# FAILURE MODES FOR RESIDENTIAL PASSIVE STACK RADON CONTROL SYSTEMS

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## ABSTRACT

In new house construction, initial experiments with passive stacks have shown that there is a potential for significant radon mitigation performance. However, some houses have achieved better mitigation performance than others, and this paper reviews the experience of passive stack failure modes from recent observations of installations of new houses and from previous research on passive stacks. Some builders in the Washington, DC area are required by local code to install passive stacks, and radon mitigators have observed many installation problems. Two basic types of passive stack problems have been found: poor installation and basement depressurization. Installation problems include blockage of the stack pipe, leakage of the stack pipe, stack termination in the attic, leaky sump lids, poorly trapped condensate drains, small stack pipe too small, stack runs through unheated spaces, and condensation trapping. Basement depressurization in these houses is generally due to imbalances in the forced air system, which is generally caused by large leaks on the return side of the duct system.

## INTRODUCTION

Although passive stacks have been shown (1,2) to provide significant radon mitigation performance, it is not clear if we currently understand their failure modes well enough to write a fool-proof code or specification that will avoid most of the installation errors. It is hard to predict exactly what contractors will do with a new technology that they do not understand well, but radon mitigators in the Washington, DC area have already had some experience in examining faulty passive stack systems that now are required by some of the local building codes. This paper summarizes some of this experience from diagnosing faulty installations. It is unclear what the impact of some of the installation problems is, and some of them suggest further topics for future research in passive stacks This research should lead to revised code or specification language that will make it clear to builders how to avoid most poor passive stack installations.

Simple installation errors include installing the stack pipe in an unheated space like a garage, or blocking the stack pipe with construction debris. More complex installation problems include untrapped condensate drains that are depressurized by heat pump air handler fans, and leakage in the connection between the stack pipe and the slab. Other errors such as basement duct leakage that depressurizes the basement involve the impact of other systems in the house such as the forced air system. Then there are unknown factors such as the use of the stack pipe small than 3 inch diameter, the straightness of the pipe, and the wind effects on the open exit pipe.

## STACK INSTALLATION ERRORS

A number of passive stack installation problems have been observed in the Washington, DC metropolitan area, and they appear to be caused by misunderstandings by builders about the technology, the lack of performance test methods, or poor workmanship.

### Blockage of Stack Pipe

When the stack penetrates the slab, it is very easy to block the stack by either bottoming the pipe in the dirt below the aggregate layer or by allowing construction debris to fill the pipe. Both of these cases have been observed when new homes with passive stacks had elevated radon levels, and mitigators were called in to install a fan on the passive stack. This type of error may be very difficult to avoid by means of a performance specification or simple test, and inspection is unlikely to identify it because the problem is hidden beneath the slab. One partial solution is to have some type of standard fitting at the

bottom of the pipe, like at "T" that is connected to perforated drainage pipe. This is similar to a water drainage system which builders are familiar with, and is therefore less likely to be incorrectly installed.

Leakage of Stack Pipe

Some builders have not firmly connected all sections of the stack pipe, and the stack effect is either negated or soil gas is vented into the house. The solution to this problem may be to require the same solvent welding of all pipe connections that is required for water pipes or sewage pipes.

Stack Termination in the Attic

Some builders terminate the stack pipe in the attic, possibly to avoid the expense and unsightliness of another pipe penetration through the roof. This installation may not lead to a radon problem in the house if the attic is well vented, but it may lead to a severe moisture problem in the attic because the stack gas is high in moisture and it may condense or freeze in the attic. This practice should be clearly rejected by building codes.

Leaky Sump Lids

One of the most serious possible passive stack installation errors may involve the use of some types of commercially available sump lids. Most of the effective passive stacks that have been studied were sealed directly into the concrete slab, and not into sump lids. Now at least one commercially available sump lid now comes with several gaskets to seal a stack pipe, wire, and the lid to the concrete. However, there is no easy way to determine if all these seals are leak-tight, and a leaking gasket may short circuit the passive stack. This may be a serious problem because builders are already starting to install passive stacks connected to these sump lids, and they are not aware of any special sealing requirements. It is not clear how a sump lid can be tested for air leakage, especially if it has several pipes and wires penetrating it. It seems likely that passive stacks will be defeated if there is any leak in their above grade components, and that attaching them to sump lids has a high probability of failure unless the whole lid structure is perfectly sealed.

Poorly Trapped Condensate Drains

There does not seem to be a clear understanding as to how construct a condensate line trap that will not dry out over the winter. When these drains are connected to the negative side of the air handler and to the subslab aggregate layer, drains with a dry trap have been observed to pump radon throughout the house,

despite the action of a passive stack. Some "U" traps that have dried out over the winter are only one to two inches deep, and traps that have filler pipes attached to them appear to dry out faster than those with no filler pipes. If "U" traps are used on condensate drains they should probably be at least three inches deep and they should not have filler pipes.

### Stack Diameter

Some builders are reported to be using stack pipe smaller than 3 inches for passive stacks. This seems risky at our present state of knowledge since there does not appear to be any data on the effectiveness passive stack smaller than 3 inches. More research is need on this topic.

### Stacks Run Through Unheated Spaces

It is common to see stacks that are partially run through unheated spaces like garages. Even if only part of the stack is in an unheated space, the performance is thought to be proportionally reduced. Code should specify that stacks must be run through heated space.

### Condensation Trapping

Passive stacks appear to have just as much condensation running back down through them as conventional active systems do, and it is very important to construct the stack so that water can not be trapped in it.

## BASEMENT DEPRESSURIZATION

### Duct Leakage

Duct leakage may be the most significant failure mode for passive stack houses with forced air distribution systems, and we need a simple test to determine whether a problem exists. Without such a test, it will probably not be effective just to specify that the ducts should be sealed as a stack effect reduction technique. One potential test method is to turn on the forced air fan, stand on the basement stairs, and close the basement door down to about one inch. If any draft toward you can be felt, then the basement is being depressurized excessively. This test appears to be simple enough to be usable by builders and code inspectors, but it need to be field tested.

## CONCLUSION

In order to provide a passive stack construction specification that will avoid most failure modes, we need to take

a look at what mistakes builders are making now when they install these systems. Installations in localities like Montgomery County, MD where passive stacks are now being installed could be studied to understand how the present specifications are being interpreted. When passive stacks with installation problems are found, they should be studied in detail. The result of this study should be a tighter specification that will help builders avoid faulty passive stack installations.

## REFERENCES


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