CHASING Radon

by Lesley Herrmann

photos by Erik Daugherty of E3 INNOVATE

In a previous article entitled "Solving the Unintended Consequences of a Home Performance Renovation", (HE Winter '18, p. 12) I discussed the work that my company, E3 INNOVATE, did on a remodeled home in Nashville, Tennessee to fix the home performance issues that arose from a poorly executed sealed crawl space system. The homeowners initially called in E3 after their renovation because of concerns with odors and high radon levels.

I ended the last article after having completed the home performance renovation work, which included a complex radon mitigation system. Radon levels had dropped from an average of around 15 pCi/l to 4.1 pCi/l in the living space. The homeowners were satisfied, and we continued to monitor the situation with ongoing maintenance. This is what happened next.

HOMEOWNER BACKGROUND

Dave and Shirley Walton purchased their 1950s home in 2015 and added over 1,000 square feet of living space for a total of about 6,700 square feet. Their renovation created a tight home! The final testing report showed an air leakage rate of 2.7 ACH50. This is much tighter than what we typically see in middle Tennessee. The current code in Davidson County, where Nashville is located, is 7 ACH50 or less.

To address the primary concerns of odor and radon, E3 completely reinstalled the sealed crawl space system with mold remediation and added a multi-branch active radon mitigation system. The challenge with this design was the large segmented footprint of the crawl space. With about 6,700 square feet of floor area, this crawl space was divided into four compartments with four different access points. Two of these compartments (the primary and secondary crawl spaces) had a few smaller, very tight cavities that were left unsealed in the original encapsulation process. E3 managed to lay laminate in these areas and properly secure it to the foundation walls.

The radon system E3 installed included the use of an HP220 radon fan on the exterior of the home. The network of PVC and perforated piping spanned the majority of the footprint of the house (see Figure 1). Numerous gate valves and monometers along the network of PVC piping allowed for the balancing of the system and provided greater control overflow rates. Because of the simultaneous need to address odors and radon, E3 utilized an energy recovery ventilator (ERV) to help flush the house with fresh air as well as to dilute radon. A radon control device, a "radostat," installed in the master bedroom, continually monitored radon levels. When radon exceeded 4.0 pCi/l, the sensor would trigger the ERV to run at full capacity to help with dilution. Early data showed the rising radon levels would peak at 4 pCi/l and then fall once the ERV kicked on.

This was probably one of the most integrated and complex radon systems in the whole state of Tennessee, but unavoidable challenges like the use of a crawl space foundation under a very large home, the location in a class-1 radon zones, and the surrounding shallow bedrock created the need for a complex design.

The homeowner was pleased with the results and felt confident that all of the systems were working together to improve their indoor air quality.

WHAT HAPPENED NEXT

Shortly after completing the project, E3 provided the homeowners with a complementary Bluetooth-enabled radon monitor from AirThings. This device was installed in the front corner of the house, above an area of the crawl space that was not directly connected to the radon mitigation system because of inaccessibility. The thinking here was: provide the homeowner with reassurance that their home was safe and well managed, even in the worst possible place in the home. If radon levels were managed here, then, in theory, the rest of the house should be okay too.

E3 also provided long-term radon monitoring, as shown in Figure 2. The initial radon results (before the multi-branch mitigation system) is shown on the far left side of the figure (14.6 pCi/l). Once the system was complete and balanced, long-term radon remained below 4.0 pCi/l in the master bedroom and in the pantry area from mid-June 2018 to early May 2019. Short-term radon levels were likely higher during the winter monitoring period because of predictable seasonal fluctuations. However, the chart indicates that the longer-term average encompassing this time period was still below the recommended threshold. Radon levels tend to be elevated during the winter season due to changes in temperature, ambient pressure, precipitation, ground saturation, frozen soil, and the stack effect. As the results indicate, the mitigation system did an acceptable job at managing radon.

Then, sometime during June of 2019, the homeowner noticed that the ambiguous odors coming from the return air ducts in the

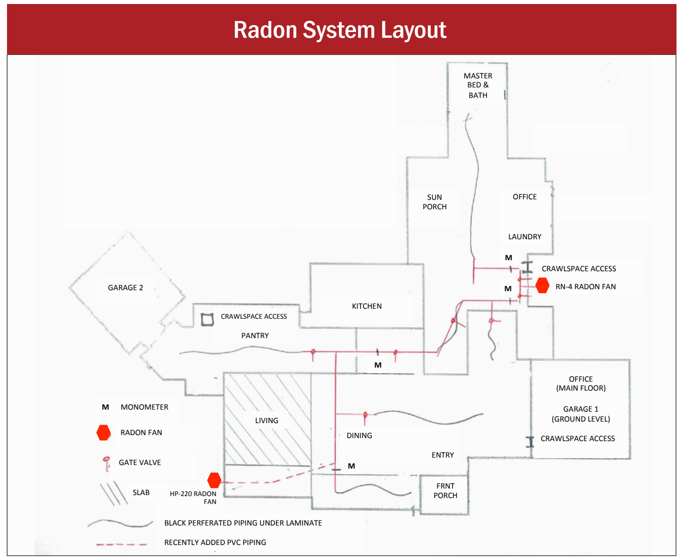

Figure 1. Radon mitigation system layout shows PVC piping, perforated piping, gate valves, monometers, and radon fans.

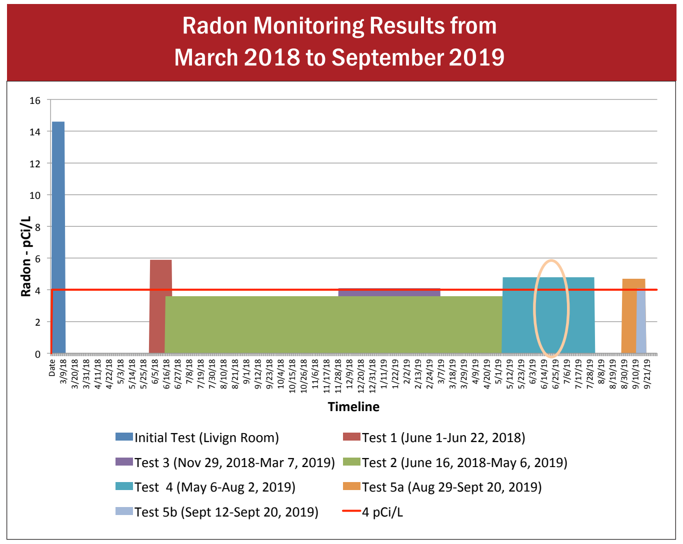

Figure 2. Radon data collected by E3 INNOVATE from March 2018 through September 2019. Remediation helped bring average levels below 4.0 pCi/l while changes to the balance of the system caused levels to rise.

central part of the home had returned once again. To address the issue, E3 began tinkering with the system by adjusting the ERV settings and the radon gate valves; in mid-June of 2019, the ERV was turned off temporarily as requested by the homeowner as a quick fix. This time period is indicated with the oval on the chart in Figure 2. Unfortunately, the ERV served as an important part of the radon mitigation system. Turning the system off caused radon levels to rise slightly above the 4.0 pCi/l threshold to 4.8 pCi/l in the fall of 2019 and later to around 8.0 in the early spring of 2020.

The test results captured during this adjustment period include some amount of time before the modifications took place, so this average is a combination of radon levels before and after adjustments to the ERV and gate valves.

Chasing odors led to chasing radon levels. The AirThings device that was given as a free gift to the homeowners began igniting some anxiety, both for the homeowner and E3. Now, the odors were gone, but radon once again became an issue.

To address the homeowner's concern, E3 visited the site numerous times to try to rebalance the gate valves in an effort to re-adjust the suction in the radon system. Suction in the crawl space under the master bedroom was choked off to trigger the ERV to cycle more frequently in an attempt to further dilute radon. However, once we put all the pieces together, we discovered there was a flaw in the radon system design, which was apparent only after fiddling with the gate valves.

Although the ERV did not serve the master bedroom directly, E3 suspected that with enough fresh air in the house, mixing would occur, and levels would come down. That was not the case. The ERV was installed to supply air through the duct system serving the main living area of the house. The master bedroom is located down a long hallway off the living space. It turned out that natural mixing was insufficient for the ERV system to manage radon in the master bedroom. Although the ERV likely helped keep radon low in the main living area, the balance of flow rates through the mitigation piping was also important.

After a full year of adjusting gate valves with minimal results, the homeowner was now quite frustrated and wanted an immediate solution. The only option was to install a second radon fan and a connection branch on the opposite side of the house, which the homeowner wanted to avoid in the beginning because of the eyesore he thought it would create and the added cost. But the time had come, and it was clear: a second radon fan was necessary.

E3 replaced the existing radon HP220 fan with a new RN4 fan, which is typically used only in commercial settings because of its high flow rate. The benefit of the RN4 is that it offers the ability to adjust fan speed, an important feature for balancing. The HP220 fan was moved to the opposite side of the house since that section of piping was furthest from the suction point.

Once the second fan was installed, radon levels quickly fell to 3.2 pCi/l. Problems solved? We'll see. Whether or not the additional negative pressure will have any effect on humidity levels is the story for yet another article. We will have to wait until the humidity returns to Nashville to find out.

A HYPOTHETICAL SITUATION

Let's imagine for a moment that a different situation had occurred. Say the homeowner performed his own radon test—as many homeowners do—and discovered high radon in the house, so he called a remediation company. The remediation company comes out and installs the system with a three- to four-foot piping span under the crawl space laminate in one section of the crawl space to pull the radon and soil gases out. When the installer completes the work, he collects payment and heads off to the next job. There is no post-testing, monitoring, or follow-up, and there sure as heck is no

left An RN-4 radon fan with 6-inch piping serves as the primary outlet. *right* A secondary PH-220 radon fan with 4-inch piping serves as the secondary outlet and provides additional suction in the system.

free Bluetooth monitoring device left onsite for the homeowner to receive daily radon measurement updates to his phone!

We recognize that our initial design had its flaws, but we cannot ignore the common practice in the industry. The traditional approach to radon mitigation in a sealed crawl space in the Southeast is to put the biggest fan on the house you can and run the PVC under the vapor barrier with a short "T." Far too often, active radon systems are installed after construction, resulting in basic piping layouts and quick installations. Very few people are re-installing sealed crawl space systems and taking the opportunity to design a radon mitigation network, if you will, on homes with very large crawl spaces.

If a basic radon system were installed on this home, would it have worked? It's highly unlikely. There would have been far too little suction from one location in the crawl space to pull from the rest of the 6,700-square-foot footprint of the house.

One might question: How many radon systems installed on larger homes actually work after installation? Or, do they act more like a placebo? Do homeowners question the performance of their radon system or do they simply trust that if there is a pipe on the side of the house, everything is okay? One must follow up with post-testing after the installation of a mitigation system to ensure that radon levels have fallen appropriately. Twelve-month testing as well as winter-season testing is recommended to identify long-term averages and worst-case scenarios.

LESSONS LEARNED

The takeaways from this project are the following:

1. Homes with a large footprint and complex crawl spaces in areas with high radon levels will likely need multi-branch, multi-fan systems, yet the majority of the industry is implementing single-pipe, single-fan systems. There has never been a discussion of the use of gate valves, system balancing, or radon piping layout design in any of the radon training courses E3 INNOVATE has participated in; however, this project has proven the need for these elements for larger homes.
2. The industry is in need of a tool for designing involved radon mitigation systems. We have software for designing HVAC duct systems, so is it not possible to create one for radon as well? It would have been extremely helpful to know during the design phase of the project what the flow rates through the different branches of the radon piping would be, how the gate valves could be used better to balance the flow, and what size fan and how many would be needed to create enough suction in all branches of the system for the design to be effective.
3. Radon monitoring should be part of an ongoing maintenance program for large homes with expansive radon systems for at least two years after installation to ensure fine-tune balancing and effectiveness.

Nashville faces unique radon challenges because of the hilly, rocky terrain, the widespread use of crawl space foundations, its location within a class-1 radon zone, and the growing number of large homes in the area. The building community needs to be made aware of these challenges and special attention should be paid to the design and testing of radon mitigation systems during the construction of new houses of all sizes, but particularly larger homes. Hopefully this article provides insight for builders and homeowners alike into the challenges that can occur when trying to address radon in retrofit situations.

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