversed: The air being exhausted is used to cool the incoming air. This saves between 50 and 80 percent of the warmth (or coolness) that would be lost in an equivalent ventilation system without the device.

Installation

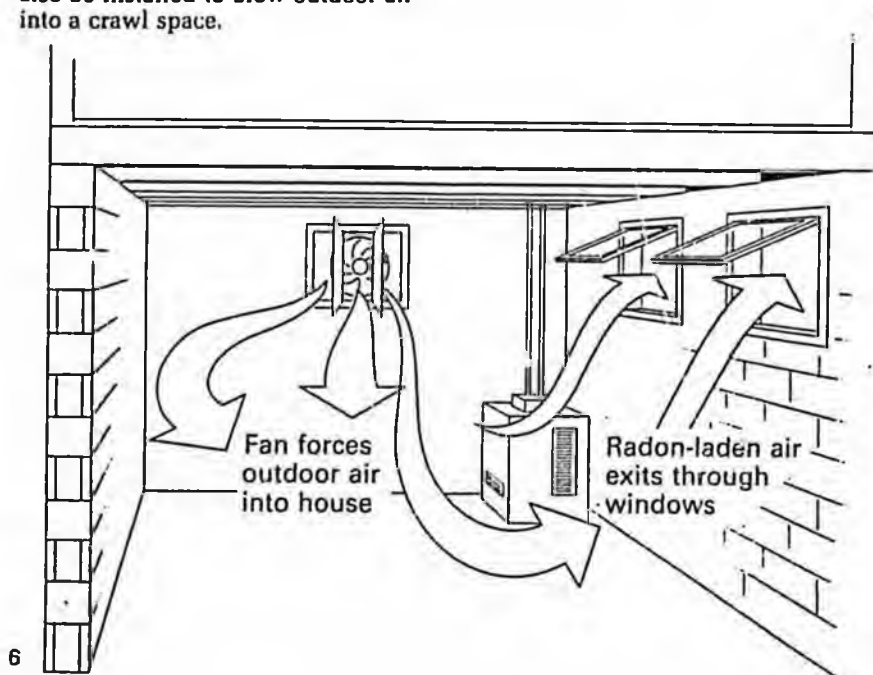
Ducted units are designed, installed, and balanced by experienced heating/ventilation/air conditioning contractors. Wall-mounted units are generally less complex, and can sometimes be installed directly by the homeowner.

Cost

Installation costs (materials and labor) will range from \$800 to \$2,500 for ducted units and are roughly \$400 for wall-mounted units.

The cost for electricity to operate one of the larger units with two 200-cfm fans is about \$30 per year.

Using a heat recovery ventilator could save you 50 to 80 percent of the increase in heating and cooling costs that would result from achieving a comparable amount of ventilation without heat recovery.



Reductions

A radon reduction of 50 to 75 percent can be achieved in houses of typical size and infiltration rate, assuming between 200 and 400 cfm of HRV capacity. Reductions can be greater in tight houses. Reductions will vary throughout the house, depending on ducting configurations.

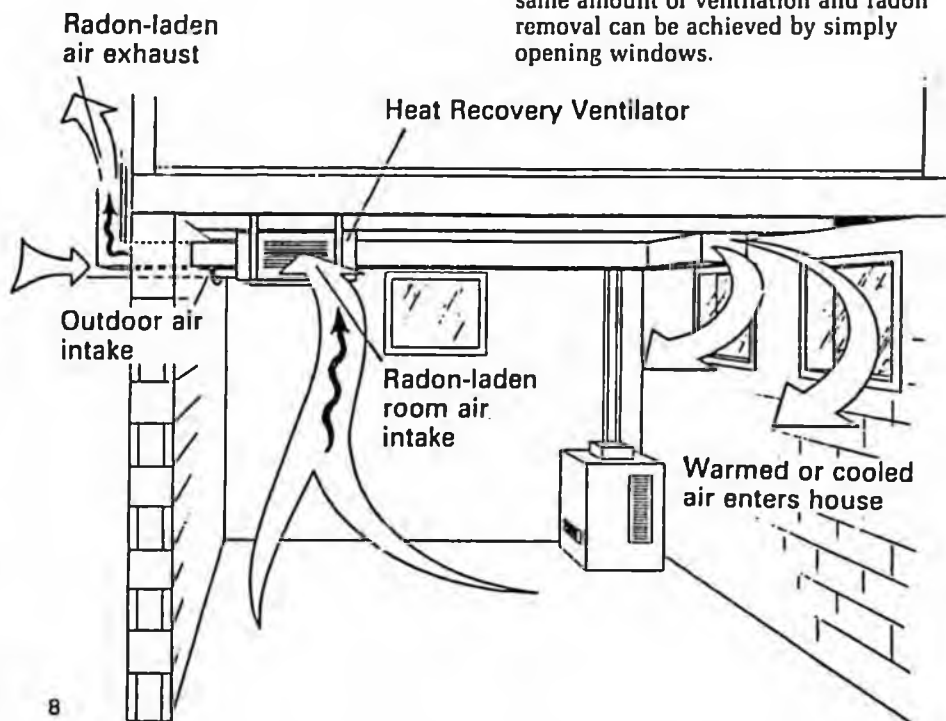
Limitations

The applicability of HRVs for radon reduction will likely be limited to situations where only moderate reductions are needed and where winters are cold. If an HRV is intended to serve as a stand-alone measure to achieve 4 pCi/L in a house of typical size and infiltration rate, the initial radon in the house could be no greater than 10 to 15 pCi/L. Greater reductions can be achieved in tight houses.

Procedure

To simplify the necessary ducting runs to different parts of the house, the heat recovery ventilator unit, consisting of the core and fans, can be located in an inconspicuous part of the house—such as an unfinished basement or utility room. Care must be taken to keep fresh air supply registers well-removed from return air withdrawal points, locating the radon-laden air returns in the basement or lowest level. It is crucial that the flow-rates in the fresh air intake duct and the radon-laden air exhaust duct be balanced. If more air is exhausted than is brought in, the house will become depressurized and even more radon may be drawn into the house. Be sure the balancing is done with no pressure difference between indoors and outdoors, since the unit will tend to maintain any pressure difference that exists when it is balanced.

Heat recovery ventilators are usually cost-effective only if operated during cold weather or in hot weather if the indoor versus outdoor temperature difference is large. At other times, the same amount of ventilation and radon removal can be achieved by simply opening windows.



Method

Covering Exposed Earth

open again. Therefore, periodic checking and maintenance are required.

Procedure

Any basement earthen floor should be excavated as necessary and a poured concrete floor installed. Before the concrete is poured, four inches of crushed stone should be placed over the earthen floor to permit easy radon reduction by sub-slab suction if needed at a later date. All joints must be carefully sealed. When the covering encloses an air space, such as that around a sump pump, a small fan should be installed to exhaust the air to the outside, preferably at roof level.

A crawl space connected to a basement can be covered, ventilated, and/or sealed off from the basement.

A crawl space not connected to a basement can be ventilated (as discussed in the section on natural ventilation), or the earthen floor can either be covered with a gas-proof liner (with passive vents to the outside) or covered with concrete.

How It Works

Reduces the flow of radon into the house.

Exposed earth—in basement cold-rooms, storage areas, drain areas, sumps, and the like, as well as in crawl spaces—is often a major entry point for radon.

Installation

Requires installation by competent, experienced contractors or highly skilled homeowners.

Cost

Covering or sealing small areas (and ventilating covered air spaces as necessary) often costs under \$100. Pouring a new slab would cost considerably more in a large unpaved area.

The annual cost for operating a fan would be about \$30.

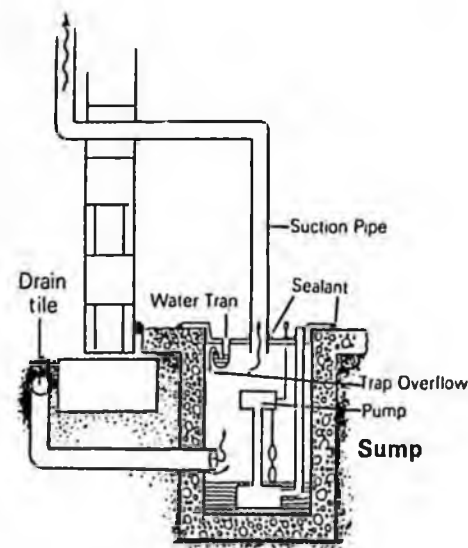
Reductions

Since radon can seep through any small opening, the degree of radon reduction achieved by sealing any particular area cannot be predicted. Effectively blocking a major entry point, however, should result in some reductions of the overall radon level in your house. In houses with marginal radon problems, covering exposed earth, along with sealing cracks and openings, may be a sufficient remedy.

Covering exposed earth is also likely to enhance the effectiveness of most other radon reduction methods, such as block-wall ventilation and sub-slab suction.

Limitations

As a house settles and reacts to external and internal stresses, covered areas can



Sealing Cracks and Openings

How It Works

Reduces the flow of radon into the house.

Radon is a gas that can pass through any opening in a floor or wall which touches the soil. It can enter your house through: openings around utility pipes, joints between basement floors and walls including perimeter (French) drains, other floor drains (especially those that discharge to dry wells), the holes in the top row of concrete blocks, and tiny cracks and openings (such as the pores in concrete blocks). Sealing such cracks and openings is often an important preliminary step when other methods are used. For houses with marginal radon problems, sealing alone may be sufficient.

In some houses, certain areas will be difficult, if not impossible, to seal without significant expense. These

include: the top of block walls, the space between block walls and exterior brick veneer, and openings concealed by masonry fireplaces and chimneys.

Installation

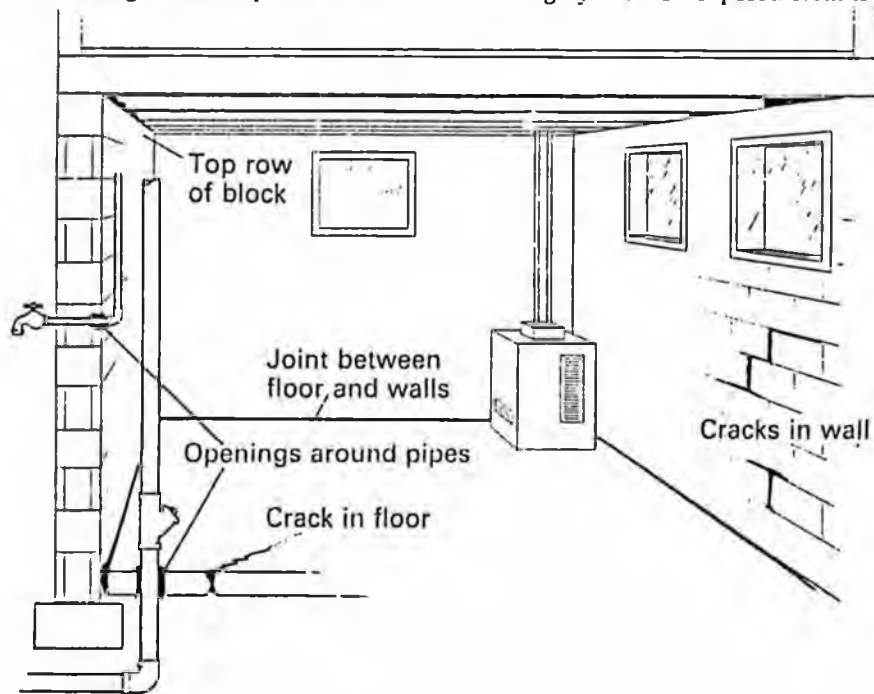
Since effective sealing generally requires meticulous surface preparation and carefully controlled application of appropriate substances, the work is often most effectively done by experienced and competent contractors or highly skilled homeowners.

Cost

Costs are highly variable. Do-it-yourself closure of accessible major entry points can be low in cost. Putting traps in drains and covering sumps can be low to moderate in cost. Applying membranes and coatings can be expensive.

Reductions

When sealing is used alone, you should expect only low to moderate reductions in radon levels. If sealing is done thoroughly—and all exposed earth is



covered—reductions may be sufficient in some houses. Sealing is required for block-wall ventilation and some sub-slab suction systems to work effectively.

Limitations

It is very difficult to find all the cracks and openings in your house. This method may have little effect on radon entry unless nearly all the entry points are sealed. Furthermore, settling of the house and other stresses may create more cracks as time passes. Also, the openings in the top row of concrete blocks in a wall are often inaccessible or otherwise difficult to seal tightly. As a house settles and reacts to external and internal stresses, old seals can deteriorate and new cracks can appear. The aging process ultimately ends the ability of sealants to block out soil gases. Therefore, checking and maintenance are required at least yearly.

Procedure

If possible, the holes in the top row of concrete blocks in the basement walls should be sealed with mortar or urethane foam.

Seal wall and floor joints with flexible polyurethane membrane sealants.

Cracks and utility openings should be enlarged enough to allow filling with compatible, gas-proof, non-shrinking sealants.

A water trap should be installed in floor drains connecting to drainage or weeping-tile systems. Water traps allow water that collects on basement floors to drain away but greatly reduce or entirely eliminate entry of soil gas, including radon. Water traps must be kept filled with water to be effective.

Perimeter drains (French drains) should be filled with a urethane foam; however, some alternative plan for water drainage should be provided.

Porous walls (especially block walls) require the application of waterproof paint, cement, or epoxy to a carefully prepared surface.

Drain-Tile Suction

How It Works

Water is drained away from the foundation of some houses by perforated pipes called drain tiles. Drain tiles are rarely completely filled with water. If these drain tiles form a partial or continuous loop around the house, they may be used to pull radon from the surrounding soil and vent it away from the house.

Installation

Normally requires installation and testing by competent, experienced professionals. Some homeowners, however, might be able to install a drain-tile suction system themselves (particularly where work inside the house does not require removing concrete).

Cost

Installation costs (labor and materials) would be between \$700 and \$1,500 for an exterior drain system and between \$800 and \$2,500 for a system that drains into a sump. The actual cost will largely depend upon the amount and location of piping and the fan location. For simple exterior installations, the cost of materials (fan, plastic piping, and some incidentals) should not exceed \$300.

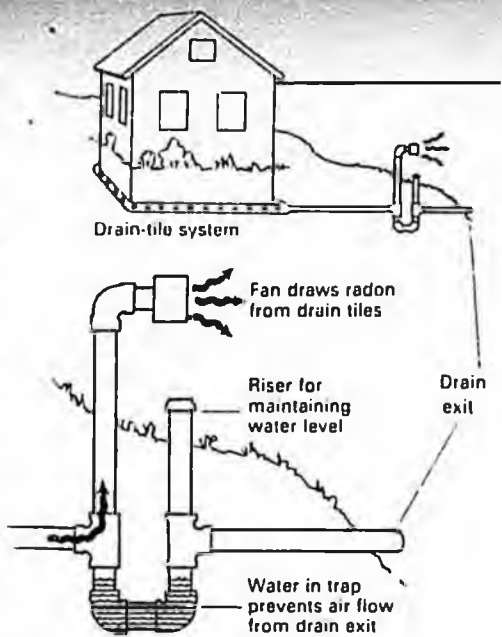
Operating costs should be roughly \$30 per year for fan electricity and \$100 per year for the heating penalty resulting from increased house ventilation.

Reductions

In some houses, the installation of a drain-tile suction system has resulted in radon reductions of over 99 percent.

Limitations

The primary disadvantage of drain-tile suction is that many houses will not



have complete drain-tile loops. Installation of drain tiles in houses that do not have them is sometimes not cost-effective. If some portion of the perimeter footing does not have drain tiles beside it or if the tiles are damaged or blocked, that portion of the perimeter might fail to be effectively treated. It is very difficult to determine how extensive the drain tiles are around a house. If drain tiles are likely to form a large portion of a complete loop, the advantages of the drain-tile suction approach may make it more cost-effective to try this approach first before attempting a more expensive technique.

Procedure

Water collected by drain tiles normally flows through a pipe to a drainage area away from the house or into a sump. Radon can be pulled from the soil beneath a house by attaching an exhaust fan to the collection pipe or to the sealed sump (see page 9).

To prevent outside air from being drawn from the end of the collection pipe, a water-filled trap should be installed in the pipe beyond the point where the fan is attached. This trap (similar to the trap beneath a kitchen sink) must be placed below the freeze line. The trap must be kept filled with water in order to be effective.

Method

Sub-Slab Suction

How It Works

The lowest floor of most houses, other than those built over crawl spaces, consists of a concrete slab poured over the earth or on top of crushed rock (aggregate). Radon can be drawn from under the slab and vented away from the house.

Installation

Installation of a sub-slab suction system is not an easy "do-it-yourself" job, but some installations might be successfully completed by a homeowner with the necessary skills. A do-it-yourself installation might be most logically attempted when it is known that a good layer of aggregate underlies the slab.

Cost

Installation cost for a multiple-pipe, through-the-slab system would be about \$900 to \$2,500 if completed by a professional. Material costs for a fan, piping, and incidentals would be about \$300. Typical operating costs would be roughly \$30 per year for electricity and \$100 per year for the heating penalty resulting from increased house ventilation.

Reductions

Installation of a sub-slab suction system can reduce indoor radon levels by 80 to 99 percent. In many cases, reductions of 95 to 99+ percent have been achieved when good permeability exists beneath the slab.

Limitations

Sub-slab suction has been one of the most widely used and successful radon reduction techniques. It is most useful with foundations built on good aggregate or on highly permeable soil.

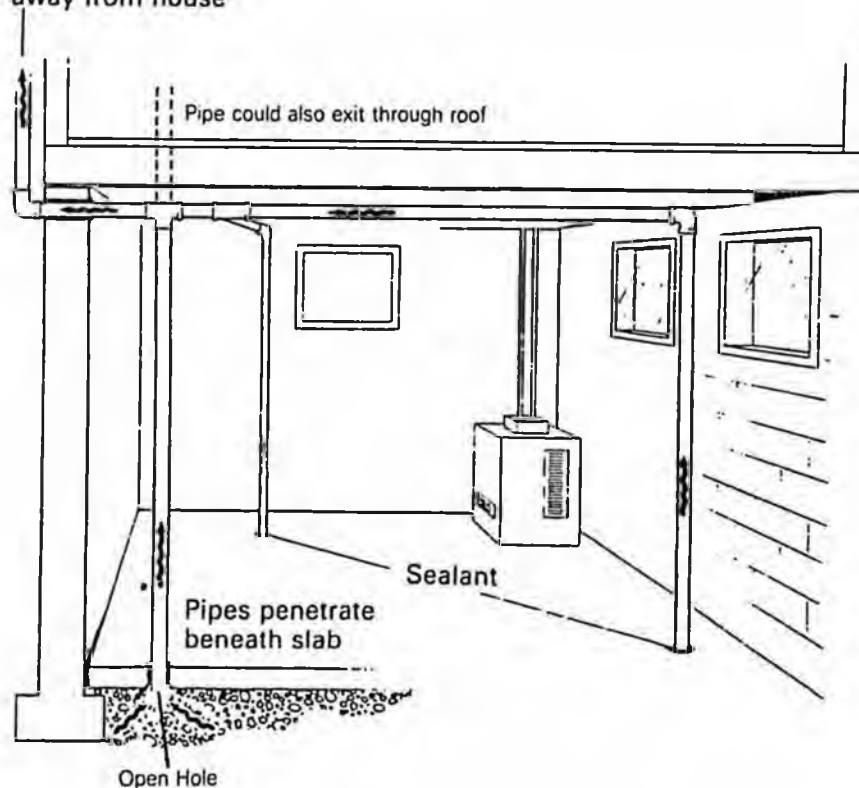
When permeability under the slab is not so good, sub-slab suction will often still be applicable. If permeability is less than desirable, more suction pipes might be needed. Positioning of the suction pipe also may become more important.

Sub-slab suction systems require both a fan capable of maintaining at least 0.5 to 1.0 inch pressure and closure of accessible openings in the slab.

Procedure

A fan is used to ventilate soil gas away from the foundation by means of individual pipes which are inserted into the region under the concrete slab. The pipes can be inserted vertically downward through the slab from inside the house, as illustrated, or can be inserted horizontally through a foundation wall at a level beneath the slab. This latter approach is more practical for slabs poured near the surface of the ground. Pipes should exhaust at roof level, away from windows and vents that could permit the gas to re-enter the house.

Outside fan draws radon away from house



Method

Block-Wall Ventilation

How it Works

Draws radon from the spaces within concrete block walls before it can enter the house ("wall suction") or blows air into block walls so that radon is prevented from entering the walls ("wall pressurization").

The concrete blocks used to construct many basement walls contain hollow spaces which are connected both horizontally and vertically. Radon from the soil—which enters the wall through joints or tiny pores and cracks—can travel through these connected spaces and enter the basement through similar openings on the interior side or through the openings in the top row of block.

Installation

Requires installation and testing by competent, experienced professionals or highly skilled homeowners.

Cost

The installation of a series of exhaust pipes in an unfinished basement would cost from \$1,500 to \$2,500. A baseboard collection system in a similar basement would cost about \$2,000 or more to install.

Annual operating costs would typically be \$30 to \$60 for electricity and \$200 to \$400 for additional heating costs.

Reductions

Very effective (up to 99 percent radon reduction) in houses with good closure and sealing of all major wall openings. In other houses, radon reduction will be significantly less.

Limitations

Applicable only to houses with hollow block basement walls. Block-wall suction may not be successful if you cannot seal the top of the walls, the space between the walls and any exterior brick veneer, and openings that could be concealed by masonry fireplaces or chimneys. Noticeable cracks and openings should be sealed.

Block walls dividing the interior of a basement sometimes penetrate the floor and touch the underlying soil. Exhaust pipes must be installed in all such walls.

Procedure

There are two basic approaches to block-wall ventilation.

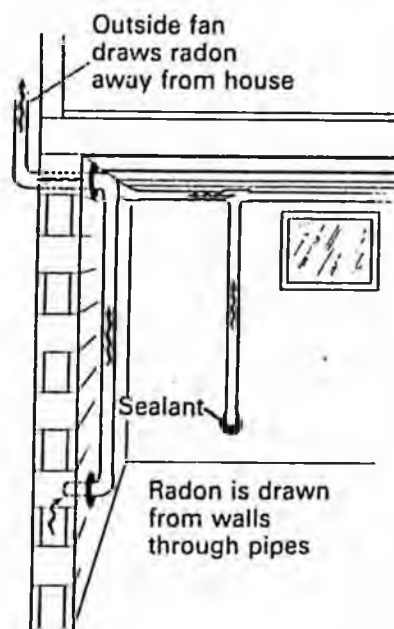
Although this method can be used for any radon level, it is best suited to levels above 0.2 WL (40 pCi/L). The easiest approach is to insert one or two pipes into each wall and use fans to draw radon out of the walls and vent it outdoors, or use fans to pressurize the walls to prevent radon entry. The other approach involves the installation of a sheet metal "baseboard" duct around the perimeter of the basement. Holes are drilled behind the duct into the hollow spaces within the blocks. This second approach produces more uniform ventilation and may be more pleasing in appearance.

In houses which have channel drains cast in the concrete floor next to the block walls, the baseboard approach should work particularly well, since it would ventilate the drains as well as the walls.

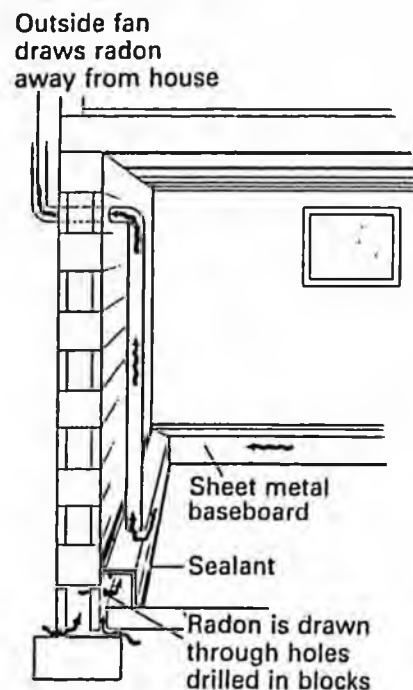
For either wall-ventilation approach to work, all major holes (especially the tops of the blocks) must be sealed. As we pointed out previously, this might be difficult—if not impossible—to do in certain places. (Both of the approaches are shown below in the "suction" mode.)

Pipes should exhaust at roof level away from windows and vents that could permit the gas to re-enter the house.

Pipe-in-wall approach



Baseboard approach



Method

Prevention of House De-pressurization

How It Works

Reduces the amount of radon drawn into your house.

Some exhaust fans and combustion units (such as woodstoves and fireplaces) can lower the air pressure in your house by consuming air and/or exhausting it to the outside. The lower the air pressure in your house, compared to that in the soil, the more radon-laden air may be drawn inside from the underlying soil.

Installation

If exhaust fans must be used, slightly open windows near the fans. Likewise with windows near fireplaces, woodstoves, and other combustion units. Doing so will facilitate the flow of make-up air from outdoors. Install a permanent system to supply outdoor air to household combustion units. For central, forced-air heating and cooling systems, seal off any cold-air return registers that are located in the basement. This reduces leakage of basement air into ducts.

Close air-flow bypasses (openings through the floor between stories) to inhibit air movement up through the house. Close openings through the house shell on upper levels to reduce air outflow from the house.

Note: Many combustion units are designed to accept outside air, but for many others a modification is not only illegal but may be unsafe. Gas furnaces are a prime example. In this case, directing outdoor air to a point near the furnace or enclosing the furnace in a room that is vented outdoors are appropriate measures.

Cost

Some causes of depressurization can be eliminated by the homeowner with little cost.

Installation costs for providing supplemental air will vary greatly depending upon the type and location of the combustion unit being modified. For some, there may be a slight increase in operating cost due to the typically lower temperature of the air being heated.

Reductions

Because each situation is different, it is impossible to predict the reduction in radon levels that can be expected as a result of reducing sources of depressurization in a house. There have been a number of individual applications where radon reduction has been significant.

Limitations

The effectiveness of depressurization reduction techniques for lowering radon levels will be time-dependent. For example, a technique aimed at

reducing depressurization by an exhaust fan or a fireplace could have a significant impact when the appliance is being operated; however, the average annual effect will be lower if the appliance is operated for only a relatively small percentage of the year.

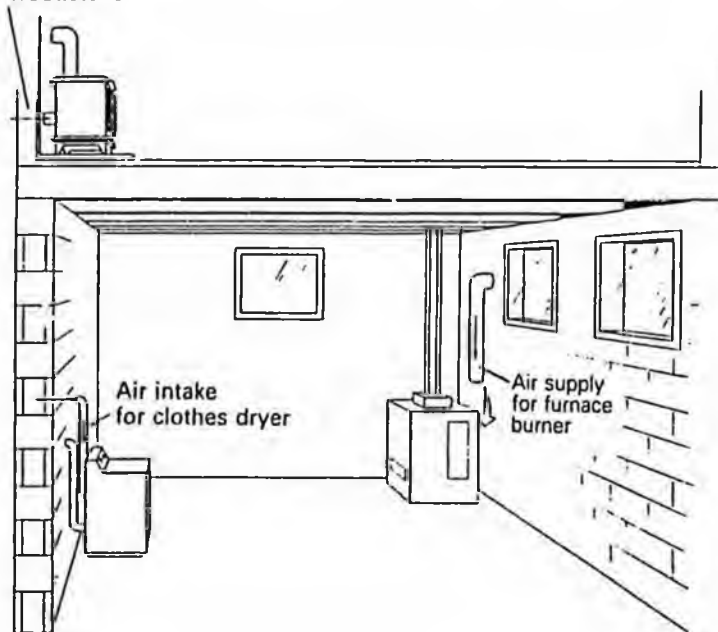
Procedure

Follow the procedures given under "Installation." When possible, avoid the use of exhaust fans or provide a route for outdoor air entry to compensate for exhausted house air.

Provide outdoor air in the vicinity of combustion units. Ductwork or piping can be run from any suitable exterior wall to the combustion unit. A manual or automatic damper should be placed in such ductwork to prevent entry of cold air when the stove or furnace is not in operation. Screen the outside end of ductwork to bar pests and debris.

Ensure that windows on the downwind side of the house are opened only when windows on the upwind side are also open.

Air intake for woodstove



Method

House Pressurization

How it works

Maintains that part of the house which is in contact with the soil at a pressure higher than that of the air in the soil. This prevents soil gas—including radon—from entering the home. The most common application of this method is to blow upstairs air into the basement; however, in some homes, blowing upstairs air into a crawl space may also be applicable.

Installation

Requires installation by competent, experienced contractor or a careful and skilled homeowner.

Cost

Varies depending upon the work required to tighten the basement shell. Installation cost typically would be comparable to a simple wall ventilation system (\$1,500-\$2,500). Operating costs will include the electricity to run the fan (about \$30 to \$40 per year) and the heating penalty resulting from increased infiltration upstairs caused by the fan (as much as \$400 to \$500 per year).

Reductions

Initial results from a few basement pressurization applications indicate that radon reductions of 70 to 90 percent are possible.

Limitations

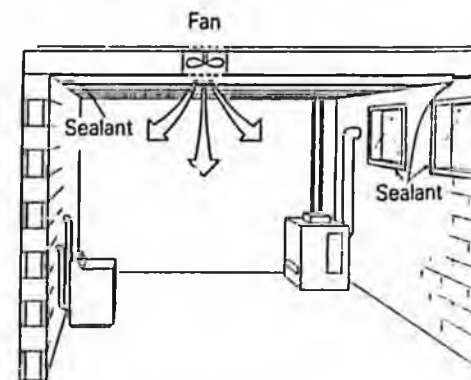
The application of this technique is strictly limited to houses with either basements or heated crawl spaces that are relatively tightly sealed from the living area. Care must be taken to prevent back-drafting of upstairs combustion units. Also, the performance of the system could be completely negated if homeowners open basement doors or windows.

Some homeowners may object to fan noise and vibration if the fan is mounted in the floor of living areas. To overcome that problem, the fan may be mounted on the basement floor and ducted to the living area.

This is one of the least-tested techniques. Structural effects and reliability are not well known.

Procedure

Tighten shell between the basement or crawl space and the upstairs and between the basement or crawl space and the outdoors. Blow upstairs air down in the basement or crawl space. If openings must be made in the upstairs floor, the openings should have a reasonable cross-section to avoid suffering a severe energy penalty.



Comparison of Features

Method	Installation Cost	Operating Cost	Maximum Possible Reductions*	Comments
Natural ventilation:				
Basement or lowest floor	Minimal	High to very high	Up to 90+ %	Useful immediate step to reduce high radon levels.
Crawl space	Minimal	Moderate	Up to 90+ %	
Forced ventilation:				
Basement or lowest floor	Low to moderate	Very high	Up to 90+ %	More controlled than natural ventilation.
Crawl space	Low to moderate	Moderate	Up to 90+ %	
Heat recovery ventilation				
Ducted	Moderate to high	Low to moderate	50-75%	Air intake and exhaust must be equal. Also, expect lower radon reductions for houses with moderate to high air exchange rates.
Wall mounted	Low to moderate	Low to moderate	No data available	
Covering exposed earth	Moderate to high	Low	Site specific	Required to make most other methods work.
Sealing cracks and openings	Minimal to high	Nominal	Site specific	Required to make most other method work.
Drain-tile suction	Moderate to high	Low	Up to 99+ %	Works best when drain is continuous, unblocked loop.
Sub-slab suction	High	Low	Up to 99+ %	Works best with good aggregate or highly permeable soil under slab.
Block-wall ventilation	High	Low	Up to 99+ %	Applies to block-wall basements. Sub-slab suction may be needed to supplement.
Prevention of house depressurization	Low to moderate	Low	Site specific	May be required to make other methods work. May see seasonal impact.
House pressurization	Moderate to high	Moderate	Up to 90% (limited data)	Most cost-effective when basement is tightly sealed.

*These represent generally the best reductions that a single method can accomplish. You may get higher or lower reductions depending on the unique characteristics of your house. It is likely that reductions in your house will not be as great as those shown. Especially with high initial radon levels, several methods may have to be combined to achieve acceptable results.

Sources of Information

If you would like further information or explanation about any of the points mentioned in this booklet, you should contact your state radon program office listed at the end of this booklet.

If you have difficulty obtaining needed information, you may call your EPA regional office listed below. The radiation program staff will be happy to provide you with assistance.

EPA Regional Offices

EPA Region 1
JFK Federal Building
Boston, MA 02203
(617) 565-3234

EPA Region 2
(2AIR:RAD)
26 Federal Plaza
New York, NY 10278
(212) 264-4418

Region 3 (3AH14)
841 Chestnut Street
Philadelphia, PA 19107
(215) 597-4084

EPA Region 4
345 Courtland Street, N.E.
Atlanta, GA 30365
(404) 347-2904

EPA Region 5 (5AR20)
230 South Dearborn Street
Chicago, IL 60604
(312) 886-6165

EPA Region 6 (6T-AS)
1445 Ross Avenue
Dallas, TX 75202-2733
(214) 655-7208

EPA Region 7
726 Minnesota Avenue
Kansas City, KS 66101
(913) 236-2893

EPA Region 8
(8HWM-RP)
999 18th Street
One Denver Place, Suite 1300
Denver, CO 80202-2413
(303) 293-1648

EPA Region 9 (A-3)
215 Fremont Street
San Francisco, CA 94105
(415) 974-8378

EPA Region 10
1200 Sixth Avenue
Seattle, WA 98101
(206) 442-7660

State-EPA Region

Alabama	4	Kansas	7	North Carolina	4
Alaska	10	Kentucky	4	North Dakota	8
Arizona	9	Louisiana	6	Ohio	5
Arkansas	6	Maine	1	Oklahoma	6
California	9	Maryland	3	Oregon	10
Colorado	8	Massachusetts	1	Pennsylvania	3
Connecticut	1	Michigan	5	Rhode Island	1
Delaware	3	Minnesota	5	South Carolina	4
District of Columbia	3	Mississippi	4	South Dakota	8
Florida	4	Missouri	7	Tennessee	4
Georgia	4	Montana	8	Texas	6
Hawaii	9	Nebraska	7	Utah	8
Idaho	10	Nevada	9	Vermont	1
Illinois	5	New Hampshire	1	Virginia	3
Indiana	5	New Jersey	2	Washington	10
Iowa	7	New Mexico	6	West Virginia	3
		New York	2	Wisconsin	5
				Wyoming	8

State Radon Contacts

<p>Alabama Radiological Health Branch Alabama Department of Public Health State Office Building Montgomery, AL 36130 (205) 261-5313</p> <p>Alaska Alaska Department of Health and Social Services P.O. Box 11-06F Juneau, AK 99811-0613 (907) 465-3019</p> <p>Arizona Arizona Radiation Regulatory Agency 4814 South 40th Street Phoenix, AZ 85040 (602) 255-4845</p> <p>Arkansas Division of Radiation Control and Emergency Management Arkansas Department of Health 4815 W. Markham Street Little Rock, AR 72205-3867 (501) 661-2301</p> <p>California Indoor Quality Program California Department of Health Services 2151 Berkeley Way Berkeley, CA 94704 (415) 540-2134</p> <p>Colorado Radiation Control Division Colorado Department of Health 4210 East 11th Avenue Denver, CO 80220 (303) 331-4812</p> <p>Connecticut Connecticut Department of Health Services Toxic Hazards Section 150 Washington Street Hartford, CT 06106 (203) 566-3167</p> <p>Delaware Division of Public Health Delaware Bureau of Environmental Health P.O. Box 637 Dover, DE 19903 (302) 736-4731</p>	<p>District of Columbia DC Department of Consumer and Regulatory Affairs 614 H Street, NW, Room 1014 Washington, DC 20001 (202) 727-7728</p> <p>Florida Florida Office of Radiation Control Building 18, Sunland Center P.O. Box 15490 Orlando, FL 32858 (305) 297-2095</p> <p>Georgia Georgia Department of Natural Resources Environmental Protection Division 205 Butler Street, SE Floyd Towers East, Suite 1166 Atlanta, GA 30334 (404) 656-6905</p> <p>Hawaii Environmental Protection and Health Services Division Hawaii Department of Health 591 Ala Moana Boulevard Honolulu, HI 96813 (808) 548-4383</p> <p>Idaho Radiation Control Section Idaho Department of Health and Welfare Statehouse Mall Boise, ID 83720 (208) 334-5879</p> <p>Illinois Illinois Department of Nuclear Safety Office of Environmental Safety 1035 Outer Park Drive Springfield, IL 62704 (217) 546-8100 or (800) 225-1245 (in State)</p> <p>Indiana Division of Industrial Hygiene and Radiological Health Indiana State Board of Health 1330 W. Michigan Street, P.O. Box 1964 Indianapolis, IN 46206-1964 (317) 633-0153</p>	<p>Iowa Bureau of Environmental Health Iowa Department of Public Health Lucas State Office Building Des Moines, IA 50319-0075 (515) 281-7781</p> <p>Kansas Kansas Department of Health and Environment Forbes Field, Building 321 Topeka, KS 66620-0110 (913) 862-9360 Ext. 288</p> <p>Kentucky Radiation Control Branch Cabinet for Human Resources 275 East Main Street Frankfort, KY 40621 (502) 564-3700</p> <p>Louisiana Louisiana Nuclear Energy Division P.O. Box 14690 Baton Rouge, LA 70898-4690 (504) 925-4518</p> <p>Maine Division of Health Engineering Maine Department of Human Services State House Station 10 Augusta, ME 04333 (207) 289-3826</p> <p>Maryland Radiation Control Department of the Environment 7th Floor Mailroom 201 W. Preston Street Baltimore, MD 21201 (301) 333-3130 or (800) 872-3666</p> <p>Massachusetts Radiation Control Program Massachusetts Department of Public Health 23 Service Center North Hampton, MA 01060 (413) 586-7525 or (617) 727-6214 (Boston)</p> <p>Michigan Michigan Department of Public Health Division of Radiological Health 3500 North Logan, P.O. Box 30035 Lansing, MI 48909 (517) 335-8190</p>	<p>Minnesota Section of Radiation Control Minnesota Department of Health P.O. Box 9441 717 SE Delaware Street Minneapolis, MN 55440 (612) 623-5350 or (800) 652-9747</p> <p>Mississippi Division of Radiological Health Mississippi Department of Health P.O. Box 1700 Jackson, MS 39215-1700 (601) 354-6657</p> <p>Missouri Bureau of Radiological Health Missouri Department of Health 1730 E. Elm, P.O. Box 570 Jefferson City, MO 65102 (314) 751-6083</p> <p>Montana Occupational Health Bureau Montana Department of Health and Environmental Sciences Cogswell Building A113 Helena, MT 59620 (406) 444-3671</p> <p>Nebraska Division of Radiological Health Nebraska Department of Health 301 Centennial Mall South P.O. Box 95007 Lincoln, NE 68509 (402) 471-2168</p> <p>Nevada Radiological Health Section Nevada Department of Human Resources 505 East King Street, Room 202 Carson City, NV 89710 (702) 885-5394</p> <p>New Hampshire New Hampshire Radiological Health Program Health and Welfare Building 6 Hazen Drive Concord, NH 03301-6527 (603) 271-4588</p>	<p>New Jersey New Jersey Department of Environmental Protection 380 Scotch Road, CN-411 Trenton, NJ 08625 (609) 530-4000/4001 or (800) 648-0394 (in State) or (201) 879-2062 (N. NJ Radon Field Office)</p> <p>New Mexico Surveillance Monitoring Section New Mexico Radiation Protection Bureau P.O. Box 968 Santa Fe, NM 87504-0968 (505) 827-2957</p> <p>New York Bureau of Environmental Radiation Protection New York State Health Department Empire State Plaza, Corning Tower Albany, NY 12237 (518) 473-3613 or (800) 458-1158 (in State) or (800) 342-3722 (NY Energy Research & Development Authority)</p> <p>N. Carolina Radiation Protection Section North Carolina Department of Human Resources 701 Barbour Drive Raleigh, NC 27603-2008 (919) 733-4283</p> <p>N. Dakota Division of Environmental Engineering North Dakota State Department of Health & Consolidated Laboratories Missouri Office Building 1200 Missouri Avenue, Room 304 P.O. Box 5520 Bismarck, ND 58502-5520 (701) 224-2348</p>	<p>Ohio Radiological Health Program Ohio Department of Health 1224 Kinnear Road Columbus, OH 43212 (614) 481-5800 or (800) 523-4439 (in Ohio only)</p> <p>Oklahoma Radiation and Special Hazards Service Oklahoma State Dept. of Health P.O. Box 53551 Oklahoma City, OK 73152 (405) 271-5221</p> <p>Oregon Oregon State Health Department 1400 S.W. 5th Avenue, Portland, OR 97201 (503) 229-5797</p> <p>Pennsylvania Bureau of Radiation Protection Pennsylvania Department of Environmental Resources P.O. Box 2063 Harrisburg, PA 17120 (717) 787-2480</p> <p>Puerto Rico Puerto Rico Radiological Health Division G.P.O. Call Box 70184 Rio Piedras, PR 00936 (809) 767-3563</p> <p>Rhode Island Division of Occupational Health and Radiological Control Rhode Island Department of Health 206 Cannon Bldg. 75 Davis Street Providence, RI 02908 (401) 277-2438</p> <p>S. Carolina Bureau of Radiological Health South Carolina Dept. of Health and Environmental Control 2600 Bull Street Columbia, SC 29201 (803) 734-4700/4631</p>	<p>S. Dakota Office of Air Quality and Solid Waste South Dakota Dept. of Water & Natural Resources Joe Foss Building Room 217 523 E. Capital Pierre, SD 57501-3181 (605) 773-3153</p> <p>Tennessee Division of Air Pollution Control Custom House 701 Broadway Nashville, TN 37219-5403 (615) 741-4634</p> <p>Texas Bureau of Radiation Control Texas Department of Health 1100 West 49th Street Austin, TX 78756-3189 (512) 835-7000</p> <p>Utah Bureau of Radiation Control Utah State Department of Health State Health Department Building P.O. Box 16690 Salt Lake City, UT 84116-0690 (801) 538-6734</p> <p>Vermont Division of Occupational and Radiological Health Vermont Department of Health Administration Building 10 Baldwin Street Montpelier, VT 05602 (802) 828-2886</p> <p>Virginia Bureau of Radiological Health Department of Health 109 Governor Street Richmond, VA 23219 (804) 786-5932 or (800) 468-0138 (in State)</p> <p>Washington Environmental Protection Section Washington Office of Radiation Protection Thurston AirDustrial Center Building 5, LE-13 Olympia, WA 98504 (206) 753-5962</p>	<p>W. Virginia Industrial Hygiene Division West Virginia Department of Health 151 11th Avenue South Charleston, WV 25303 (304) 348-3526/3427</p> <p>Wisconsin Division of Health Section of Radiation Protection Wisconsin Dept. of Health and Social Services 5708 Odana Road Madison, WI 53719 (608) 273-5180</p> <p>Wyoming Radiological Health Services Wyoming Department of Health and Social Services Hathway Building 4th Floor Cheyenne, WY 82002-0710 (307) 777-7956</p>
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United States
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U.S. Department
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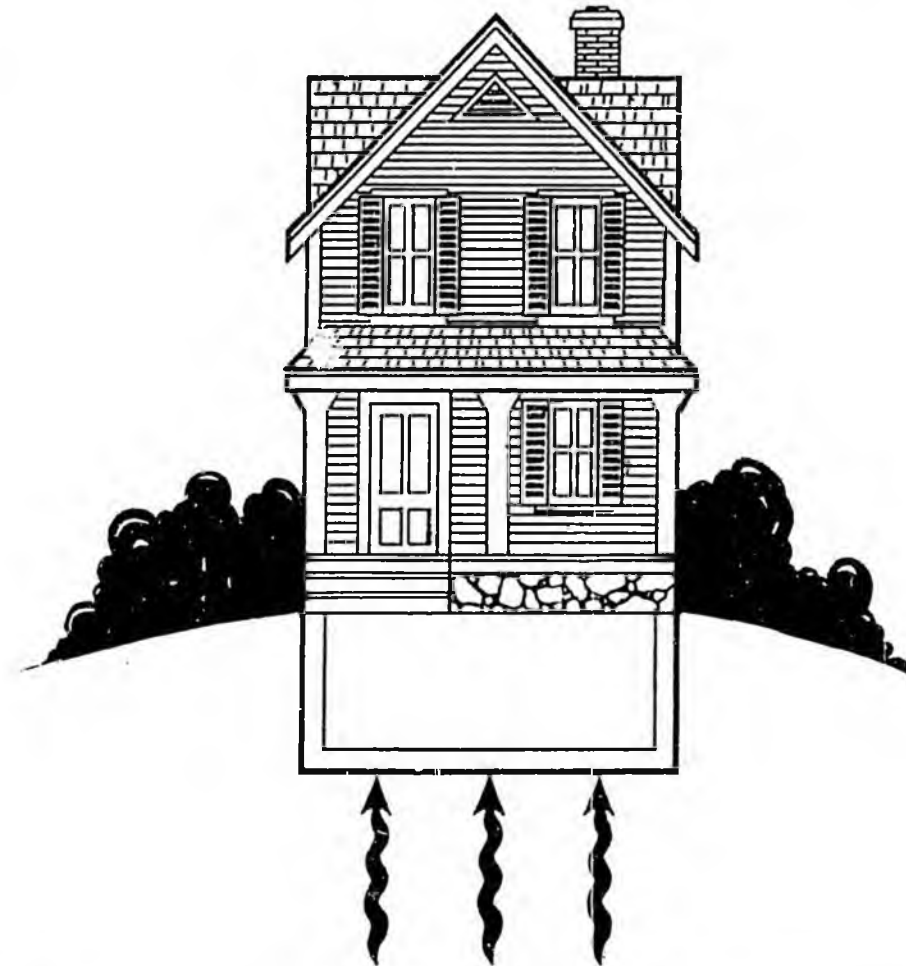
Centers for
Disease Control

August 1986

OPA-86-004

A Citizen's Guide To Radon

What It Is And What To Do About It



The U.S. Environmental Protection Agency and the U.S. Centers for Disease Control are concerned about the increased risk of developing lung cancer faced by persons exposed to above-average levels of radon in their homes. This pamphlet is a joint effort by EPA and CDC. Its purpose is to help readers to understand the radon problem and decide if they need to take action to reduce radon levels in their homes.

The U.S. Environmental Protection Agency and the U.S. Centers for Disease Control strive to provide accurate, complete, and useful information. However, neither the agencies, nor other persons contributing to or assisting in the preparation of this booklet—nor any person acting on the behalf of any of these parties—makes any warranty, guarantee, or representation (express or implied) with respect to the usefulness or effectiveness of any information, method, or process disclosed in this material or assumes any liability for the use of—or for damages arising from the use of—any information, method, or process disclosed in this material.

What is radon?

Radon is a radioactive gas which occurs in nature. You cannot see it, smell it, or taste it.

Where does radon come from?

Radon comes from the natural breakdown (radioactive decay) of uranium. Radon can be found in high concentrations in soils and rocks containing uranium, granite, shale, phosphate, and pitchblende. Radon may also be found in soils contaminated with certain types of industrial wastes, such as the byproducts from uranium or phosphate mining.

In outdoor air, radon is diluted to such low concentrations that it is usually nothing to worry about. However, once inside an enclosed space (such as a home) radon can accumulate. Indoor levels depend both on a building's construction and the concentration of radon in the underlying soil.

How does radon affect me?

The only known health effect associated with exposure to elevated levels of radon is an increased risk of developing lung cancer. Not everyone exposed to elevated levels of radon will develop lung cancer, and the time between exposure and the onset of the disease may be many years.

Scientists estimate that from about 5,000 to about 20,000 lung cancer deaths a year in the United States may be attributed to radon. (The American Cancer Society expects that about 130,000 people will die of lung cancer in 1986. The Surgeon General attributes around 85 percent of all lung cancer deaths to smoking.)

Your risk of developing lung cancer from exposure to radon depends upon the concentration of radon and the length of time you are exposed. Exposure to a slightly elevated radon level for a long time may present a greater risk of developing lung cancer than exposure to a significantly elevated level for a short time. In general, your risk increases as the level of radon and the length of exposure increase.