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RRNC: Radon Resistant New Construction Fact or Fiction

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Abstract

Since the first findings of naturally occurring indoor radon in Pottstown, PA, efforts have been made to prevent entry of radon into our homes and workplaces. Prior to this time, extensive work had taken place in Colorado to prevent radon entry from uranium mill tailings that had been distributed to the building industry as construction techniques that range from simple to complex. It has been the consensus of the involved government entities and the radon industry that installing radon components during the construction of new homes is an effective method of reducing the radon health risk. In this presentation, we will review sixteen years of field experience as well as consolidated results of the effectiveness of this philosophy.

A review of a field study of homes with known elevated radon concentrations and approved "Radon Resistant New Construction" are included in this data. Also, a review of specific defects found in passive builder piping installed by non-qualified professionals will be presented and we will discuss some of the successes and complications confronted by states who have implement a radon hazard sub-code.

Radon Resistant New Construction

By David Grammer, RAdata

Introduction

After 20 years of experience, we have found great opportunity to validate the efforts that we are making in the radon industry. This opportunity has given us the ability to present reliable radon testing and treatment solutions to the public. Due to the fast-paced nature required during the startup of this new industry, it is obvious that some of our choices have been inappropriate. As government and industry have worked hand-in-hand to present a package that would increase public safety, it was assumed that the goal was common. During the past ten years, the efforts made by the US EPA have moved away from the ambitions and intentions of the industry at large. This separation is caused by the US EPA's desire to streamline and reduce the expense and effort required to satisfy the Radon Abatement Act of 1988.

Having participated in the radon industry since 1984, I, personally, have had the opportunity to see government recommendation come and go. I've also seen industry standards change from acceptable practices to violations of the current government standard. Initially, sealant work on foundations was considered a reasonable approach as a first step to radon mitigation. Many government agencies and documents recommended closing off openings in the slab with caulking and sealing procedures. These requirements and recommendations have demonstrated our failure and inability in trying to block out radon's entry into structures. Where manufacturers would suggest that their products could adequately control radon flow into buildings in lab-type experiments, time has proven that, in the real world of construction, efforts to seal out radon have failed. In fact, more recent government documents have not only moved away from these recommendations but have boldly stated that sealant work alone is not a viable approach to radon control. Government guidance for the application of radon control in existing structures clearly states that sealant work alone may initially retard radon flow but cannot be deemed a permanent fix. This is due to the ability of radon gas to reestablish itself under the slab and to find entry points through the concrete directly. In addition it has been found that sealant work breaks down over time, allowing radon gas transport into the structure. It is our intention to compare and associate previous recommendations by the EPA that have failed to the current recommendation that radon can be sealed out during the construction phase of new buildings.

Through the past decade, the US EPA and other agencies have made great effort to "resolve the radon problem." In that effort, the US EPA has provided builders throughout America with a complete solution to resolve the issue of radon mitigation in both residential and non-residential buildings. It has simplified the current methods of sub-slab depressurization down to a less expensive, more convenient, passive piping system while still maintaining all of the theory that governs how the industry has always handled radon remediation. Many other agencies have also provided much-needed closure to the radon problems in our home. For example, the New Jersey Radon Hazard Sub-code has been revised to relieve liability for losses and damage from builders who take "proper steps" to make new construction resistant to radon.

Despite the near-closure of this issue, thousands of new homes turn up every year with elevated levels of radon. What is more shocking is the number of those homes that have passive piping installed. The issue at hand is the goal of the interested parties. The legislations set forth by the US EPA on radon resistant new construction fulfills the goals set by the Radon Abatement Act of 1988, provides a simple and inexpensive answer to the builders' question of how to deal with radon, and provides peace of mind to the homeowners of America, making it a theoretically ideal solution. However, like a child with a new toy, the EPA quickly implemented this approach before proper examination and long-term testing could take place.

Radon Hazard Sub-Code 52:27D - 123a

"No person who constructs a school or residential building in compliance with these standards shall thereafter be held liable for the presence of radon gas or radon progeny in the school or residential building, or for any losses or damage to persons or property resulting therefrom."

Our work has shown that builder-installed passive piping proves a valuable asset to radon mitigation once a fan has been installed. However, our experience, as well as studies conducted both in-house and by the NY DHHS, have shown that the passive piping alone has been unreliable and unpredictable, becoming effective in only the most ideal weather, building, and geological conditions.

The Physics of Radon Remediation

Let us begin with discussing how passive piping works in relation to the standard sub-slab depressurization systems. The key, in either case, is to remove the radon gas from the soil and disperse it into the air so that it will be diluted to a safer concentration.

In early attempts, the radon industry tried sealants to prevent the entry of radon gas into the home. The logic here being that, given an air-tight home, the gas would take an easier route up through the soil and out into the lawn or other surrounding landscape and then disperse into the air. Unfortunately, these attempts proved ineffective for a variety of reasons. First and most importantly was user error. The task of sealing a room is extremely difficult. It takes very skilled personnel and extensive pressure testing. Very often, a sealed building is by no means airtight. In addition, it has been found that radon gas can seep through as much as six feet of solid cement. The difference in negative pressure between the basement and the air around the home proved insufficient for radon mitigation.

As a solution, radon mitigators implemented the sub-slab depressurization system. This system would create a drastically lower pressure in the pipe, drawing the air and gas from below the foundation with an electric fan and release it into the air above the building. By doing this, the radon gas would not stay below the home long enough to seep into the basement. This system succeeded in reducing radon levels in all treated homes to below 4.0 pCi/L.

The drawback to a sub-slab depressurization system, however, is the effort and cost needed to implement it. The basement must be properly sealed to help maintain pressure and then a pipe must be run outside of the home and through the attic. There, a fan must be installed to properly draw gas from below the foundation. The whole system can cost over one thousand dollars to install.

The passive piping radon resistant new construction can cost less than half of the price of a sub-slab depressurization system and is installed in the construction of the home, reducing both the effort of installation and the visibility of the pipes.

RRNC: Passive Piping

Passive builder pipes are based off of a long-standing approach to ventilation of unwanted gasses used in a multitude of industries. A pipe is run from under the foundation, through the building, and out into the open air above the roof. There, wind blows across the top of the pipe, skimming the top layer of air from the pipe. Like in other radon systems, this creates a lower pressure inside the pipe, drawing air and unwanted gas from the soil.

Despite the soundness of this theory, a series of studies conducted by RAdata and a study conducted by the NY DHHS have shown a lack of dependability in the passive piping systems. In the RAdata studies, the passive piping was not successful in any of the homes. The NY DHHS study showed slightly more favorable results due to the very low radon levels in the study. Of the 45 homes in the study, only 20 had radon levels above 4.0 pCi/L at the beginning of the study. However, of those 20 homes, less than two thirds of the passive piping systems managed to lower the radon levels to a safe concentration. In addition to this lack of consistency, a much more startling find was made. A total of 19 homes in the two studies were found to actually have elevated radon levels with passive piping systems functioning.

Proponents of the passive piping systems have dismissed these findings as errors in reading the test devices. However, these studies were conducted with care and precision, and in the RAdata study, homes were retested an additional time to verify results. In addition, all studies concluded the same unexpected results of elevated radon levels with passive piping installed, the largest of which being an increase of 30.9 pCi/L. The largest percentage increase was a 159% increase in radon concentration when a passive piping system was active. These are not simple errors in reading or typing mistakes. They are large, dangerous swells in radon concentration that must be acknowledged and dealt with.

Potential Problems of Passive Builder Piping

The primary problem with the EPA's approach to Radon Resistant New Construction is the lack of testing and development of the theory. Currently, the only information available pertaining to this issue is a set of contradictory studies by the EPA, RAdata, and other groups, showing a wide range of results from complete success to complete failure and everything in between. As stated earlier, proponents of the passive piping systems have hidden behind excuses, writing off contradictory data as testing errors.

In the absence of hard answers to our results, we have used our experience and the knowledge developed in relating industries to deduce educated guesses as to where to look to find answers to these mixed results in the studies.

Ground-Gas Flow

When passing through soil, Radon, as well as other gasses, will follow a route of least resistance. Throughout the ground, soil forms unpredictable patches of dense and loose dirt. Pressure, moisture, and consistency of stones, dirt, and other soil components all contribute to a complicated maze of large and small passages through the ground which will have a profound effect on the route which gas will take. One of the primary obstacles for any radon system to overcome is the task of drawing all of the radon through the soil, despite the natural paths that the gas will be inclined to take. If there is insufficient negative pressure from the passive pipe, the radon gas may simply flow to other areas of the foundation away from the passive piping.

In-Home Negative Pressure

In the mid-eighties, under the suggestion that radon could be held out of a structure by a barrier between the concrete slab and the soil. I have had the luxury of trying several different mechanisms. This ranged from the simple installation of a 6 – 10 mil vapor barrier under the slab to much more intensive installation of a 40 mil roofing membrane as a barrier. In applying this PVC membrane to the foundation of structures was required that the manufacturer train and certify employees and myself in the proper installation of their product. Along with this training came a certification from the manufacturer for a status of approved contactor for installing their product. Where their training and product was specifically designed to teach me how to install this product as a roofing barrier against water, it was a fair assumption that the product could be used to control radon gas flow. In the application, we mechanically fastened metal strips coated on one side with PVC material to the foundation. Once in place, the void between these metal strips and the foundation was filled with a polyurethane caulk. The roofing material, which was available in 6 ft. wide by 50 ft. long rolls, would be cut to appropriate length and then solvent-bonded to the strips that were fastened to the foundation. These metal strips were installed at the top and bottom of the foundation as well as in 3-foot vertical intervals. Once in place, the mounting frame gave us the ability to securely fasten the membrane to the foundation in what we perceived to be an airtight connection. The metal strips, which were three inches wide, bridged the seam where the 6-foot wide membrane joined. The membrane was securely attached to the exterior of the foundation from the top of the grade all of the way to the bottom of the footer. Since the materials we were applying exceeded the minimum requirement of tar coding as a waterproofing mechanism on the foundation walls, the tar was eliminated. In applications over concrete block, a concrete parching was installed before the membrane. This application was tried on both a block and poured foundation. Once in place, the typical exterior footer drain and gravel was placed against the bottom of the membrane along the footer. At that point, the foundation was carefully back-filled as to avoid damage to the membrane during the process. The same 40 mil materials were installed over a 4-inch gravel base under the proposed slab. The seams were solvent- and heat-welded as appropriate. The membrane would lay on the top of the footer and wrap up the foundation 4 - 6 inches. The extension up the foundation wall was attached with the same metal strips as on the exterior of the building. At that point, the 4-inch slab was poured tight to the foundation walls. All shrink cracks and control joints were caulked after the slab was cured. Upon completion of the construction, the two houses were tested for the presence of radon. The first home, constructed with a block foundation, failed with a radon level of 6.0 pCi/L. The second home, built with a poured foundation, failed its test at an incredible 50 pCi/L. The cost, which was in excess of $5000 per structure, and its failure to control radon levels caused us to no longer recommend this work as a viable radon control approach.

Modern Radon Resistant New Construction techniques with passive piping only incorporate a minimum 6 mil vapor barrier to be installed over a gravel base under the slab. The assumption by non-radon professionals is that this vapor barrier will prevent the flow of radon gas into the structure. It is true that the concrete society recommends the use of a vapor barrier to reduce vapor transport. However, this transport reduction is recommended to reduce vapor moisture transport from the soil to the slab as it cures in order to prevent cracking of the slab from moisture differentials and to prolong the life expectancy of the slab itself.

Variable Wind Speed

Like sub-slab depressurization systems, passive piping uses a power source to create a negative pressure, or vacuum, inside the pipe. Where sub-slab depressurization system uses an electric fan to create its vacuum, passive piping uses natural wind power. Unfortunately, wind is a variable power source. At times, a brisk wind above a home may create a significant amount of negative pressure, whereas a calm day could render the system completely inactive. In addition, the change in wind speed by elevation could play a major role in the effectiveness of the system. An overall windy day could create as much negative pressure in the home as it does in the pipe in certain conditions.

Human Error

As we moved into the early 90s, the prevalence of radon in New Jersey motivated the NJ DEP to strike a deal with the New Jersey Department of Community Affairs. The

Department of Community Affairs governs and dictates policy to the building industry of New Jersey and as a joint effort, an agreement was reached to include preparation during the construction phase of residential buildings for future radon control. This agreement took the form of the New Jersey Radon Hazard Sub-Code, implemented in May of 1991. A revision made in 2002 attaches to the sub-code a limitation of liability extended to the building community. The sub-code now states that if it is followed in the construction of new houses, the builder has no other liability associated with radon. This latest change to the sub-code raises questions as to the intent of the sub-code in its entirety. Part of the original agreement with the Department of Community Affairs was to allow builders to look outside of the NJ DEP certified radon industry to have the work completed. When builders were allowed to use non-radon professionals in the implementation required to satisfy the sub-code, the integrity of the work conducted was compromised. In addition, the recent revision removes any incentive to the building community to properly provide a radon safe building. With this lack of incentive or requirement, much of the building industry attempted to reduce the cost necessary to implement these standards. One of the side effects is a language barrier created at the worksite which, while it does not necessarily effect the workmanship, does inhibit an inspector or builder's ability to communicate specifics of how the work should be conducted.

In an attempt to remedy this problem in quality of passive piping, the Rutgers Eastern Regional Radon Training Center developed a 1-day CEU course for municipal building inspectors. It was felt that this educational effort would better equip the municipal construction officials with the knowledge of how to inspect and control quality of the construction requirement. Whereas this educational effort was beneficial to the proper installation passive piping systems, the whole process only moves the cost of paying for quality workmanship from the builder to the tax-payers paying for these courses to be run.

Do these findings make passive piping useless?

No. Specifically what these findings show is that passive piping is not a reliable complete radon solution. Any of the factors listed above as potential problems can not only create fluctuation in the system's effectiveness from home to home, but also can cause a system to be both successful and unsuccessful in the same home at different times depending on conditions. However, our experience and the sited studies have shown that simply adding the proper electric fan to a properly installed passive piping system will universally reduce any home's radon level to below 4.0 pCi/L. The addition of these fans creates a constant significant increase in negative pressure in the pipe. With this addition, the minor environmental factors become inconsequential in the mitigation of radon gas below the foundation.

To make a proper assessment of whether passive piping should continue to be implemented, it is necessary to conduct further research to address the failures in our studies and the study conducted by the NY DHHS. The lack of answers we are faced with is evidence that we don't truly understand how passive piping works in the field.

Once we have a better understanding of how this approach works, we can make intelligent statements as to the implementation of radon resistant new construction. However, until that point, anything anyone says is at best and educated guess.

As we can see from the data, testing for radon and the standard procedure for radon mitigation is still an important part of this industry, even when dealing with new homes with passive piping.

What To Do Now

In these studies we have found reason for significant doubt of the effectiveness of passive piping in successfully removing radon from homes. Because of that doubt, it is alarming that so many homeowners are under the misconception that a "radon resistant home" is a radon safe home. Cause for further concern lies in the contents of the New Jersey Radon Hazard Sub-Code, which implies that homes with passive piping are universally safe from radon contamination. This type of legislation can not only effect the quality of work in buildings, but can also inadvertently lure home-owners into a false sense of security, thinking that they are safe from radon with only passive systems in place.

It is vital that builders and homeowners fully understand the need for testing regardless of radon resistant measures. It is also important that laws do not permit or encourage a lack of responsibility on the part of the builder when it comes to making homes safe from radon. In a document published in 1998, the EPA lists 4 steps to protecting a home from radon. Step 3, immediately after installing the radon reduction system, is to test your home, just to make sure. Step 4 is to activate the system by installing an electric fan if the radon levels are still high. There is a unanimous opinion among the experts of this field that testing and active radon systems are still essential to the radon mitigation process. This unanimous opinion should be reflected with what homeowners are told and what laws support.

The health effects of radon gas in homes are well known and accepted. With radon being the second leading cause of cancer in the United States, the industry as a whole must embrace methods and procedures with 100% success rates. Where it is true that some passive piping systems bring levels to below 4.0 pCi/L, it is also apparent that, with no traceable pattern, these systems can fail. As per the status quo of the past two decades of the radon industry, the only way to know is still to test.