Inspecting Radon Systems in New Construction

Technical Bulletin-06-20-2

June 2020

Introduction

An increasing number of buildings are being constructed with radon control systems incorporated during construction. This is true for single family structures as well as larger multi-family buildings, schools and commercial buildings.

This steady growth is due to the value-added nature of these systems and the adoption of building codes and requirements established by lenders.

Regardless of the reason, experience over the last decade has shown the same process for installing and inspecting other systems such as plumbing and electrical systems needs to be applied to radon systems to insure the system operates as intended when construction is completed.

The intent of this bulletin is to provide guidance to builders and building departments as to what items should be inspected for and at what stages of construction. Furthermore, it is based upon the approaches that are described in more detail in the publication, *Measuring and Mitigating Radon in Colorado* herein referred to as the Technical Guidance Manual.

The focus here is on single family homes. The same inspection needs apply to larger structures with the exception that the systems are larger and phased construction may require multiple inspections. However, inspections at the various stages still apply.

Concept – Passive to Active

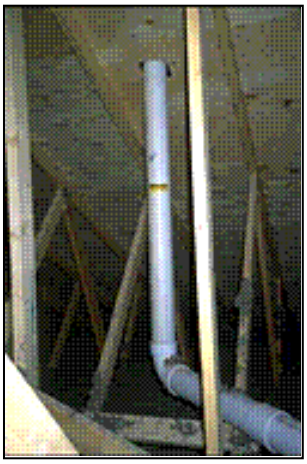
The basic concept of radon control system is a focus on radon that enters a home from the underlying geology or soil. Although radon can also enter a building via a groundwater supply or from contaminated building materials this is rare and not the focus of radon related codes, such as Appendix F of the IRC.

Radon laden soil gases enter a structure due to negative pressures that can exist within a building due to exhaust systems, natural thermal stack effect as well as soil pressures caused by wind and other environmental factors.

The basis for radon systems is to have a means for soil gasses to be collected beneath the foundation and conveyed to the atmosphere prior to their entry through the foundation.

The overall approach described in guidance documents and codes has been to facilitate the collection of soil gasses to the point where a passive vent stack, routed up through the interior and exiting the roof, can exert its own stack effect and preferentially draw the radon out prior to its entry into the home. This is referred to as a ***PASSIVE*** System.

However, if the passive system is unable to fully reduce the indoor radon (typically to less than 4.0 pCi/L), provisions would have been made for the addition of an inline radon fan, in an appropriate location, that would create sufficient differential pressure to further reduce indoor radon. This is referred to as an ***ACTIVE*** System.



Passive

Active

Although there can be some differences in the design if an ACTIVE approach is taken from the outset, the installation parameters are essentially the same with the exception of the presence of the fan, electrical, and a performance indicator.

One might consider that a post-construction radon test should be sufficient to validate a system. Experience has shown that defects that are not identified during construction are costly to repair after completion even to the point where the installed system is abandoned and a retrofitted system must be installed. This is especially true in the case of multi-family structures where multiple systems exist and displacement of tenants and removal of wall finishes may be required.

An effective and reliable system requires both: staged inspections and post-construction radon testing.

Sub-Grade - Slabs

The intent of the radon system is to be able to facilitate the collection of soil gasses from beneath all slabs below all living spaces of the building. Most codes exempt slabs of attached garages or detached buildings unless they are also living spaces.

There are three alternative methods that can be utilized for this as described in the Technical Guidance Manual and as specified by the radon system designer.

- 4-inch layer of clean aggregate beneath the slab
- Loop of 3-4-inch perforated pipe in a gravel filled trench
    - Can also function as interior perimeter drain
- 1-inch x 12-inch flat mat laid in a rectilinear loop around perimeter of foundation.

Regardless of the approach, the key items to inspect for:

Are all areas of the slab being treated?

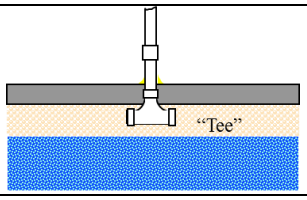
- Where grade beams or intermediate footings exist, the collection pipe must pass through these barriers to insure full coverage.
- For the full gravel option, pipe sleeves through the grade beams may be used to facilitate communication.

Will the soil gas collector retain water?

- Radon systems must be able to allow condensed water to drain into the sub-grade.
    - Fully perforated pipe insures this.
- Ensure elevation changes are executed with perforated pipe so water can drain into subgrade.
- Ensure that elevation of soil gas collector is above the surface water control level as determined by sump or perimeter drain.

Will aggregate or other construction materials fill the soil gas collector?

- Older, yet still referenced publications depicted a Tee set into gravel. This is not recommended as gravel will fill the TEE and obstruct the system.
    - A minimum 20-foot long perforated pipe should connect to the riser to preclude obstruction.
- The solid PVC riser through the slab that will connect to the final radon vent pipe should have a temporary cap on it to preclude concrete and construction debris from entering it.



NO	**YES**
Tee will fill with Aggregate	Aggregate Precluded

Are other drains connected to the soil gas collector?

- Window well drains or downspout drains should be segregated from the soil gas collector.
- If radon system doubles as a surface water drain, sump must have a gasketed and bolted cover.

Insure perforated pipe does not extend above the slab but rather conversion to solid PVC pipe occurs below slab.

NO	**YES**
Non-perforated pipe above slab	Cap and label riser

Sealing Slab

The top of the soil gas collection layer should be sealed such that air from beneath the slab is isolated from the interior. Depending upon code requirements and system designer specifications, this can be done in either one of two ways:

1. Vapor barrier/soil gas retarder installed beneath slab with:
    - Seams overlapped and taped.
    - Sheeting brought up foundation wall 4 inches and sealed to wall.
    - Sheeting taped around plumbing penetrations.
    - Sheeting beneath plumbing block outs.

OR

2. Slab caulked with polyurethane caulk at:
    - Floor to wall joints-including over expansion boards.
    - Control joints.
    - Around plumbing and conduit penetrations.

Please refer to Radon Aware Technical Bulletin 06-20-1, which based upon a Colorado study recommends caulking the slab and installing vapor barrier as would be normal without special sealing of the vapor barrier.

Note that in some cases, both approaches may be called for based upon local codes or if other soil gasses are being treated such as Volatile Organic Compounds (VOCs).

	
NO Wrong Caulk-Joint not tooled	**YES** Polyurethane over floor to wall joint

Sub-Grade - Crawlspaces

In the case of a crawlspace, no slab is installed. Consequently, a polyethylene barrier must be installed to act as an air barrier. In this case, the barrier will need to be reasonably well-sealed. However, it is not practical to obtain a perfect seal. So, the intent is to reduce the amount of air leakage as much as possible and to secure it so the poly will not shift with traffic that could create a large air gap.

Is the poly sheeting durable?

- The minimum thickness is typically 6-mil.
- If traffic is expected or mechanical equipment set upon it, 10 mil is more practical.

Are the edges secured and sealed to wall?

- The edge should be brought up on wall far enough for it to be secured (typically 12 inches) but not secured to wooden rim joist.
- Edges either taped or sealant used to provide reasonable air seal at walls.
- Secure with termination bar or shot pins to hold in place.

Are seams sealed?

- Overlapped and taped, or
- Overlapped with compatible caulk between layers.

Is poly sealed to radon riser pipe and other plumbing risers?

- The seal at the radon vent riser is critical.
    - Tape sheeting to side riser, or
    - Use grommet around pipe sealed to poly.

To avoid damage to sheeting during construction the installation of the membrane may be delayed until after sub-flooring is on or even later.

	
NO Poly not sealed around riser	**YES** Poly sealed well with grommet type seal

Inspections with Active System

In the case of passive systems where no fan is installed, a visual inspection is all that can be done to determine proper sealing of either a slab or a membrane in a crawlspace.

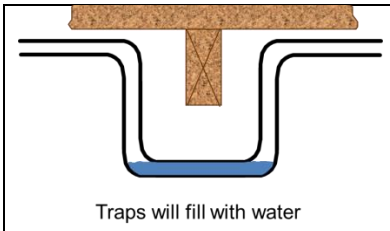
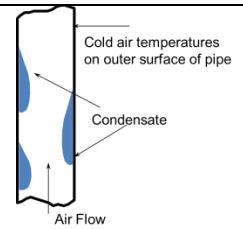
In the case of an active system, with the fan running one can hear leakage or see if smoke is drawn down an unsealed opening in the slab. In addition to hearing a leak in a crawlspace system, one should also see the poly drawn down tightly to the earth.

Given the ease of which problems can be identified with an active system operating, some builders have opted to install an active system from the outset. In larger buildings, many specs require the temporary installation of a radon fan to determine slab leakage prior to framing and floor finishes.

Vent Pipe

The radon vent pipe is the means by which the radon bypasses the building. Consequently, its construction is critical to the entire system and its routing must be executed carefully.

What many non-radon certified installers do not realize is that in addition to radon, the system is also extracting other vapors from the soil, with the most critical being moisture. The air from the subgrade will contain water vapor. As the pipe passes through cold spaces, such as an attic, it will condense inside the pipe and fall due to gravity. If there is a trap in the line, it will accumulate and block the air flow (not to mention gurgle in the night). Also, if there is a leak in the joint or if HVAC ductwork is used, it will leak water into the home. This has been observed in all climates, regardless of how dry the climate is. Inspect it like one would inspect a sewer line.

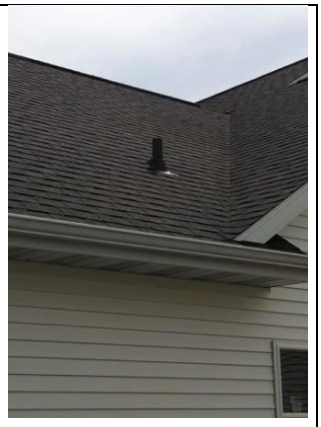
	
NO Condensed Moisture will Accumulate at low spots	**YES** Condensation must be able to drain to sub-grade

Assuming one is inspecting a passive system, the vent pipe should run though the interior of the building rather than an outside wall to maximize its thermal draw on the subgrade. The routing should also be as direct as possible, avoiding as many fittings as possible. In other words, view it like a chimney. More latitude in routing and fittings can be allowed with active radon systems, provided there are no water traps.

Things to inspect for:

- *Is the vent pipe the correct material and joints properly made?*
    - Minimum 3-inch, PVC or ABS, DWV
    - Joints primed and glued?
- *Are there any traps or low spots where water can accumulate?*
- *Is the routing for a passive system reasonably direct up and through roof?*
- *If pipe runs through a fire wall, is a fire barrier used to maintain fire wall rating?*
- *Are metal nail plates installed at top and bottom of framing to protect pipe from drywall nails?*
- *Is the discharge through the roof and away from openings into the building?*
    - 12 inches above roof surface
    - 10 feet away from any openings that are on a plane less than 2 feet from the discharge

NO
Discharge next to window and adjacent story



YES
Discharge through roof and away from openings

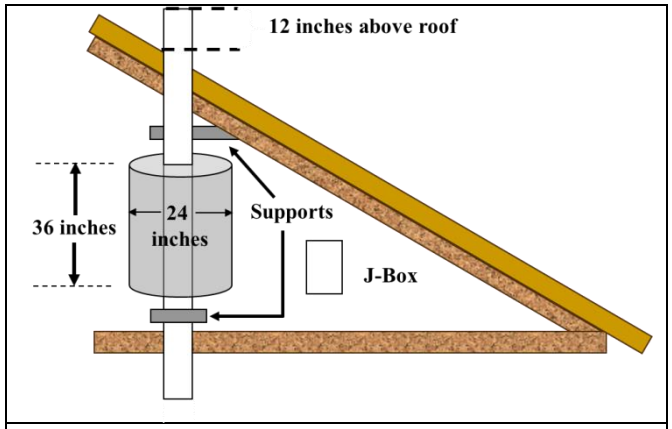
- *Is there a rodent screen on termination?*
    - ½ to ¾ inch stainless mesh
- *Is pipe adequately supported?*

Caution to installer: Prior to connecting the vent pipe to the soil gas riser:

- Remove temporary cap.
- With a flashlight, look down riser stub to insure it is not blocked or has been disconnected below the slab.

Radon Fan

Regardless if a system is being installed as a passive or an active system, provision for the fan or future fan must be made. The primary aspect of this is due to potential leakage of radon from the fan housing or discharge piping, this portion of the system is to be outside the envelope of the house. Typically, the fan is to be located in an attic, unless the attic is part of the conditioned space, then the fan has to be elsewhere, such as on the roof in an appropriate enclosure. It also means the fan cannot be in a crawlspace.



Space allowance for future fan in attic

Things to inspect for:

- *Is the fan and discharge piping outside the interior envelope of the house?*
- *Is the fan mounted vertically to allow for condensed moisture to drain down into vent system and sub-grade?*
- *Is the fan attached to the vent pipe with flexible couplers to reduce vibration and allow for future replacement?*
- *Is power provided or available with disconnect?*
    - May not require separate circuit depending upon local code.
- *Is the fan rated for use as a radon fan?*
- *Is there access to the fan location?*
    - Catwalk or close proximity to attic access.
- *Has a performance indicator been installed or allowed for?*
    - Typically, a vacuum gauge with a port on pipe below fan and located in a spot where homeowner can view.
    - Shows loss of vacuum as an indication of system failure.
- *Are there supports above and below fan to allow for fan removal?*

	
NO Fan not vertical nor accessible	**YES** Fan vertical and in attic

Performance Indicators Examples for Active Fan

	
U-tube Manometer connected to suction piping with label indicating initial installation vacuum	Electrical current style indicator. Wired in line with fan

System Labeling and Documentation

As an operating system, current and future occupants, as well as tradespeople need to be able to identify elements of the system. The following labels and or advisements should be present and inspected for:

System Label:

- In a prominent location.
- Indicates the presence and type of radon system installed:
  - Active: Where fan is located.
  - Passive: Future fan location and need to test after occupancy.
- Installer contact information.
- Date of installation or activation.
- Breaker number for fan or future fan.
- Advisement to test every two years after activation.
- Contact information for state or local health department.

Vent Pipe Label

- On pipe where readily visible and also behind finished walls that could conceal a full story of pipe.
- Basement, crawlspace, attic –not needed on roof pipe.

Sump pit cover label

- On lid of gasketed and bolted sump lid.

Crawlspace membrane label

- Install on membrane near access hatch.

Performance Indicator (if system activated)

- Indication of initial performance.
- Instruction of how to interpret and who to contact.

Breaker Panel

- Label breaker that supplies power to fan or can be used for power if fan added at a later date.

Documentation

- Description of system.
- Any post-construction measurement results or advise to test if a passive system.
- Precautions regarding system such as:
  - Removing or damaging membrane in crawlspace.
  - Removing and replacing sump lid when accessing sump pump.
- Warranties of system performance and equipment manufacturer warranties.

Summary and Resources

The purpose of this bulletin is to provide the intent of key elements of radon systems, which if overlooked can cause the system to fail or result in costly repairs. Additional inspection elements are likely to exist based upon varying specifications or iterations of codes as they are amended or adopted. Building departments and builders are advised to create their own checklists using this bulletin and additional details available in the more comprehensive Technical Guidance Manual cited below.

The details included herein and within the Technical Guidance Manual are based upon the primary authors oversight of inspections on over 16,000 radon systems installed over the last decade in the Rocky Mountain West with one primary lesson learned:

> *Written specifications are useful but both mechanical inspections as well as validation through post-construction testing are necessary.*

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

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

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

Radon Aware

In Colorado, about 50% of homes have unhealthy radon levels; that's equivalent to every person in the home having 200 chest x-rays every year. This compares with only 6% of homes having unhealthy radon levels across the rest of the country.

Radon is a naturally occurring, invisible gas that decays into radioactive particles and increases the risk of lung cancer for those living with radon trapped inside their homes. Radon exposure causes as many as 500 lung cancer deaths every year in Colorado.

The Public Health Radon Reduction Roadmap (PHR3) project aims to reduce radon exposure and its associated risk of lung cancer by encouraging and supporting Colorado communities in becoming *Radon Aware*. Education, training, and technical assistance is provided to Local Public Health Agencies, Elected Officials, Building Officials, Builders, Building Professionals, Affordable Housing Agencies/Authorities, Real Estate Professionals, and Homebuyers to promote the use of use of certified radon contractors and radon reduction best practices for existing and new single-family homes and existing and new multi-family homes.

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COLORADO
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Department of Public Health & Environment

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