RADON-RESISTANT CONSTRUCTION: INSTALLATION COSTS & ENERGY BENEFITS

Background

Radon is a naturally-occurring radioactive gas that is a known human carcinogen. It is estimated that approximately 14,000 lung cancer deaths occur annually in the United States due to radon exposure.

During the past decade, passive and active radon-reduction systems have been included as design features in the construction of approximately one million new homes. These systems reduce radon gas entry into homes by removing radon from beneath the foundations, using soil depressurization techniques known as "sub-slab depressurization" and "sub-membrane depressurization". This fact sheet provides information regarding the estimated costs associated with incorporating these features during the construction of new homes. Energy-saving considerations are also discussed.

Components of Passive Radon-Reduction Systems

A home's foundation design will determine the installation techniques used for a passive radon-reduction system. Homes with a full basement or a slab-on-grade foundation typically incorporate the following major components of a passive radon-reduction system (see Figure 1):

- A uniform layer of clean aggregate (gravel) at least four inches thick is laid below the slab foundation.
- 6-mil thick polyethylene sheeting (or equivalent) is placed on top of the aggregate layer.
- A PVC or other gas-tight vent pipe, preferably four inches in diameter (but at least three inches in diameter), is securely embedded vertically into the aggregate with a "T" or similar support. The pipe runs upwards through the home's floors and attic, and terminates above the roof.
- Penetrations and other openings in the slab and below-grade foundation walls are sealed.
- Caulking and other weatherization are installed to reduce infiltration and exfiltration.

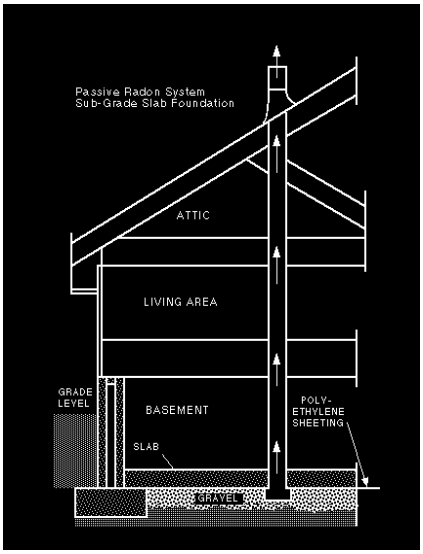


Figure 1: Typical Basement or Slab-On-Grade Foundation

- An electrical junction box is installed in the attic, to provide a power source for a fan in the event system activation is needed to further reduce indoor radon levels (see **Post-Occupancy Testing & System Activation**).

Homes with crawl space foundations will have a slightly different passive radon-reduction system installed (see Figure 2). The major components are:

- 6-mil thick polyethylene sheeting (or equivalent) is placed directly on top of the soil in the crawl space. The polyethylene sheeting is completely sealed including all seams, around the perimeter of the foundation, and around any penetrations.
- A PVC or other gas tight vent pipe, preferably four inches in diameter (but at least three inches in diameter), is connected to perforated drain tile via a "T" fitting below the sheeting. The pipe runs upwards through the home's floors and attic, and terminates above the roof.
- All openings between the home and the crawl space are sealed.
- Weatherization is installed to reduce infiltration and exfiltration.
- An electrical junction box is installed in the attic, similar to that previously described for the basement and slab-on-grade foundation system.

Post-Occupancy Testing & System Activation

New homes should be tested for indoor radon levels soon after occupancy. If levels are 4 picocuries per liter of air (pCi/L) or higher, passive radon-reduction systems should be activated to further reduce indoor radon levels. Activation is accomplished by installing an electrically-driven in-line fan in the vent stack, preferably in the home's attic. The fan is accompanied by a safety device which monitors operation and indicates an alarm condition in the event there is a loss of flow through the vent stack.

For more information on radon-resistant design alternatives and fans for active radon-reduction systems, please refer to additional EPA fact sheets on these subjects. These fact sheets can be obtained by contacting the National Safety Council's Radon Helpline at 1-800-55-RADON.

Installation Costs

In the early 1990's, the EPA funded a study to estimate the installation costs associated with passive and active radon-reduction systems [1]. Several sources of information from various regions of the country were evaluated. The study relied heavily on information from the National Association of Home Builders Research Center, and actual building demonstration programs in the Northeastern United States.

The estimated average incremental costs (above current construction practices) to incorporate radon-reducing design features into new homes with basement, slab-on-grade and crawl space foundation constructions are provided in Table 1.

Several of the passive system design features are already recognized as good construction practices and are required in many jurisdictions by state or local building codes. In other areas, builders may already voluntarily implement these features. For example, an aggregate layer below a poured concrete slab foundation works well to facilitate drainage and prevent moisture problems, while a polyethylene sheeting vapor barrier is effective in reducing soil gas and moisture entry into homes.

The estimated costs associated with installing the passive and active radon-reduction systems will likely vary with geographic location, as building codes, material costs and labor costs are not uniform throughout the nation. The study mentions that installation costs may range as high as $1500 in some areas, where few or none of the passive system design features are required by existing building codes. Conversely, in areas where several of the radon-reducing design features (such as the aggregate layer, polyethylene sheeting, and foundation sealing) are already included in the local building practices, installation costs may be as low as $100 or less.

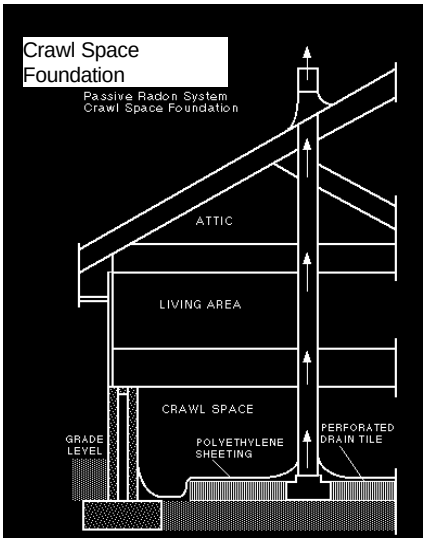
Energy Benefits of Passive Systems

Homes equipped with passive radon-reduction systems are expected to have energy-saving benefits. Sealing foundation openings and sealing openings in the building superstructures will reduce the entry of unconditioned outdoor air into homes. This sealing reduces the potential for a phenomenon known as the "stack effect". Warm air rises within a house and will leak from openings in the upper portion of the house, such as the attic. As this leakage occurs, a negative pressure condition can result in the lower portion of the house with unconditioned replacement air being drawn in. Often times, the replacement air comes from beneath the house and can contain radon and other soil gases. Energy-saving benefits will also result from sealing air conditioning ductwork in attics and crawl spaces.

Table 1. Estimated Average Incremental Construction Costs of Radon-Reducing Design Features by Foundation Type.

Foundation Type	Passive System	Active System	
		Fan	Total
Basement & Slab-on-grade	$500	$250	$750
Crawl space	$350	$250	$600

The amount of energy cost savings will depend on the regional climatic conditions, current home weatherization techniques, the type of energy that is saved (e.g., electricity, gas, oil), and the



cost of energy in that region. In view of these variables, there is considerable uncertainty as to exactly how much energy cost savings will be realized in a given home.

The EPA-funded study estimates that the average annual energy cost savings are approximately $60-65 per home. These estimated savings could be significantly higher in extreme climate locations. The result can be substantial energy savings over the life of a home. For example, if the incremental installation costs of a passive system are approximately $500 and the annual energy savings are about $65, the payback period is less than eight years. After payback, the passive system continues to save the homeowner energy costs. Passive radon-reduction systems not only help saves lives, but can also provide substantial energy savings to home owners.

Energy Use and Active Systems

When an active radon-reduction system is installed, conditioned indoor air can be drawn through any unsealed openings in the foundation by the active system's fan. Active radon-reduction systems also have an energy cost associated with continuous fan operation. Active system fans typically consume an average of 65 Watts electric power, which translates to an

annual operating cost of approximately $40 for a nominal utility rate of 7¢ per kilowatt-hour. Actual operating costs will vary with fan motor size and local electricity rates. The energy saving benefits from caulking, improved weatherization, and sealing of air conditioning ductwork in attics and crawl spaces can offset the operating costs of the active system fan.

Reference

[1] "Analysis of Options for EPA's Model Standards for Controlling Radon in New Homes." ICF Inc. & Camroden Associates, Inc. July 1992. Draft report accepted as final.

This information was compiled by the Indoor Environments Division of the U.S. Environmental Protection Agency for use by architects, designers, home builders, contractors, home buyers and other interested individuals.

Detailed model building standards for radon-resistant construction, architectural drawings, advice on alternative radon-control methods, and information on indoor radon testing are available at no charge by contacting the National Safety Council's Radon Helpline at 1-800-55-RADON.

May 1998