RADON RESISTANT NEW CONSTRUCTION: AN INITIAL EVALUATION CAUSES SOME CONCERN

Robert K. Lewis
PA DEP/Bureau of Radiation Protection/Radon Division
Harrisburg, PA

In 1991 the US Environmental Protection Agency (USEPA) published guidelines for builders and homeowners to use during new home construction to prevent radon entry and for activation at a later date if necessary. It was anticipated that these radon resistant new construction (RRNC) techniques applied during new construction would be cheaper and possibly more efficient than existing homes that needed to be retrofitted for a radon reduction system at a later date. It was also expected that homeowners would have a certain "peace of mind" knowing they had RRNC features installed in their new homes.

This paper provides some preliminary and sometimes casual investigation of the various RRNC techniques that are employed by new home builders in Pennsylvania.

Introduction

The 1991 USEPA document, Radon-resistant Construction Techniques for New Residential Construction, EPA/625/2-91/032, provided five basic ingredients for incorporation during new home construction: a permeable material under the slab, vapor barrier, sealing, both foundation and for stack effect, piping network, and power source. With these five steps properly incorporated most new homes that prove to have subsequent radon problems should be able to be successfully and easily remediated. This is evident from the fact that thousands of existing homes retrofitted for sub-slab depressurization systems work well.

In addition to the 1991 USEPA document, the American Society of Testing and Materials (ASTM) came out with a standard for radon control options during new construction, E1465-92. The USEPA followed up in 1994 with their Model Standards, which was intended for States and other jurisdictions during the development of their building codes. Finally, in 1995 the Council of American Building Officials (CABO) attached Appendix F, Radon Control Methods, to their One and Two Family Dwelling Code.

The most logical areas for incorporation of RRNC features would be in EPA Zone 1 counties. In Pennsylvania there are 49 of 67 counties designated Zone 1. The problem we face in Pennsylvania is that there are no uniform building codes, additionally those incorporating RRNC features during new construction are exempt from the State requirements which effect all others performing radon testing or remediation work.

Builders therefore can do anything they want or install RRNC features in anyway they want as long as they meet the local codes.

Objective

The primary objective of this study was to observe and investigate a random number of homes with RRNC features incorporated by area builders. Based upon personal communications and field observation it was apparent to this author that some of the RRNC installations were not done in the most appropriate or efficient manner, at least based on the current fore mentioned literature.

Discussion

As of the writing of this paper a total of 14 homes were investigated. Additional data may be presented verbally at the 1999 CRCPD/AARST meeting that is not included in this paper. The 14 homes represented different types of house construction, primarily two-story, but also contemporary, ranch, and slab-on-grade. All of the homes were in EPA Zone 1 counties and included different types of geology.

Four different scenarios of installation were employed in these 14 homes; in one home the homeowner and his in-laws built the house and installed the RRNC features, in seven homes the builder (sub-contractors) installed the RRNC features, in three homes the builder installed the RRNC features "under the guidance" of a state certified radon mitigator, and in three cases the RRNC features were installed directly by a state certified radon mitigator.

Unfortunately radon testing was not conducted in all 14 homes. Some homes were still unoccupied during our field visit.

There is no rigorous statistical analysis presented that compares contractor installed systems verse certified mitigator installed systems. Table 1 does provide data on passive, basement radon levels verse basement radon levels after installation of fan. In some cases diagnostics were performed to try and determine why the contractor installed system was not producing the necessary radon reduction. However, the major discussion below is based primarily on observation during site visits.

The homes below are listed by the city in which they are located. The Millersburg home was the one home in the study where the homeowner and his in-laws built the home and installed the RRNC features. Ironically, in this installation we found a well installed system, as far as we could see, and post-mitigation radon levels (2 pCi/L) would tend to support this observation.

The Mt. Joy home was a large (3100 sq. ft.) ranch with full basement. A perimeter channel drain was around the entire wall-floor joint, and open. This channel drain

amounted to 40 square feet of opening. There were other unsealed openings such as sump hole, expansion joints, floor cracks, and pipe penetrations. There was no vapor barrier under the slab. The exhaust stack for the system connected with the interior footer drain next to the basement wall that was at the walkout side of the basement. The remaining three basement walls were all partially or completely below grade. Due to the poor pressure field extension, high air flow, smoke stick indications around a basement window, and post-test radon levels (30 pCi/L) it was suspected that this arrangement was short-circuiting through the footer or with the exterior footer drain. The contractor could well have run the exhaust stack at the other end, non-walkout side, of the basement. This would have also avoided the pipe running up through the master bedroom walls and having the fan directly above the master bedroom in the attic.

In Wyomissing Hills we examined a large two-story home very close to the Reading Prong. This home had no piping network under the slab. The aggregate that was examined was 2b but it was certainly not clean. The 3" exhaust pipe penetrated just to the under side of the slab and was directly in contact with the aggregate. There was no pit excavated. The pipe run up through the house followed a rather circuitous route, when in fact a completely straight route from the center of the basement could have been chosen. There are numerous unsealed entry points in the foundation and the wall-floor crack only 2" from the penetration point provides for an easy short-circuit route as shown by smoke. With a fan installed in the attic the pressure field only covered one-half of the basement and radon levels were still 50 pCi/L.

A contemporary home in Catawissa had both an interior (radon and water control) and an exterior footer drain. The interior drain was connected to the exterior drain and the exterior drain ran to daylight. The block walls were not capped. Most of the basement was finished thus we were unable to examine the foundation. With a Fantech FR-175 the basement radon level was about 20 pCi/L.

A two-story home in Bloomsburg had 2b stone under the slab but no piping network. Next to one of the foundation walls a 3" pipe penetrated the slab and ran up through the house to the attic but on an exterior wall. The exhaust point in the attic was so close to where the rafter met the floor joist that a fan could not be directly installed. Due to this difficulty the homeowner cut the pipe in the basement and ran the pipe through the rim joist to the side of the house. There was an unsealed sump and a floor-wall crack around the entire perimeter of the basement. With sealing done by the homeowner and a XP-101 fan installed outside the basement level was 1.7 pCi/L. down from 100 pCi/L.

A home in Benton had extremely high premitigation basement radon levels of 865 pCi/L. There was a 3" piping network under the slab, which was connected to a 4" pipe that ran up through the interior of the house into the garage attic and then out the garage roof. There was a wall-floor joint, expansion joint, and wall penetration that were not sealed in the basement. The walls were poured. A GP-501 was installed in the garage attic and the radon levels came down to 50 pCi/L in the basement. This project is ongoing.

The seventh home visited was in Lancaster. This was a typical two-story colonial with full, unfinished basement. There were numerous unsealed entry points; floating-slab, open sump hole, open block tops, expansion joints, and floor cracks. A 4" exhaust pipe penetrates the slab at one corner of the basement. There was significant air leakage at this penetration due to the floating slab. Other air leaks were also observed. A Fantech FR-150 was located below the floor joists in the basement. The exhaust pipe, though on the inside of the house was on an exterior wall and exhausted through the roof. In spite of the numerous entry points, air leakage, and fan in the basement the post-mitigation basement radon level was still less than 2 pCi/L.

Another home in Catawissa was investigated. In this home, even though the sub-contractors installed the RRNC features they were under the supervision of one of the State certified radon mitigation contractors. This system appeared to be nicely installed. There is supposedly 4-6" of clean 2b stone under the slab, a straight run of 3" pipe in the aggregate, no entry points were observed in the basement, the exhaust pipe ran up through the garage attic, with plenty of room for a fan and electricity was provided. The exhaust point then goes through the roof. Post-test results confirmed initial suspicion of a well installed system by showing 0.9 pCi/L in the basement.

A very large home in Wyomissing was also observed. The pipe run from the basement to the attic though on the inside of the house was again on an exterior wall. The exhaust point in the attic was very close to where the rafter met the floor joist thus excluding the possibility of easy fan installation. There was no power supplied for a future fan in the attic. We were suspicious as to how well the pipe run from the basement to the attic was sealed since we saw styrene fittings connected to PVC pipe in the basement.

A two-story colonial in Allentown had the 4" black corrugated pipe laid under the slab in aggregate. The exhaust point was in the corner of the basement next to the sump hole and cut off about 12" above the slab. This pipe was wide open! The basement was a floating-slab and not sealed. The sump was covered with a piece of plastic and there were several unsealed expansion joints. Fortunately, initial radon levels were only 3.3 pCi/L at least in August.

The two-story home in Hershey was the only home in the study with foundation made from Superior walls. A 3" interior footer drain (radon system) ran into an open sump hole and then ran up the wall and into an attached garage and out the garage roof. There is also an exterior footer drain that also ties into the sump hole. There was one small floor crack down the entire width of the slab. The remaining entry points were all associated with the superior walls. Where the wall and the slab met there were often numerous openings. At the base of the wall are locations to bolt the two wall sections together, these also leak. As individual wall sections are joined one to the other a bead of polyurethane caulk is run down the height of the wall where the two sections join. However, as the two wall sections are jostled into place this caulk may not provide for a good seal. Finally, at the base of the walls in the corners the walls adjoin with 45-degree

angles and these showed a good ¼ inch opening to the soil. With a fan installed on this system all of the above entry points showed leakage. The pre-mitigation levels were only 4 pCi/L and post-test results showed 1 pCi/L. Thus even with excessive leakage the system still performed as needed.

The home in Blandon was the one home that had the RRNC features installed by a State certified radon contractor. This was one of the nicest systems we saw, however, not perfect. The block tops were not all sealed, there was one unsealed floor crack, and the exhaust point through the roof was only 3-4" above the roof. On the good side the basement was very tight, the pipe was labeled, there was adequate room in the garage attic to install the fan and it was pre-wired, the exhaust point was in a good location, and radon levels were reduced from 12.6 to 0.5 pCi/L. Subsequent conversation with this contractor found him to be raising his exhaust point 12 inches above roof line.

As mentioned earlier in the paper four different scenarios for installation of RRNC features were employed in the homes from this study. Data was not collected to say one method was any better that another method or to say this method achieved an average radon reduction of 97% whereas this method only achieved an average reduction of 90%. However, the one RRNC installation by the State certified contractor was devoid of any major mistakes, it presented the easiest installation of a fan, and it produced very good post-mitigation radon levels. This scenario may also present a nice business opportunity for the Certified community, at least in Pennsylvania. There also seems to be an incentive for the certified contractor to do the installation the right way the first time since they know they may have to come back and "finish off" the system.

When the certified contractor oversees the RRNC work by sub-contractors there is more room for error. It is impossible for the certified contractor to be at the job site during all phases of the RRNC work. This leaves open the possibility for mistakes or careless installs. These sub-contractors most likely aren't thinking about the effects radon will have on any future homeowners and may cut corners.

The final two scenarios, a homeowner-builder or a new home contractor can both do very good RRNC systems. However, it will take some homework on their part to find out how to properly install and what to install during new home construction. I believe it was evident from this study that contractors often did not understand what they were trying to accomplish during a RRNC install. They must understand that we are trying to obtain a lower pressure via a fan under the slab than above the slab, and in-order to do this we must move some air from under the slab and not the basement, through a permeable material and safely exhaust this product to atmosphere. They must also understand that safety, efficiency, and aesthetics come into play.

Conclusions

Radon resistant new construction features were examined in different house types, throughout different parts of the state, installed by different new home contractors, and installed under different scenarios.

Some of the most common problems encountered were numerous entry points left unsealed in the foundation, openings to daylight short-circuiting the activated systems, poor locations and convoluted routes for pipe runs from basement to attic, insufficient space in attics to easily install fans, and lack of good, clean aggregate. Another potential area for concern is attached, slab-on-grade family rooms and garages. None of the homes in this study had any of the RRNC piping network extend under these areas.

This study saw well installed systems produce very good radon reduction, poorly installed and inefficient systems produce good radon reductions, poorly installed systems produce poor radon reduction, and poorly installed RRNC systems completely abandoned and homeowners or certified contractors starting from scratch.

One solution to this problem would be continued and more thorough education and outreach to the building community. This could be done at home builders shows, through the Home Builders Association and local associations, over the Internet, and at least in Pennsylvania through the Pennsylvania Housing Research Center. Another option is for the certified mitigation community in Pennsylvania and other states to contact new home builders and offer a partnership, the new home builder builds the house and the certified radon mitigator installs the RRNC features. In Pennsylvania we are also working with Vocational Technical schools to train students on RRNC installations before they enter the work force.

A major objective of this study was to bring to light some of the inefficient and improper methods of installation of radon resistant new construction features by new home builders. If installed properly these features can provide for a long lasting, efficient, and effective radon reduction system. If installed improperly they may or may not be effective and they will generally be less efficient. Hopefully, those of us in the radon field will be on the lookout for these installations, and educate and inform those as necessary and as opportunity presents itself.

Table 1

Passive Vs. Active, Basement Radon Levels

Site	Passive	Active	Percent Reduction
Millersburg	34 pCi/L	2 pCi/L	94.10%
Mt Joy	83 pCi/L	30 pCi/L	63.80%
Wyomissing Hills	85 pCi/L	50 pCi/L	41.10%
Catawissa	30 pCi/L	21 pCi/L	30%
Bloomsburg	100 pCi/L	3.5 pCi/L*	96.50%
Benton	865 pCi/L	50 pCi/L	94.20%
Lancaster	6 pCi/L	2 pCi/L	66.60%
Catawissa	60 pCi/L	1 pCi/L	98.30%
Wyomissing	10 pCi/L	awaiting	**********
Allentown	3.3 pCi/L	**********	**********
Hershey	4 pCi/L	1 pCi/L	75%
Blandon	12.6 pCi/L	0.5 pCi/L	96%

* Homeowner altered from contractor design