

**WASHINGTON PASSIVE STACK STUDY**

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**ABSTRACT**

The purpose of this ongoing study is a statistical analysis of the effectiveness of passive stack radon mitigation under the Washington State Indoor Air Quality Code, a building code law effective 7/1/91. This law requires the installation of passive stack radon systems in new homes and apartments in 8 radon problem counties. It also requires the distribution of radon monitors, by building inspectors, to all new homes and ground floor apartments. Results from these tests indicate instances of radon levels above 4 pCi/l in an additional 14 counties. Focusing on Spokane County, test results indicate that the code systems are not proving to be significantly adequate to prevent radon levels above the US EPA action level of 4 pCi/l. For example: Spokane County radon test results for 210 homes have been received as of 3/94. Of homes with passive stack systems only 55% tested below 4 pCi/l. In contrast 100% of homes which received alternative complete active sub-slab-suction radon systems tested below 4 pCi/l.

**BACKGROUND**

The Washington State Indoor Air Quality Code (RCW 19.27.192) includes the following radon provisions:

1. Three month alpha-track radon monitors are provided by the building inspector at the time of final inspection to all new homes and all new ground floor apartments. Occupants or owners voluntarily participate by testing the new structure. Cavalier Corporation was contracted to provide the radon monitors and compile test results.
2. Based upon earlier statewide radon tests by several State and Federal agencies 8 radon problem counties were identified. Builders in these counties must install passive stack systems in the structures according to specific code prescription or "alternate" systems approved by the building department. (see description of systems below and attached drawing)

**DESCRIPTION OF SYSTEMS COMPARED IN STUDY**

1. Code version, Passive System:
  - \* 4" of washed aggregate (radon rock) beneath concrete slab
  - \* 6 mil. polyethylene (visqueen) between the aggregate and the concrete slab
  - \* 3" or 4" schedule 40 passive vent pipe from beneath the slab vertically through attic and roof, with room in the attic for a possible future fan and electricity available. Stack must be within the heated envelope of the structure
  - \* Seal floor cracks and penetrations
2. Cavalier version, Active sub-slab-suction system:
  - \* Any diggable soil, sand or gravel beneath the concrete slab
  - \* 4" ADS perforated pipe installed in a complete, connected loop within the soil beneath the slab in a ratio of 1 lineal ft per 10 sq ft of floor
  - \* Seal floor cracks and penetrations
  - \* Vertical radon vent of 4" ABS
  - \* Centrifugal in-line radon fan, 90 watt, in attic

## QUALITY CONTROL ASPECTS OF THE STUDY DATA

1. Random aspects: The alpha track radon monitors are by state law supplied to every new home and new apartment by individual building departments through the inspectors who perform final inspections prior to occupancy. These were all the same brand of test monitor which prevents bias which might have resulted from the differences between laboratories. Loss of the kits or non-use by homeowners is also random.

2. Method used to determine which homes have active and passive radon systems in Spokane County: Cavalier Corporation installs only complete, active radon systems. The 63 test results from active systems are Cavalier systems as identified by address. Therefore, among these 63 identified as active systems there is no margin of error. The study data covers a period of time when other contractors had just begun to install active systems. These were so few in number that none are likely to be inadvertently included. These would be wrongly categorized as passive systems, if the homeowners have tested. Therefore any bias would be only in the "passive" test results inadvertently categorized as "active". There is also no reason to believe that any builders or homeowners were installing code "passive" systems and upgrading to "active" before testing. Resistance to radon prevention has been widespread with builders usually opting for least work and cheapest price.

3. The percentage of homes which would have passed or failed without the use of the present code: Numerous studies have placed Spokane County radon test results between 39% and 63% above 4 pCi/l with an averages ranging from 6.2 to 11.3 pCi/l.

Study:	Year:	No. of tests:	% above 4 pCi/l:	Average:
"Radon" (Cohen)	1987	94	39%	6.2 pCi/l
Bonneville Power	1988	(29,000 statewide)	(Spokane 10 pCi/l)	
Cavalier Corp.	87-89	488	63%	11.3 pCi/l
EPA/DOH	1991	409	61%	

## QUALITY CONTROL ASPECTS OF THE INSTALLATIONS

1. Did builders install passive systems according to code?: Spokane County and City building departments perform inspections at every step of construction. Un-detected non-compliance with the specifications of the passive radon system are rare. Inspectors even go to the extent of rejecting the aggregate (radon rock) if it has any fines or the plumber has mixed native soil in the aggregate as he installed his pipes. The builder is then required to wash the radon rock or add more radon rock. The only non-compliance which may be widespread is the omission of the soil-gas-retarder-membrane, 6 mil. polyethylene (visqueen). This is not because of lax inspection but because some concrete workers boast that they pull and discard the visqueen just before the cement truck arrives. In retrofitting brand new homes Cavalier has found about 50% have no visqueen.

2. Was there any bias in house construction features for successful passive systems?: Cavalier has perceived none. We get calls to fix "passive" systems and see all structure types represented and all the heat system types represented. We do however perceive a bias which relates to soils. Passive systems are more likely to fail on highly permeable soils.

3. Was there any installation method which had a high success rate?: This study compares only the two methods, code passive version and Cavalier active version. Defining success as radon levels below 4 pCi/l, the Cavalier version had a 100% success rate. Code version resulted in a 55% success rate (45% failure rate). In the four studies referenced above, homes testing above 4 pCi/l ranged from 39% to 63%. Therefore, the 45% failure rate may or may not indicate some success but certainly not significant success.

## INDIVIDUAL CASE EXAMPLES

1. Case examples of active systems: Cavalier records allow us to keep track of all active systems we install, about 20 per week. The alpha-track monitors are provided by the building inspectors but some tests are lost before the home is sold and some homeowners don't test. This results in a disappointing "return rate". However, 100% of our complete active systems, which have been tested, have tested below 4 pCi/l.

2. Case examples of Cavalier systems in which homeowners have deliberately tested with and without the fan running: We have had 4 instances which homeowners have informed us about. In all cases the homes tested above 4 with the fan turned off and below 4 with the fan running. In all cases the homeowners had heard rumors that the fan was not necessary and chose to "experiment" both ways on their own.

3. Case examples of passive systems which tested above 4 pCi/l. These are just a few of many cases:

(A) Clock Tower Apartments - These were 7 apartment structures built in 1993. There were no known code violations. All 7 structures tested above 4 pCi/l. Fans were added by Cavalier 6/94 with no retest results yet.

(B) Harley - This was a 2 story 1993 home with a 2500 sq ft basement on very gravely soil with 76 pCi/l test of passive system and no code violations. Cavalier added a 90 watt fan to the 4" ABS passive pipe reducing radon levels to 40 pCi/l. Diagnostics revealed that the suction field did not extend beneath the entire slab (likely due to the extreme permeability of the soil and the large size of the structure). Cavalier added a second 6" active sub-slab suction system reducing radon levels to below 2 pCi/l.

(C) Freeman - This was a 2000 sq ft 1993 rancher in which the home-builder installed the passive system. The home tested high. There were no visible code violations. A radon contractor performed diagnostics and added a 150 watt fan. The homeowner was distressed that radon levels still exceeded 20 pCi/l and changed radon contractors, hiring Cavalier. Cavalier diagnostics revealed that the passive radon vent was plugged with clay soil below the slab. Cavalier improved the existing system and added a 6" retrofit system reducing radon levels to below 1 pCi/l.

(D) Castor - This was a 1700 square foot 2 story home which tested above 40 pCi/l. One code violation was discovered, the absence of visqueen. Cavalier added a 90 watt fan to the 3" passive vent resulting in a 20 pCi/l retest. Cavalier then improved the underslab connection of the existing system and added another 6" system reducing radon levels to below .5 pCi/l.

(E) Kovick - This was a 1992 one story home which tested in the 40's in the basement. The only visible code violation was that the passive vent terminated below the roof in the attic. The building inspector ordered the builder to continue the vent pipe through the roof which he did 6/94. Kovick retested on the main floor resulting in 20 pCi/l. The comparison with the earlier basement test is not really possible but unfortunately this is the way Kovick retested. Kovick has not yet decided whether to have the home mitigated professionally.

(F) Muzzy - This was a rancher with unsatisfactory radon levels. A temporary fan was added to the passive system stack on the roof. Radon levels were reduced to below 4 pCi/l. When a crew was dispatched to install the fan permanently in the attic it was found that there was no room for it in the attic due to poor location choice. The situation is not yet resolved.

(G) Various clients - Radon fan added to 6 passive system with satisfactory retest results.

## TEST RESULTS

### Statewide Data

Total Number of statewide test results to 3/94: 2208  
Number of statewide test results at or above 4 pCi/l: 125  
Number of test results at or above 4 pCi/l in the 8 radon problem  
"passive stack" counties: 78  
Total number of counties with tests at or above 4 pCi/l: 22

### Spokane County data

Total number of test results in Spokane County: 210  
"Passive stack" code version systems, tests at or above 4 pCi/l: 66  
"Passive stack" code version systems, tests below 4 pCi/l: 81 (55%)  
"Alternate" complete active systems, tests at or above 4 pCi/l: none  
"Alternate" complete active systems, tests below 4 pCi/l: 63

## CONCLUSIONS

The intent of code version passive systems was two-fold, according to its authors. First, it was anticipated that the passive piping in tandem with the visqueen and sealing floor cracks would result in significant radon reduction in new homes. This has not been the result. At worst, failure has increased by 6%. At best an 18% improvement has been achieved. The second intent was providing a ready means of converting from passive to active if radon levels warranted the conversion. Thus the passive piping and the electrical supply were to be readily accessible in the attic. Adding the fan was intended to consistently reduce radon levels adequately. Instead results have shown that radon reduction varies relative to system components, structure size, soil types and workmanship of the original installer.

# Radon Control For Higher Risk Counties

WASHINGTON  
STATE  
ENERGY  
CODE  
PROGRAM

## Section 500 VIAQ Code

### Radon Control In High-Risk Counties

