Designing Radon Reduction Systems in Existing Multi-Family Structures

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Public Health Radon Reduction Roadmap (PHR3)

Introduction

Considerable attention has been given to the incorporation of radon control systems during the construction of new multi-family structures. This has been a requirement for HUD financed projects for the last few years, but also as building departments have added provisions to their multi-family codes. This addresses radon related health concerns for new projects. But what about existing multi-family buildings?

Radon concerns are equally prevalent in older, existing structures, as in newly constructed buildings. This equal potential is a function of the soil and underlying geology, rather than the construction of the building. Therefore, existing buildings are just as likely to have elevated indoor radon levels and hence should be addressed.

A growing number of property management firms are being tasked with conducting radon surveys, either as a matter of policy or as a requirement of refinancing. Where elevated levels are found, a response is in order to verify exposures, and if confirmed, take action to reduce levels to less than accepted guidance which is typically 4 pCi/L (pico Curies per liter).

The intent of this technical bulletin is to provide an insight into the process by which a radon system can be designed and incorporated into an existing multi-family structure.

Other technical bulletins and information regarding the incorporation of radon systems for new homes and multi-family buildings can be found in the resources cited at the end of this bulletin and at the Colorado Department of Public Health and Environment(CDPHE) website at www.coloradoradon.info.

Process for Addressing Elevated Radon

There are five distinct steps that should be taken after a radon survey has identified potential concerns. It is recommended they be followed in this suggested order.

1. Assess survey and confirm elevated radon levels
2. Conduct field investigation to identify approach
3. Implement plan by maintenance or obtain bids
4. Verify effectiveness with retests
5. Institute an O & M Plan

This bulletin focuses on the first four step. Other bulletins and resources address the last step. (See References)

Assess Survey and Confirm Elevated Radon Levels

The first step is to verify the results of a survey and to ensure it is complete.

Long-Term Follow-Up

Typically, a radon survey is conducted utilizing measurement devices that are deployed for a 2-3 day period. This testing methodology requires closed unit conditions where the tenants can enter and leave the unit but keep doors and windows closed throughout the test. The results of a test like this indicate radon potential, rather than what an occupant may be exposed to on a long-term basis. To estimate long-term exposures, a long-term test of at least 90 days can be used to confirm actual exposures under normal living conditions as closed unit conditions are not required.

So, one follow-up approach would be to deploy long-term test devices in those units that exhibited elevated levels.

Short-Term Follow-Up

If time is of the essence and a 90 day plus retest is not practical, a repeat short-term measurement is appropriate. This would also be performed under closed building conditions. The results of the second test would be averaged with the first test results, with the resultant average being the basis to determine if remediation efforts are warranted.

Initial Duplicate Testing

In cases where time was critical, radon measurement professionals following ANSI/AARST Multi-Family Measurement standard (MAMF-2012) would have deployed duplicate test devices during the initial test period. Having two measurement results can preclude the need for follow-up testing if the averaged result of the two concurrently deployed devices is above the guidance (typically 4.0 pCi/L).

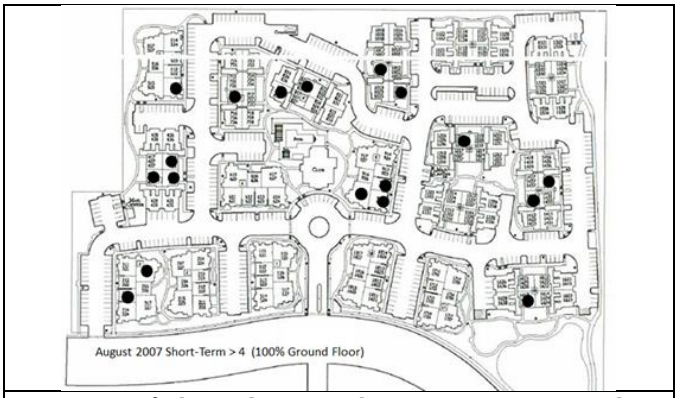
This does not preclude performing another short-term test or a long-term test for verification. In fact, it would be logical to do so, as the result of any short-term test is biased to the conditions that existed during the 2-3 day testing period.

Completeness and Visualization

Radon primarily comes from the underlying geology. So, if confirmed radon tests have identified one or more units with elevated indoor radon, all ground floor units have the potential for elevated radon, either now or in the future.

If the initial survey did not include 100% of the ground floor units as well as 10% of upper floor units (as current standards now require), those untested units should be tested and confirmed.

The confirmed readings should be plotted on a site and/or floor plan to visually identify where the design effort, as well as future retesting efforts, will focus.



Location of Elevated Units within an Apartment Complex

Conduct Field Investigation to Identify Approach

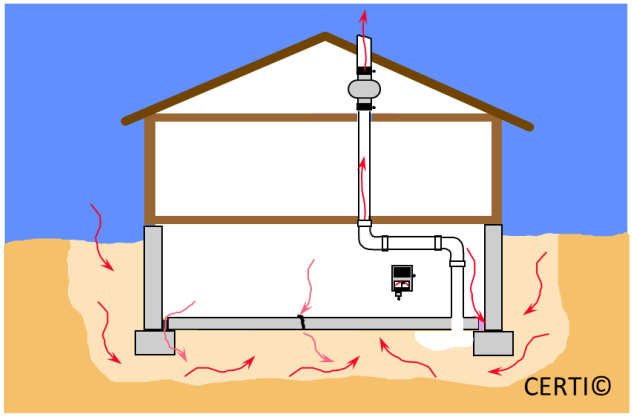
HVAC Considerations

Typically, multi-family units are constructed with residential sized heating ventilating and air conditioning systems (HVAC) and hence play a far lesser role in multi-family units as compared to schools and office buildings which have more robust HVAC systems. However, newer multi-family buildings are designed with fresh outdoor air make-up. If this is the case, one reason a particular living unit is elevated could be due to its fresh air make-up not functioning. A quick review by maintenance may address this problem provided it is retested to confirm reductions.

Another aspect of multi-family units with forced air systems is where the ceilings are used as return air plenums. When this is done, the entire ceiling is under negative pressure. If the ceiling communicates with the soil via void spaces in walls, radon can be drawn in. These areas should be isolated with fire rated walls, but fire rated does not mean airtight. Sealing openings in these walls may prove to be sufficient.

Active Soil Depressurization

The most common approach for reducing radon in multi-family structures is the use of a system that draws radon laden soil gases from beneath the foundation/slab and exhausts them to a safe location outside the building. This is the same approach used in single family homes. However, due to the larger footprint of a multi-family building, the suction may need to be applied to several locations to ensure proper coverage.



An Active Soil Depressurization System Draws Radon Laden Soil Gases from Beneath the Foundation and Exhausts them to Safe Location Outside

The foundation design can also impact how complex the system is. In the case of a slab-on-grade foundation, there can be multiple footings supporting bearing walls. These deep footings can limit the extent that a discrete suction point can reach under a slab to collect radon. This is particularly true where post-tension slabs employ a maze of grade beams that disrupt sub-grade air collection.

Alternatively, if post-and-beam construction was used where there is no continuous footing, but rather discrete pads, an active soil depressurization system can impact a large area -- even the entire footprint.

Because there are a lot of variables in the sub-grade, including the type of fill and its level of compaction, it is strongly advised to conduct a simulation of an active soil depressurization system. Assuming that a system should be installed in every living unit is a very costly approach and is overkill.

Through a thorough building investigation, the location of suction points that will maintain aesthetics and reduce impact on limited living space, can be determined. The number of systems can be reduced when suction points are in places that improve soil gas collection. Examples include connection to foundation drainage systems, or in plumbing trenches having clean gravel that in many cases would allow for a single system to treat the entire footprint, thus avoiding a system per unit.

Rules of thumb, such as an assumed area of impact for each system does not work. In the case of a post-tension slab, with many grade-beams, the area of impact could be a fraction of what it would be for a building with piers or pads.

If the foundation is an earthen crawlspace, extensive diagnostics are not needed. In this case, a poly barrier would be laid on the dirt, sealed to the sidewalls and at seams and penetrations. Soil gases are extracted from beneath the poly sheeting and exhausted outside. Since there are few if no barriers to gas collection, these systems are straightforward and therefore do not require diagnostics. However, fan and vent pipe size will need to be determined.

ASD Diagnostic Approach

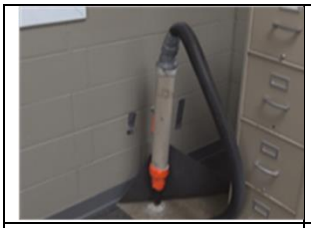
To determine the layout and locations of an active soil depressurization system, the technician working in concert with facility maintenance personnel and reviewing available plans, will identify preferred locations for a possible suction point. This initial selection will be based upon ease of installation, minimizing occupant impact, and maximizing the area of impact of a system.

After a preferred location is determined, a 1¼ inch hole is drilled through the slab. This could be from inside the building or horizontally through an outside foundation wall in the case of a slab-on-grade structure to minimize occupant impact.

A high-capacity shop vacuum is connected to this hole to simulate what a permanent active soil depressurization would do.

Small 3/8-inch pilot holes are also drilled at various locations through the slab inside the building. These are typically located in closets or peeled back corners of carpet to allow for repair and concealment after diagnostics are completed.

A differential pressure measurement device is used to measure the vacuum created under the slab at a particular test point when the shop vac is turned ON and OFF.



Suction Hose of Shop Vac Connected to Sub-Grade

Differential Pressure Measurement through small hole drilled in slab

Through an iterative process, a diagnostician can determine how much of a slab can be impacted by a suction point at the selected location. This could be the entire slab if an influence is measured at the far end of the building. This is possible if the subgrade is unobstructed or if a location with good communication (plumbing trenches for example) is selected.

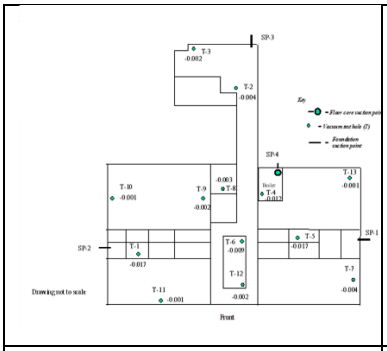
The result could be that only a small portion of the slab is impacted, in which case, a second logical point is located, and the simulation is repeated to see if the areas that were unimpacted in the first test could be treated by a second collection point.

Concurrent with this test, the volume of air being extracted is measured to determine fan sizing and determine if a single, branched system could extract the requisite air from multiple suction point as needed.

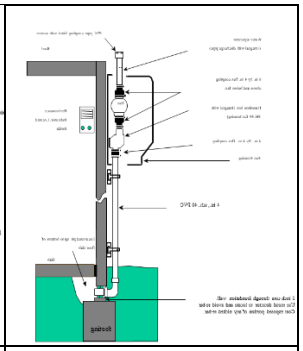
Air Flow Measured to Determine Fan and Vent Pipe Size

When interpreting the measurements, there is no minimum amount of differential pressure that needs to be achieved. If a change is observable, and verified by repeating the test, the actual active soil depressurization system will most assuredly impact that area when it is permanently installed.

A detailed plan can be developed that shows the location of suction points and a schematic of the system with enough detail that an experienced radon contractor can install it.



Diagnostics Yield Diagram of Suction Points



Design Schematics and Specs are Developed from Field Data

Implement Plan by Maintenance or Obtain Bids

Some items identified during the field diagnostic exercise may be easy maintenance tasks. This would especially be the case with the repair of restricted fresh air to HVAC systems.

The active soil depressurization systems could also fall within the skill set of maintenance personnel, but for many reasons it may be best to contract this with certified radon contractors experienced in multi-family projects.

Having the diagnostic data and plan prior to obtaining bids provides clarity to radon contractors when they provide an estimate. Some property owners have skipped over the field design step assuming the radon contractor can determine the best approach. Although this could work without the field data, bids are likely to be widely different based upon what assumptions are made, and often on the conservative, high side.

Radon mitigation for multi-family structures can be complex due to building size, height, and foundation design. It is unlike residential projects where typically one system will provide the desired reduction. Rather, multiple systems will be needed, but the fewer the better, to reduce installation cost, occupant disturbance, aesthetic impact, and reduced maintenance in the future.

When selecting a radon contractor, one should require certification by one of the national certification bodies. Beginning in July 2022, the State of Colorado will be licensing radon contractors and therefore contractors performing the work will need to be licensed.

The contractor should also have the appropriate contractor license for remodeling multi-family structures and all electrical should be performed by a licensed electrician.

Lastly, a permit will be required by the local building department and having the design details developed from the field work would allow for plan review and approval.

Verify Effectiveness with Retest

After the work has been completed, its effectiveness needs to be verified by retesting the radon. Pressure field measurements are interesting, but the success of the design and the installation can only be proven by a radon test.

At a minimum, the units that were determined to be elevated from the initial test, and were confirmed as elevated, should be tested.

For a more complete determination, the entire complex should be tested to include 100% of ground floor units and at least 10% of upper floor units. This provides a better basis for going forward as the installation of the active soil depressurization systems likely benefitted more than just the target units.

The Colorado Department of Public Health and Environment recommends retesting multi-family buildings that have been mitigated every two years. This should include the units that were mitigated as well as unmitigated units since they are sitting on the same radon potential geology as the elevated units. Things change -- foundations shift, HVAC systems deteriorate, and perhaps during the initial survey the occupants did not follow instructions to keep their windows closed and the radon in their unit really was elevated.

For more details on system design and testing for multi-family properties both new and existing, the reader is referred to the CDPHE document *Measuring and Mitigating Radon in Colorado, 2018*.

Resources

Resources available at Colorado Department of Public Health and Environment website www.coloradoradon.info:

Technical Manual:
Measuring and Mitigating Radon in Colorado, Colorado Department of Public Health and Environment, 2018

Videos:
Installing Radon Systems in New Home Construction
Installing Radon Systems in Multi-Family Buildings

ANSI/AARST Standards for Multi-Family Buildings
https://standards.aarst.org/