

# Radon-Resistant New Construction Practices in the Sale of New Homes

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## **Builder Qualitative Market Research Summary**

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<sup>1</sup> U.S. Environmental Protection Agency (February 2003). *Consumers' Guide To Radon Reduction*.  
[epa.gov/radon/pubs/consguid.html](http://epa.gov/radon/pubs/consguid.html).

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## Overview

The EPA is seeking to better understand successful radon-resistant new construction business and marketing practices among US homebuilders, with the goal of developing guidelines and strategies to assist other builders in conveying the value of radon reduction to prospective homebuyers.

The following report summarizes key findings from qualitative market research that was conducted by the NAHB Research Center as a second phase of the EPA's research initiative in the area of radon-resistant new construction.

## Study Methodology & Purpose

In-depth interviews were conducted among U.S. homebuilders who actively employ and promote radon-resistant new construction practices in order to understand their practices and how they position radon-resistant construction to prospective homebuyers. Ten in-depth individual interviews (IDIs) were conducted with builders over the telephone the week of August 23, 2010. Each interview lasted approximately thirty minutes and was conducted by a professional interviewer. Interviews were scheduled, and participants were paid the customary honorarium to encourage high participation rates and to raise their level of commitment to providing thoughtful and candid feedback.

This study responds to the findings of previous research that builders are typically hesitant to talk about radon with home buyers, not willing to raise doubts or questions during the sales process, fearing discussing this topic will put them at a disadvantage. This report, therefore, describes attitudes, motivations, and practices with a set of ten home builders who actively promote radon reduction systems during the sales process with success. The goal of this report is to show how builders *can* discuss radon reduction systems with home buyers in such a way that demonstrates the quality of a home without raising alarm or complicating the selling process.

Since the participants represent only a small segment of the builder population, the findings should not be considered representative of builders in general. Further, because of the sample is small, the reader should be careful not to assume the findings can be generalized even to builders who match the profile of the participants. When this report makes generalizations, the reader should understand that they are only generalizations of the ten participants.

## Interview Participants

Respondents were pre-screened from a periodic NAHB Research Center nationwide omnibus survey of builders in 2009. Builders were asked choose a statement that most agreed with their attitude towards, and usage of radon-reduction systems in new homes. The participants were selected based on how they answered this and other

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demographic questions. The participants represented a broad demographic and geographic scope, were actively building new homes, employed radon-resistant building practices, and promoted the benefits of these practices to home buyers during the sales process. All respondents were senior level decision makers (President, Partner, VP/Operations) with proven experience with radon-reducing construction systems.

The sample was drawn from different regions around the country, including PA, NJ, OH, IN, AZ, NY, CO, WI and SD. The builders represented a wide spectrum of businesses, including custom homebuilders, semi-custom and production builders. They built a wide range of homes, from vacation/second homes to high-end luxury homes.

## Summary of Key Findings

### *Attitudes and Perspective*

All of the builders in this study reported to install passive radon mitigation systems as standard features in all of the homes they build, but will install active systems if they believe the situation warrants it. These builders have adopted the installation of radon mitigation systems as standard practice and consider them as one component of a high quality home. Each represents their use of radon mitigation systems to customers as evidence that they are conscientious builders of high quality homes. Only one or two participants were required by code to install radon mitigation systems; all others related to the practice as a cost-effective preventive measure against high radon levels in the home, which would be much more expensive to remediate than to prevent. In the words of one builder, “it’s good common sense.”

The radon mitigation systems were said to be simple to install during the construction process, and these builders believe it is far more cost-effective to install the system during the new construction phase than to have to return to the home after completion. Installing a passive system provides both the builder and homeowner peace of mind in knowing they are minimizing risk of radon gas exposure, and if testing reveals higher than acceptable levels of radon, then installing fans to make the system active is easy and low-cost. From the builders’ perspective, installing the radon mitigation systems is a relatively inexpensive means of protecting homeowners, and thus protecting themselves against any potential liability that could result from the effects of radon if a system was not in place.

It should be noted that the most common terminology used by builders during the interviews was “radon mitigation system.” Therefore, this is the terminology which will be used through this report.

### *Decision Process*

The decision by participating builders of whether or not to install a radon mitigation system is not done on a house-by-house basis, but rather is a building philosophy that they commit to as a standard practice. Once that decision is made, the primary decision becomes whether a passive system will suffice or if an active system is needed. Factors determining whether an active system is needed include:

- Soil conditions (e.g., expansive soil, layered shale, and granite were said to have higher levels of radon)
- Radon zones
- Local areas known to have had higher levels of radon based on past testing

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The builders indicated that there are certain areas or neighborhoods that are known to have had higher levels of radon when tested. If building in these “known” areas, the builders reported they often install the fans to make the system active. When going into a neighborhood that is unknown to them, they first ask other builders if they have done any radon testing and if so, what the results were. If testing has revealed higher levels, then the builder will go ahead and install an active system. If other builders have not done testing or do not know, then some may use test kits once the home is built to determine if an active system is needed, while others recommend that the homeowner have the testing done and then leave it in the homeowners’ hands.

In areas where radon mitigation systems are required by code, the primary driver was believed to be soil condition. The stringency and enforcement of the codes, however, vary. The builders reported that, in some areas, the radon mitigation systems must be drawn into the blueprints, approved by the building department and constructed as drawn. In other areas, however, the codes are not stringently enforced by the building inspectors, resulting in some builders in those areas not taking the need for the systems seriously and, thus, not installing them in the homes they build. A few of the builders interviewed mentioned that radon mitigation systems are included in the International Building Code. One builder indicated that although the counties and cities in which he builds have adopted the International Building Code, they have left it optional for the builders to decide whether or not to install a radon mitigation system.

Most of the builders indicated that foundation type or home design impacted their decisions about whether or not to install a system; however, several did indicate that what was done may differ based on whether it is slab on grade construction or if there is a crawl space. It was also mentioned that on larger homes, there might be a need for two vent pipes rather than one.

### *Descriptions of the Systems Installed*

None of the builders believed that they were unique or innovative in what they were doing with radon mitigation systems. These builders did, however, feel that they pay more attention to detail than other builders and/or have more of a quality focus.

The most common type of passive radon mitigation system that builders install consists of pipes beneath the slab, a 6 mil polyethylene membrane underneath the slab, and one pipe (maybe two, depending on home size) running up through the foundation, through the house and through the roof. The builders use a 4” pipe, which is considered to be the proper size. Some specifically mentioned using a perforated or corrugated pipe. Most of the builders will go ahead and wire for fans in the event that the system needs to be made active.

Builders in the Midwest were more likely to tie the radon mitigation system into drain tiles and sump pits than are builders in other areas. These builders think more about the

relationship between the radon mitigation system and “waterproofing” than do the builders in other areas.

### *Installation*

The installation of radon mitigation systems is typically done by several subcontractors, as it ties in with their area of specialty. The concrete/foundation contractor prepares the area below the foundation, including laying the 6 mil polyethelene membrane. The plumber handles the pipe, running it from below the foundation up through the roof. The electrician installs the wiring for the fans and the fans, if necessary. Other trades mentioned, based on geographic area, included the waterproofing company and the builder’s own carpenters. The builder, acting as general contractor, coordinates these efforts.

Only one builder said he uses a radon mitigation company to install active systems. Another builder said he uses subcontractors who have developed radon mitigation system installation as an area of subspecialty. Finally, yet another builder said he had used a radon subcontractor to do everything in the past, but found that to be more expensive so he switched to regular subcontractors.

Most of the builders indicated there is no specialized training needed for the various subcontractors and that the installation is very straightforward. There are no set standards or guidelines the builders and subcontractors refer to in order to ensure correct installation; they rely on their own experience and building principles.

Quality control measures and practices varied by builder. Some builders simply assure quality through field supervision. Other builders require the subcontractors to complete a scope of work checklist and turn it in with their invoice. One builder took the initiative to develop a manual with written descriptions of how each subcontractor’s portion of the system should be installed, which included the checklist that must be submitted with the subcontractor’s invoice. In addition, this builder requires that the installation be visually inspected by a superintendent, and in some cases requires the installation to be photographed for inspection.

In areas where the radon mitigation systems are required by code, the standards for installation are driven by code enforcement.

### *Installation Costs*

The majority of the builders who participated line-item the radon mitigation system cost and discuss the system and cost as part of the checklist they go through upfront with prospective buyers. The typical cost of a passive system was said to be about \$500. One factor that can increase the cost, however, is the ground type/condition. If the ground has hard-to-remove clay, hard shale or granite, it increases the excavation cost for putting the pipe in the ground. These costs can range from \$1,500 - \$2,000 in some areas.

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The cost of active systems can range from \$800 to \$3,000. The range in cost is primarily impacted by size and the number of fans needed. Larger homes may require a couple of pipes and fans.

Several builders do not line-item the radon mitigation system cost, but rather leave the costs rolled into the subcontractor's cost (e.g. as part of concrete cost, plumbing cost, etc.). They consider the systems to be part of their homes' standard features; therefore, they do not see the need to break out the cost separately.

The majority of the builders consider the radon mitigation systems to be low cost and stress the cost-effectiveness of putting the systems in during new construction. One strategy they have found for keeping the costs down is to use the various trade subcontractors to install the system components rather than using radon specialist contractors. The concrete, plumbing and electrical contractors can easily and efficiently install their components while doing their other work.

### *Testing*

All of the builders acknowledge that the only way to determine if there are unacceptable levels of radon in the home is to test the radon levels after the home is built. The builders' approach to testing/testing recommendations is driven by several factors, which include:

- Testing history for the area (i.e., is it known to have low or high levels of radon?)
- Builder perception of testing as a "quality" attribute to be leveraged versus an expense
- Requirement by lending institution, home inspector and/or realtor

With most of the participants, the builder places the responsibility of testing on the homebuyers' shoulders. Many of the builders have confidence that the systems installed will take care of any radon, and past experience reinforces this confidence (e.g. "We've never had a home test show unacceptable levels."). If they are building in an area that has never had high levels of radon when tested, builders will install the passive system and then make the homebuyers aware that testing can be done. Some include statements in the contract recommending testing, but make a point of stating that any such testing is the homebuyers' responsibility. Given their confidence in the systems they install, some builders do not see the need to take on the expense of testing themselves prior to homeowner occupancy.

The degree to which a builder is proactive in recommending testing varies. Some builders believe that they have done all that they can do in installing the radon mitigation system and will not proactively encourage homeowners to test, especially in an area that is not considered a radon area. They are more reactive in that they will only test if required to do so by a home inspector, realtor or relocation firm. Other builders, however, encourage their homebuyers to have the home tested before moving in. This provides greater peace of mind to the homebuyers and the builders feel that they are acting responsibly on behalf of their customers.



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A few builders will take the initiative to test the homes themselves prior to occupancy. Some will have a third party professional test the home and provide certification of the test results as standard procedure. This way, if the homeowner ever questions the effectiveness of the system, they have the documentation to back things up. These builders leverage the independent testing as both a quality assurance tool and as liability protection. Other builders will discuss the testing with the homebuyers first and strongly encourage them to have the testing done. If the homebuyer agrees, the builder will have the home tested by a third party professional and provide the certification.

If building in areas where there has been little detected radon, some builders will use a radon kit to test the homes themselves prior to owner occupancy, rather than hiring a professional tester. This is done more as a builder checklist item to ensure the homes are at acceptable levels.

Several builders mentioned that the lender, home inspector or realtor may require radon testing to be done prior to sale finalization. In some areas this is for new construction as well as resale, while in other areas it is typically only done for resale.

Instances in which testing is done prior to homeowner occupancy typically include:

- Appraiser/Inspector/Realtor requirement
- County/City requirement
- Builder initiative to have third party testing and certification

### *Communicating the Value of Radon Mitigation Systems to Homebuyers*

Most of the builders first discuss the radon mitigation system as one of their checklist items and/or when they are discussing budget in the initial meeting with prospective homebuyers. They do not “sell” the system but rather position it straightforwardly as part of their standard building practice. Some builders may leverage it as one thing in a list of “reasons why” to go with them as a builder, but they typically do not spend a lot of time talking about radon mitigation specifically. The radon mitigation systems may be touched upon again at the time of contract and then when doing the walk through. If discussed during walk through, builders will typically show the homebuyers the location of the pipe, explain why it is labeled “radon” to distinguish it from other plumbing pipes, and review how the system works.

None of the builders felt like they have had any challenges discussing radon mitigation systems with prospective homebuyers or in gaining homebuyer acceptance of the systems. Nor were there any circumstances under which they said they would not discuss the systems with prospective homebuyers. The common approaches that the builders found to be successful include:

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- Positioning the radon mitigation system straightforwardly as a standard feature in all of the homes they build. The fact that it is included in every home reduces homebuyer worry or fear that there may be something wrong with their home.
- Positioning it as a preventive measure and emphasizing the cost-effectiveness of installing the system during new construction versus finding out down the road that there is a problem and having to go back in and install a system. It is much more involved and costly to have to retrofit a house than to install the system while the house is being built. The builders briefly explain how the system works and that if there is any radon gas entering the home, it will be arrested and exhausted by the system. Not only will having the system installed protect the family's health, but the cost is so minimal at new construction that there is really no reason to not do it.
- Taking a low-key approach and not trying to "sell" the system or give the impression that it is an optional feature, but instead approaching it as "this is what we do and this is why we do it" and "this is evidence that we're a more conscientious builder and build better homes."

Some builders do emphasize health-related benefits and/or indoor air quality benefits when discussing the radon mitigation systems with their prospective buyers. Examples include:

- Positioning benefits of a healthier environment for the family. The homeowners can live with peace of mind knowing that if there is a minimal amount of radon, it is being evacuated by the passive system, so the home is healthier. If the homeowners do have any lingering concerns, they can make the system active to give them greater peace of mind that any gas is being actively drawn out of the home.
- Positioning the benefits of radon mitigation as an important component of indoor air quality. Indoor air quality is not limited to reducing dust and other allergens or humidity, but also includes mitigating radon. Buyers are becoming increasingly knowledgeable about the fact that the building envelope is getting tighter and the impact that can have on indoor air quality. The conversation is more about total home environment than about radon mitigation specifically.
- Pointing out the benefit of increasing the home's resale value. Having the radon mitigation system already installed can contribute to greater resale value because it has been protecting the home and is contributing to a healthier home.

In most cases, the builders take a positive approach to discussing radon by focusing on the benefits of protection and creating a healthier home environment. One builder takes a slightly different approach. His aim is to educate prospective homebuyers about the importance of having the radon mitigation system. He emphasizes that the American Lung Association says that nearly 16,000 people a year die of radon-related lung cancer,

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that radon is the second leading cause of lung cancer, and that because they live in an area with high radon, the radon mitigation system should be included to make the home as safe as possible for the occupants.

In areas where the radon mitigation system is required by code, most homebuyers are aware that it should be included in the homes. In those areas, the builders treat it as a checklist item and confirm with the homebuyers that it is indeed included in the home. Although it is required by code, the builders do make a point of discussing it as a standard feature to reassure the homebuyers. The builders will also show the homebuyers the location of the pipe and how the system works.

### *Homebuyer Receptiveness*

Nearly all of the homebuyers the builders have worked with have been very accepting of the approach of using passive systems. The builders' straightforward approaches, and particularly the fact that the system is a standard feature in all of their homes, contribute to gaining acceptance.

A few builders mentioned that some homebuyers get a little concerned when they hear the word "radon," but the builders ease their concerns by emphasizing that the system is a preventive measure and a standard feature in all of the homes they build. Some cost-conscious buyers have explored possibility of not including the system, or if active systems are specified, then excluding fans. In those cases, the builders emphasize that the system is inexpensive and reiterate that it is far more cost-effective to include during new construction than to have to come back in later and install it.

Some builders had trouble describing the attitudes of buyers who are more receptive or less receptive because most tend to simply accept their recommendations, so there is not much feedback is obtained from buyers. This indicates that radon is not top-of-mind for many homebuyers, or at least it is a lesser concern. In general, the builders described the buyers they considered to be most receptive as:

- educated
- informed; they do their research
- having owned homes before
- a little older; have families
- health conscious, into "green" living

Builders indicated that, in general, the homebuyers they are working with are more knowledgeable because of the information available online and through home or DIY television shows or magazines. Today's homebuyers research more and come into the process better educated than in the past.

The builders struggled a bit in describing consumers who they would consider less receptive to their discussion about radon mitigation, largely because they do not feel like they get real objections to the system. When pressed, they described some consumers as a little more skeptical or uncaring. Those consumers tend to be:

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- younger and without kids (they think about now, not down the road; have different priorities)
- less educated, maybe slightly lower socio-economic background
- cost-conscious

A couple of builders also mentioned that detail-oriented, technical people such as engineers or lawyers can be a little more challenging to deal with because they want documented details.

### *Marketing Radon Mitigation Systems*

Few of the builders are actively drawing a lot of attention to radon mitigation systems, and few think in terms of “messaging” about the systems. For most, it is simply a part of the discussion they have with prospective homebuyers about how they build their houses. It had not occurred to some of the builders to use the radon mitigating systems as a way to promote themselves as a builder, partially because they do not see a need to. The way they approach the discussion of the system has been successful, so there had been no need to change. This was especially of the smaller custom builders interviewed, who rely primarily on word of mouth referrals, so they make scant use of marketing materials.

A few builders did mention that they are careful not to over-emphasize radon mitigation because they do not want to scare prospective buyers. They believe that a low-key approach is best and prefer to mention the system upfront during the initial discussions. After that, if the homebuyers want more information, they will provide it; otherwise, they will just move on. One builder reported they avoid spending too much time on the subject (a) because he does not believe it will have an important positive impact on the sale of the home and (b) because he cannot guarantee that the homeowners will not have radon and, if he cannot guarantee something, he will not market it.

Only one builder in the mix actively leverages his radon-resistant new construction practices as a selling point for his company. He includes information about what they do on his company’s website and includes links to the American Lung Association’s website so that people can go there and research to get additional information.

The builders building in areas in which radon mitigation systems are not part of code requirements did not believe that most of the builders in their area were installing radon mitigation systems. In some cases, the incidence of builders installing may be increasing as awareness increases, but the general impression is that only a minority rather than the majority install the systems. Factors that deter other builders from installing the systems include:

- If it is not part of the code requirement and, particularly, if there have been no higher than acceptable levels of radon detected, they do not perceive the need
- They have heard about radon but do not believe there is anything to be concerned about

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- They do not want to spend the money installing the system if there is not consumer demand for it
- They are unaware of radon and potential issues arising from radon gas exposure

Most of the builder-to-builder discussion of radon occurs when a builder is going to build in an area in which he has not built before and asks other builders about any radon testing that has been done in the area. Otherwise, the builders indicated that radon mitigation is not a hot topic among builders and there is not a lot of peer discussion. Despite the fact that the builders interviewed believe they are offering an important, beneficial feature that other builders are not, they do not relate to the radon mitigation system as something they should actively market. The radon mitigation system is not a primary factor driving the prospective buyer's decision to choose a builder but, more or less, a supporting point reinforcing the quality product the builder produces.

Although most of the builders do not perceive a strong need to market the inclusion of the radon mitigation systems in their homes, they do perceive some value in providing their homebuyers/prospective homebuyers with educational information on radon and the importance of radon mitigation systems. One builder stated he provides his homebuyers with a book on radon produced by the NAHB. Another builder directs his homebuyers to the EPA website to get additional information. Many of those who are not currently providing anything believed that some form of simple, straightforward information they could give to homebuyers would be useful. All were in agreement that the information should come from an established, third-party source in order to provide credibility. This would essentially validate the builders' decision to include the radon mitigation systems in the homes they build. The preference trended toward the NAHB over other entities, including the EPA. Some felt that either the EPA information might be designed to alarm people, or that it would not have the desired impact because many people find government information less credible. One builder suggested healthcare sources such as a major hospital or medical school would be good for helping to validate the need from a documented healthcare perspective.

### Green Building Programs

Several of the builders interviewed are Certified Green Professionals through the NAHB, while others employ green building standards but have not gone through the certification process. Only one of the builders thought of radon mitigation in the context of green building. This builder lumped radon mitigation in with other features offered as part of the green building standard, such as energy efficient features, geothermal heating and cooling, and insulated foundation.

The majority, even those who are Certified Green Professionals, did not think that green programs would have any impact on their decision to install or not install radon mitigation systems for two reasons: 1) they made the commitment to install the systems in all of the homes they build because they believe it is the right way to build, and 2) they don't think of radon mitigation as being related to green building. When these builders think about green building, they think in terms of energy efficiency, renewable

resources and reducing the carbon footprint. Radon mitigation, while a part of indoor air quality—and hence, it is a “green” issue—was not readily seen in these terms.

### Summary and Conclusions

The success of the builders in respect to radon mitigation systems is largely rooted in the fact that they made a commitment to include passive radon mitigation systems as a standard feature in all of the homes they build. Their motivation for doing so includes:

- The desire to ensure their homebuyers have a healthy home and are protected
- The desire to be proactive and preventative rather than reactive and potentially faced with liability

Including the passive system as a standard feature in all homes reduces homebuyer worries and essentially takes having to persuade homebuyers to get the system out of the equation. Including the radon mitigation system as a checklist item and taking the approach of “this is what we do and why” helps to minimize objections and to build confidence among homebuyers. It is positioned in a straightforward manner as a means to protect the home and give homeowners the peace of mind that any radon that does surface will be exhausted through the system. The other key to success is underscoring the cost-effectiveness of installing the system during new construction rather than risking having an issue arise later and having to go back in and install a system.

The fact that the builders rarely “market” the radon reduction systems as a benefit, but rather take a low-key approach, may also factor into homebuyer acceptance because homebuyers relate to the system as part of the builder’s standard building practice rather than something they are being “sold.” The radon mitigation system becomes one more component of the builder’s quality approach. Thus, the builders did not perceive a need for sales and marketing materials with radon reduction messaging for the purposes of promoting them, or themselves; however, they did believe that a simple, straightforward consumer-friendly informational piece from a credible, third-party source might be beneficial for when questions arise. This would be something that they could give to their customers to answer common questions and better educate them. It would also help validate the value of the system and reinforce homebuyer confidence in the builder.

## Addendum: Descriptions of Radon Mitigation Systems by Region

### Northeast (PA, NJ, NY)

- Passive system is standard in all homes. Install pipes so if there is radon under the home the pipes will vent it. Use a polyethelene membrane underneath the slab where they seal it. Pipe penetrates slab and membrane and goes down to where the radon might be. They put the membrane down 100% of the time.
- Install a passive radon mitigation system of pipe beneath the slab and running up through the roof on every house as a preventive measure. Seal the slab. If they plan to pour concrete, they put visqueen down instead of using standard 6 mil poly plastic. They then double up the visqueen, overlap the joints more than a foot, and tape them. That process is code requirement for vapor barriers, but it is also what they need to do for radon mitigation. Specific strategies employed depend on the heating system of the house. They have to pay special attention if the air handling unit is in the crawl space of the basement. They have to make sure the system is supplying enough air so they don't depressurize the crawl space because that's what controls the gases in. If the air handling/HVAC system is located within a basement or crawl space, they have to be particularly careful versus if the HVAC system is located inside the house or the garage.
- Install passive systems as standard practice on every home. It is very similar to a vent for any other plumbing fixture, but the pipe is a little heavier (use a 4" pipe). They don't put any kind of sealant on the concrete slab, but they put a network of about 4 pipes (2 ft x 2 ft section of pipe) under the floor. One pipe connects to the floor and runs up through the house. The concrete will keep the radon below it, giving it a chance to escape through the pipes. They have to take pipe through the first and second floors, and then through the attic. They have to put pipes in a place where they won't interfere with anything else in the house, and make sure that the pipe is clearly labeled "radon."
- They do an under-slab perforated pipe. They pour the footing and put 3/4" crushed stone within the whole footing level, about 12". Within that, they run a 4" perforated pipe through the whole foundation, which then comes up through the basement and the plumber runs it solid up through the roof of the house. They put down a 6 mil polyethylene plastic as part of the standards. Sometimes he will install a sump pump, and in those cases he makes sure everything is properly sealed.



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### Midwest (OH, IN, MI, SD)

- In areas where there is little detected radon, they just do a waterproofing system with an exterior drain tile. Most clients upgrade to a “30 year” so they put on an inch thickness of insulation in the foundation prior to it getting backfilled. They use a #57 limestone that covers the drain tile; then they lay a fabric over the limestone before the backfill dirt goes back in. In some instances they install an interior drain tile below the basement floor because a lot of homes in the area also have sump pumps. They tie the interior drain tile into a sealed sump pump crock. Fairly often, there is a secondary back-up sump. Sometimes they have a radon mitigating system in the form of a hard pipe coming up from the pump connected into the drain pipe from the stone that is underneath the floor. It goes to the exterior. Then on the exterior, there is an exhaust fan motor that is run out through the eaves. Fans are generally only installed if there is a test done and the radon is not at an acceptable level. In one area that they build in, there is a lot of layered shale and there are known high levels of radon. So, there, they use a spray (like a waterproofing spray) to spray the ground where the footer and whole basement floor would go. They also spray up the sides, up past the shale line and around the whole perimeter of the foundation before it gets backfilled.
- He is in an area where basements are prevalent. Through the foundation company, they install a 4” diameter perforated stock tile that is continuous around both the inside and outside of the footing. Then they install one through the center of the basement and make Ts off of it to pick up the field of the basement. The tile serves two purposes (and local code enforcement officials agree that it works best the way he does it): 1) it catches any subsurface water that may exist, as well as any radon gas – goes to a sealed basket that has an oversized vent through the roof. In attic they install a 110-volt electric outlet so that the 4” pipe can be cut and the radon power vent can be placed in the attic so that it is out of the way. Then they install a submersible sump pump in the basket so that should any water get around the footing it can be pumped away to a separate collection facility outside of the house. Prior to pouring the basement floor, they install pea stone that is 4” thick under the slab and cover the tile outside the foundation with a foot of pea stone that promotes permeability. On the interior of the basement underneath the floor, they put a 6 mil plastic vapor barrier and pour the concrete floor on top of it. If any radon gas does exist, that system will force any radon gas into the basket and it can be sent actively or passively up into the atmosphere where it becomes inert. They install this system as standard in all homes. It gives him as a builder peace of mind because it serves two purposes: foundation water mitigation and radon mitigation.
- There is currently nothing in the building codes that requires installing a radon mitigation system, but because the builder values his customers and is concerned about their health, he installs the systems. The goal is to evacuate any radon



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from the basement so “ventilation is the name of the game.” They put gravel underneath the foundation; then they install a pipe that comes up from underneath the foundation through the house and exits through the roof. The pipe is sealed against the concrete floor to make it as tight as possible.

- They have been installing passive sub-soil depressurization systems for the last 14 years. They started installing the systems through an affiliation with the American Lung Association. The builder had been looking for some advanced technology that would make their product stand out in consumers’ eyes. They were looking for a niche market in higher technology in home building, so got into energy efficiency and indoor air quality, which is how they started working with the American Lung Association.

They put in radon resistant systems as a standard feature in all of their homes. They put a plastic barrier underneath the foundation, and have a collection system tied in with the interior drain tile and the sealed sump pit, and then vent out through the roof. They put a passive system in as a standard feature and then if they are asked to, activate the system by putting an in-line fan in the vent pipe.

### West (CO, AZ)

- They do two types of construction that are directly related to radon mitigation. One is slab construction - pouring a concrete slab on top of fill (fill anywhere from 6” thick to 5’ – 10’ thick). The other is crawl space construction - building the house up so that it has a wooden subfloor and a crawlspace. Both require a footing buried at least 3 ft. deep. For slab on grade, they put down polyethylene barrier on the grade after the fill is up about half way in, then put fill on top of polyethylene tarp and tape it shut. Don’t want any penetrations to the film barrier. Once slab is poured, they caulk around perimeter of any plumbing, electric or other penetrations.

They put a skeletal backbone of pipe underground; then there might be up to two sources of vent stacking that go through the roof. They use drain pipe (PCV that is perforated at two locations) so it functions as a water drain pipe. They have not done testing, though, to see if radon comes through the drain pipe.

The only time they will use a fan is when they do the crawl space construction. They put in an attic fan in the exterior stem wall that can be activated at the owner’s discretion. The crawl space is vented and they go beyond code requirements (nearly triple what is required). Use a 5” of ventilation of crawl space for every 150 sq. ft. of crawl space as a standard for radon mitigation and for good ventilation of the crawl space. All exterior walls have horizontal vent blades that the owner can open and close.

- They have a soils condition in a large part of Colorado, which is an expansive soil. Because of that there are different floor systems that they will use in the

basement. There are generally three different types of floors for which they have to have slightly different types of radon mitigation systems. They bury a 4" flexible corrugated pipe with a fabric filter sock over it. The pipe is perforated, so the purpose of the sock is to keep the dust and dirt from clogging up the holes in the pipe. The pipe is buried in a trench embedded with gravel, and then gravel is put on top of the pipe. The trench will be designed around the particular design of the basement floor. They typically run the pipe around the inside perimeter of the basement wall and then have several cross-links from one side to the other. Depending on the size of the basement, the cross-links may be 30 to 40 feet apart. Then there will be a connection from the tube that goes to the outside of the house, which will serve as an air intake, and then on the other side of the house, there will be a pipe that will exit to the outside of the home, and that is intended to exhaust the air. Then there is an in-line fan, which generally has a power rating, depending on the size of the basement, of 50 – 100 cfm (cubic feet per minute). The purpose is to bring a small amount of air into the system, and through the aid of the in-line fan, exhaust any radon gas under the floor to prevent it entering the home. This is considered an active system. They have done passive systems in the past. For those, they placed the corrugated pipe system in the floor, then ran a pipe up through the roof. They installed the passive systems in areas where they anticipated very low levels of radon.

If they were building a suspended structural floor, they would put an air and vapor barrier on the dirt and seal it. The purpose is as much or more to control air and moisture as to control radon specifically. In this situation, they will also put in the pipe system described above. The third type of floor system is one with a cardboard void (4" – 10" thick) with a Styrofoam block with a certain crush weight over it, and then a steel rebar system tied across that into the foundation system. The radon mitigation system in that case would be virtually the same as previously described. What would happen in this system is that over time, the cardboard void system would dissipate because of potential moisture. If the ground did get moist it would easily crush the dilapidated void, which provides an air cushion space.

In the past, when doing a suspended structural floor, to mitigate both radon and air, they would provide an intake of air through the mini crawl space by installing a fan system that was constantly moving the air out. That system would work fine in a climate where there were not severe changes in the wintertime. In climates, though, when it gets really cold in the winter they were bringing in frigid air and it created a cold floor surface. That would often require heating the floor, which would then cause condensation. They discovered after years of doing this, that it wasn't the best way to do it.