RADON Mitigation

ALASKA EXPERIENCES, COSTS, RESULTS

RAD-00755

by
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INTRODUCTION

Late in 1986, high radon levels were discovered in the community of Fairbanks, Alaska. After a long series of local investigations, this initial discovery led to Alaska being included in the third series of 10-state radon surveys. The study was conducted in 1989-1990 by Environmental Protection Agency (EPA) and the Alaska Division of Geological and Geophysical Survey (Nye & Kline 1990). During the years since the initial discovery and detection of radon, mitigations of radon have been attempted locally using various methods, some recommended, and some not recommended. This publication summarizes several of those mitigation efforts.

In order for a house to admit radon and to constitute an"at risk house," there are four factors which must be present.

Homes where radon was likely to be a problem in Alaska, especially in the Fairbanks area, have become possible to characterize. Figure 1 shows a map of Alaska with a shaded area labeled "Radon Area," the area which generally coincides with a geological series know as the Yukon-Tanana uplands as well as the glacial moraine and esker terrain of the Matanuska and Susitna Valleys. The uplands are generally underlain by a metamorphic schist rock. The map also shows lines of equal heating degree days mapped onto the state of Alaska. This is important because the long winter heating season is an additional inducement to radon problems, causing winter to be the prime season for radon concerns (in the Fairbanks area the heating index, 65 degree base, is between 13,500 and 14,500 heating degree (F) days. The climate is warming, so this range is more useful than a fixed number).

In order for a house to admit radon and to constitute an "at risk house," there are four factors which must be present. Two of the factors are geological in nature:

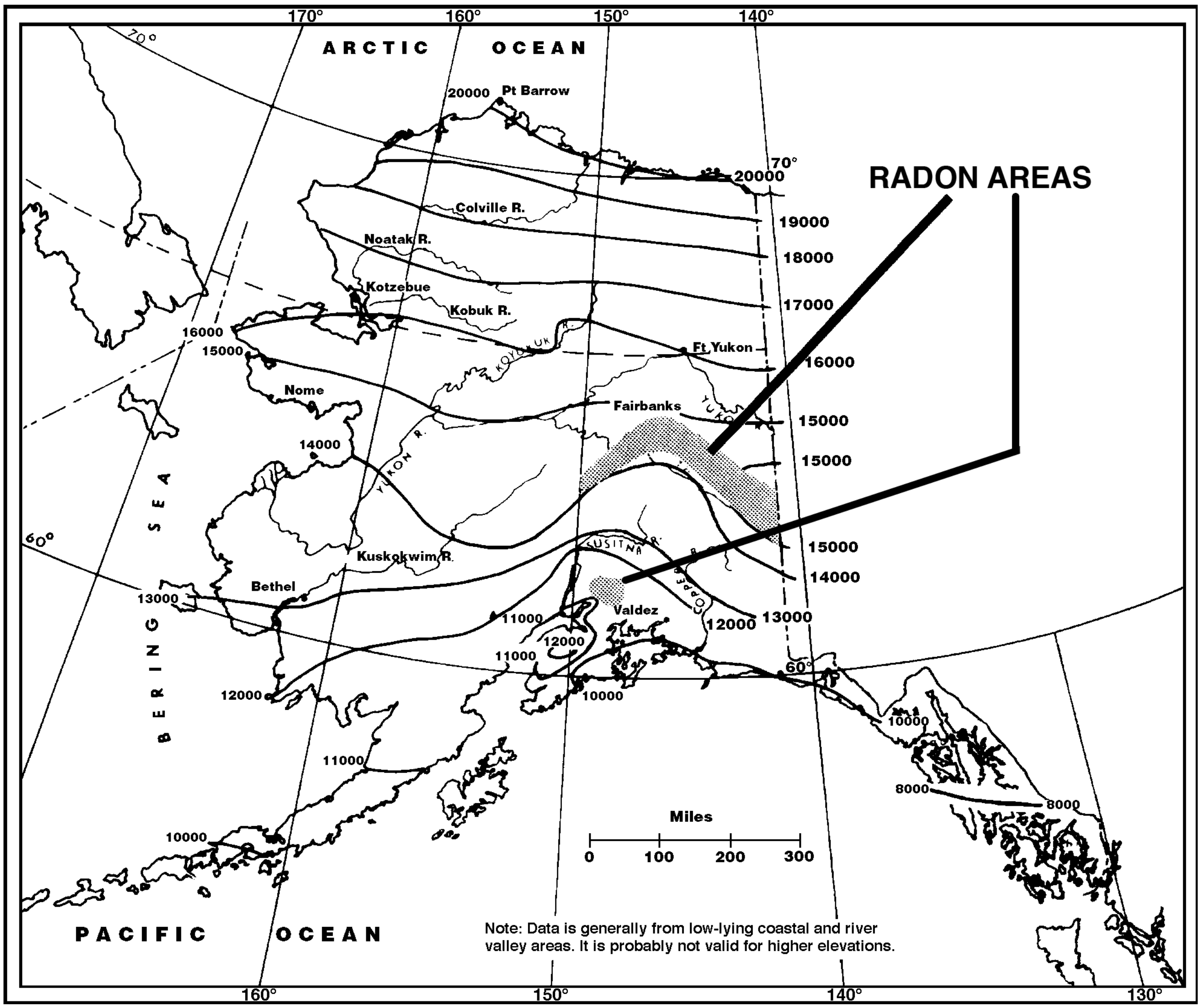

ARCTIC OCEAN
RADON AREAS
Pt Barrow
Colville R.
Noatak R.
Kotzebue
Kobuk R.
Ft Yukon
Nome
Fairbanks
Kuskokwim R.
Bethel
Valdez
BERING SEA
PACIFIC OCEAN
Miles
0 100 200 300
20000
19000
18000
17000
16000
15000
14000
13000
12000
11000
10000
8000
Note: Data is generally from low-lying coastal and river valley areas. It is probably not valid for higher elevations.

Figure 1

1. There must be an adequate uranium content of the bedrock or base soil to produce ample radon through nuclear decay.

2. There must be enough permeability in the soil to allow rapid gas movement to carry the radon from its origin to the interior of the home within about two half-lives of time (six days).

The other two factors that are required are determined by the structure of the house itself and the way it is operated:

3. The house must have soil contact and imperfections such as holes, cracks, and intentional perforation which allow movement of soil gas with radon through the envelope of the basement and crawl space.

4. There must be a lower pressure inside the house than in the soil, so that the soil gas flows into the house.

All four of these characteristics are required for radon to be a problem. The absence of any single characteristic will eliminate radon (in general).

The factors for which it is simplest to develop a mitigation strategy are those which involve the structure of the house itself and the way it is operated. The optimum strategy has now been established. It is to seal the imperfections and holes to eliminate air movement through the shell of the building, especially the basement. If this is insufficient the next step is to lower the soil gas pressure so that the pressure inside the house is higher than the pressure in the soil below the house, a strategy called "sub-slab depressurization".

Mitigation Strategies— We now can suggest a strategy which is most cost effective and appropriate to the conditions of Alaska in order to mitigate radon.

Alaskans have developed mitigation strategies based on these fundamental physical principles. With 20 years experience, we have come to some fairly good recommendations. As in any situation where you want to eliminate radon movement into the building shell, the first step is do whatever is possible to seal and caulk below the ground level (the area of soil contact with the house), be it a foundation, crawlspace, or a full basement. It is recommended that at a very minimum, a six mil. polyethylene vapor barrier be placed under the slab in any concrete floor in Alaska. This may not have been done in construction where radon is found in older houses, but penetrations of that barrier by plumbing or electrical utilities must be sealed or caulked using Tremco® acoustical sealant or an equivalent sealant with any polyethylene or plastic air and vapor barrier. This caulk is very flexible and non-hardening and it has been used very successfully for sealing polyethylene to itself or anything else. For further information see Extension publication on Caulks and Sealants EEM-01252.

For structural portions of the building, which already exist, caulk any cracks, particularly floor cracks and cracks along the inside edge of the footing, or block foundations, and use block filler paints to make sure the perforations are reduced to control radon entry. If there is any heating system installed below ground in the building, be sure that the heating system has a dedicated air supply from the outside so that it is not providing a negative pressurization of the house and adding to radon induction. This is the first step of mitigation: to eliminate all of the mechanisms that physically bring radon into the house. (Figure 2)

In addition, if it's at all possible, sealing the highest level air and vapor barrier at the top of the house, typically in the ceiling on the warm side or the underside of a cathedral ceiling, is a very good strategy because sealing this barrier makes everything else in the house work better. If air can not leak out the top of the building it is much less likely to leak in the bottom and carry with it inducted radon.

In spite of valiant attempts to seal below ground, it is often not quite enough to remediate radon levels to below 4 pico-Curies, which is the goal. Four pico-Curies is the EPA remedial action level, presumed to be a level to which it is economic to reduce radon. It has become a defacto goal for most home-owners of reasonable safety for habitation. So that is the goal most mitigation attempts to achieve.

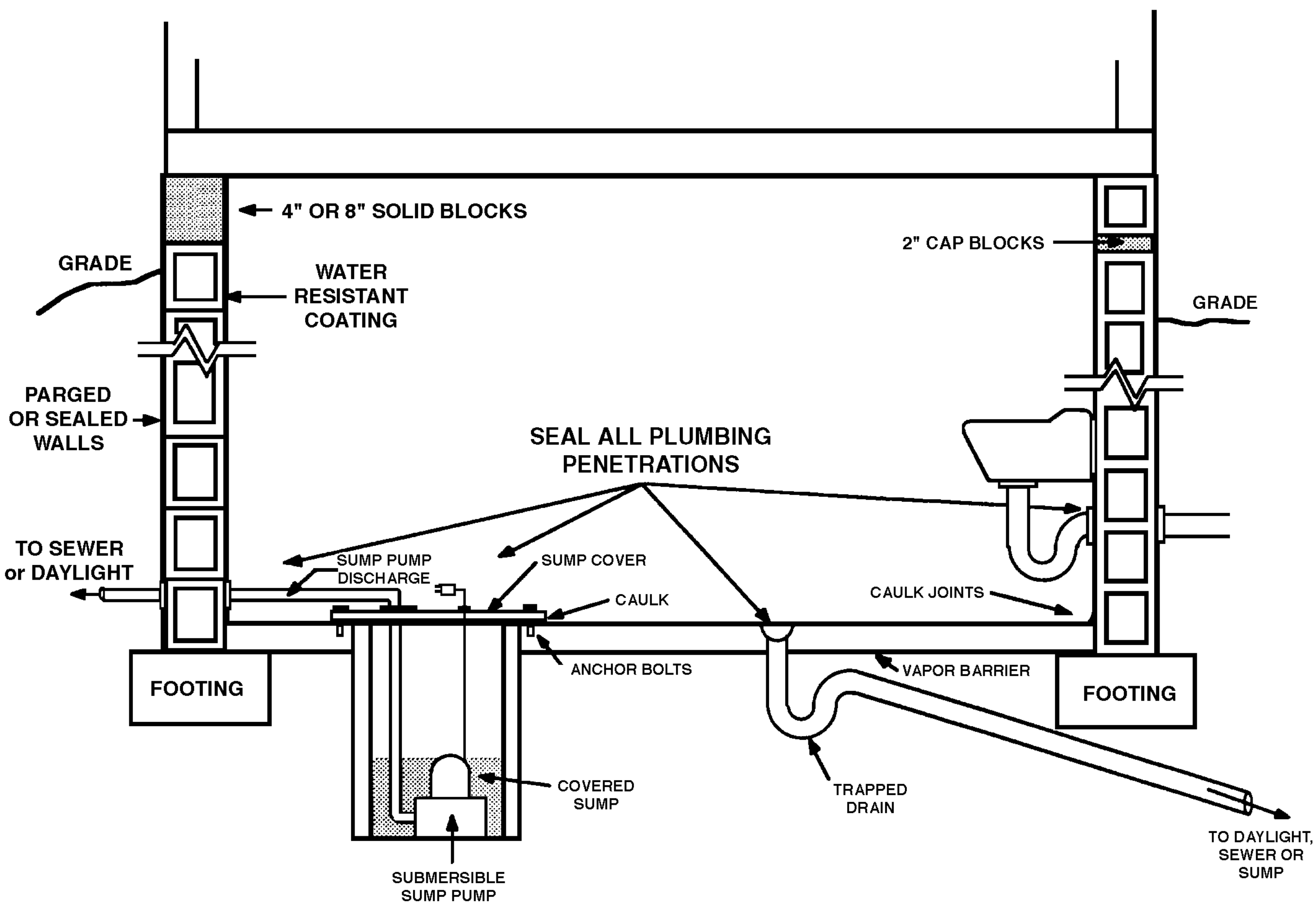
If sub-slab depressurization is necessary, this strategy is normally accomplished by using a fan. In Alaska passive ventilation without a fan won't work because the slab is sealed from above during the winter and the pressures in the house are so much greater than they are in other climates that a passive vent for radon will not serve to keep radon out of the house. Therefore the only way to ventilate below the slab to lower the pressure is by using a fan depressurization system.

In order to accomplish this, it's necessary typically to either suck from below a membrane in a crawlspace by installing a barrier-type membrane, or perhaps a perforated pipe below it. Dig a hemispherical hole to use as a suction pit below the slab or membrane. In the case of a solid slab floor for a full basement or partial basement, it's necessary to actually perforate the slab and put a suction pipe down underneath the concrete slab to depressurize the soil below.

The best strategy to use in this circumstance, if you are retrofitting a sub-slab depressurization system into a house that has a radon problem, is to seek to put the radon stand pipe, which is going to be used to remove the radon and depressurize below the slab, to a point right inside the edge of the existing footing below the slab. A corner might also be a good site. If you can intercept the fill right inside the edge of the footing, often called the lip of the footing, this is an excellent place for the suction pipe to be located.

The strategy here, which has been very successful, is that you are trying to intercept an entire perimeter of fill which is loose enough to allow air flow around that entire perimeter. In actual practice this often suffices to lower the pressure around the entire perimeter of the slab below grade. This consequently is enough to mitigate radon and lower induction levels to a safe and acceptable amount below 4 pico-Curies.

Ultimately a fan will have to be placed in the standpipe for maintaining a pressure difference between the slab (below grade) and the outdoors. The intent is to short circuit the flow of radon by lowering the pressure so that radon-laden air below the slab preferentially goes into the pipe and out to the outdoor ambient air rather than being allowed to enter the house. The entire strategy



METHODS TO REDUCE PATHWAYS FOR RADON ENTRY

Figure 2

for radon mitigation is to keep as much of the radon out of the house, because once it is inside it can only be diluted.

Some other details in finishing and achieving successful operation with a sub-slab depressurization system are worth mentioning. Much of the EPA radon advice given in a publication such as *Building Radon Out* (available on the Extension Energy and Housing website) indicates that the radon reduction system should: (1) place the fan outside the heated space in the shell of the vapor barrier in an unheated attic and (2) that the exhaust for the radon system should leave the house through the roof vertically and exhaust vertically.

Both of these strategies simply will not work in Alaska due to the extreme cold climate. Because the air stream exhausting from the slab is typically wet, it will cause hoar frost accumulation at the outlet, typically on the roof. If this outlet is vertical, frozen hoar frost will accumulate and may in fact clog and ultimately fall into the fan, unbalancing it and causing it to fail. Or a melt back can occur and the fan can build up ice in its shroud. Either of these can be fatal to the radon mitigation system and these failures have occurred in Alaska.

Another important strategy is to make sure that the fan is not in an unheated space. The EPA strategy to keeping it in an unheated space is that if there is a power failure the fan won't leak back any radon to the inhabited space. While it's true that a fan under power failure circumstances may leak, it is presumed to be rare enough that it's not a problem because putting the fan in unheated space simply will not work due to the moisture levels that will accumulate in an Alaska situation.

Because of the hoar frost, which builds up on the exhaust, it is best to exhaust the radon mitigation system laterally, perhaps out a gable end of the house or out a rim joist such that it sheds a hoar frost beard and does not accumulate moisture. Both of these practices are highly satisfactory under Alaska circumstances.

CONCLUSIONS

The best technology for radon mitigation in Alaska is sub-slab depressurization coupled with caulking and sealing below grade. This is not surprising because it clearly responds to both of the factors that were determined by the structure of the house that are related to radon entry. It changes the pressure gradient in the soil so that the pressure is less than the pressure in the home, and then diverts that air from below the slab to the outside. Also it seals all of the cracks, imperfections, holes, and intentional perforations by coupling the sub-slab depressurization with caulking and sealing below grade.

A further suggestion for new mitigation systems being installed is that the installation of a perforated pipe below the graded fill and perhaps even above the vapor barrier. A vapor retarder (polyethylene) should be installed below any kind of new foundation system. One run of perforated pipe along the deepest portion of the basement is usually sufficient for the radon mitigation system. What is meant by the deepest portion is best exemplified by describing the situation in a daylight basement where the back wall may be all the way below ground, 8 feet deep, but the front naturally comes to the surface with a door (a walk-out). Putting a single perforated pipe along the back dimension at the deepest part of the footing brings it most closely to the bedrock, which is typically the source of radon. This should result in a satisfactory mitigation.

In general a sub-slab depressurization system is the best technology to achieve radon mitigation in Alaska circumstances. Clearly sub-slab depressurization in a retrofit situation needs to be coupled with caulking and sealing below grade. This is the strategy to pursue when mitigating against radon in any Alaska climate.

Mitigation can be expected to cost in the range from $300 to $1,500 depending on the circumstances and the mechanical systems employed. The mechanical system fan should be specified to be one designed for a radon mitigation system, typically costing in the range of $160 to $200. These fans have the capability to withstand what's called static pressure, that is, they are intended to be used in a situation where a lot of suction pressure is applied but there is not much flow. All of these characteristics and details are important to achieve the best strategy and most safe and effective mitigation strategy for radon in Alaska.

From all we have learned in the past 25 years about radon, it seems that only about 20 percent of the homes in the Interior and the Matanuska Valley have a radon problem. Those that do have however, often have a severe enough problem that mitigation is necessary. This is due to our climate as much as it is to our geology.

REFERENCES

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VIDEO TAPES

The Air We Breathe, produced by Cooperative Extension Service and KUAC-TV, University of Alaska Fairbanks. A 30-minute video on indoor air pollution. 1988

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ADDENDUM FOR 2007

Since this publication was first conceived, further experience can now be reported to strengthen our advice on mitigating for radon and also for using radon resistant construction techniques to pre-emptively include radon mitigation in the foundation during its construction.

1. We can now reconfirm the advice for mitigation of radon in existing buildings. The first step to take is to seal with caulks, gaskets or block filling sealant paints—all areas of a foundation that are below grade (underground, in contact with soil). Once this is done as feasibly as possible, another radon test should be done **in winter**. If radon levels are still high, go to retrofit mitigation, item 2, which follows.

2. If sealing is not sufficient to solve the problem, we recommend the sub-slab depressurization mitigation method. In addition to the details described in this publication, EPA has an excellent comprehensive publication entitled:
   Building Radon Out, EPA/402-K-01-002, most recently updated in April 2001. It is downloadable as a pdf from the EPA website: www.epa.gov/radon/pubs/index.html This publication has ample graphics and a "nuts and bolts" section, which is very detailed. It is free for the asking from Extension 1-800-478-8324 (the radon hotline) or 474-7201 in Fairbanks, It is also available on the website www.uaf.edu/ces/faculty/seifert. Select publications, then radon.

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