

SUB-SLAB DIAGNOSTICS

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ABSTRACT

Sub-slab diagnostics have eluded most radon contractors because 90% of installed systems work OK, the contractors are familiar with the soil and construction types, it takes too much time, and some of the directions are vague as to how to do diagnostics and what may be gained from doing them. The Pacific Northwest has many soil types; granite, basalt, clay, gravel, sand, and a combination of these. Although we do much of our work in the same types of soil, diagnostics helps us understand the variations within the each of the soil types at each house. Big question. Is there pea gravel under the slab, and what is the surrounding soil? Is the pea gravel clean or filled with fines? Is it crushed rock, or has the slab been poured on clay, or is the soil so porous the sub-slab pressure field wants to go to straight down to China instead of horizontally under the slab? Sub-slab diagnostics can help determine the best location(s) for sumps, the number needed, what type of sump(s), and size the system fan(s). These diagnostics help the installation of active slab depressurization systems that will work the first time.

PURPOSE

The purpose of sub-slab diagnostics is to check pressure field extension beneath concrete slab floors, sump pressure, and CFM (cubic feet of air per minute) needed to effectively control the rate of radon entry.

The radon system fan can be sized because the sump pressure is known, the CFM is known, and the pipe route is known so statics may be calculated for the pressure drop in the pipe.

Diagnostics can determine if floor cracks and cold joints need to be sealed. Are they short circuiting the pressure field?

Diagnostics can help choose sump size. Diagnostics of pressure field extension during installation will indicate if the sump needs to be enlarged to extend the pressure field, if another location may work better, or if more sumps are needed. It also gives the contractor confidence the sub-slab ventilation system will work when installed.

Once the system is installed it needs to be commissioned to determine if pressure field extension is satisfactory, and gives confidence in the system operation.

Knowing there is adequate pressure field extension reduces call backs, and increases customer satisfaction. These are 2 details that reduce the time a contractor has to return to the job to make alterations, and leads to contractor confidence in the installation, and customer satisfaction and referrals.

DOES IT WORK?

You bet it works and it comes reasonably close to predicting actual sump pressure, flow, and pressure field extension beneath the floor, except in some extremely porous soils where the pressure field wants to go straight down (a larger than average sump, tunneling, or sub-slab laterals may be necessary to provide a satisfactory pressure field extension).

Sub-slab diagnostics involves science, experience, and intuition. The science involves the quantitative measurements obtained and the process of obtaining the data.

Experience only comes with using these techniques. Do not expect to know what everything means the first time diagnostics are done, and maybe not even the tenth time they are done. There are many variations beneath slab floors. There will be high flow/low pressure observations at pilot holes, low flow/high pressure observations at pilot holes, incomplete pressure field extension but a definite pressure change, or no change at all.

Intuition is a sixth sense that tells you to go ahead and install the system where diagnostics indicates, and that a large enough sump will communicate with the far reaches of the slab. What kind of "feeling" is obtained from the diagnostics? Only experience can impart this "feeling".

HOW IS IT DONE?

Most contractors are familiar with the term "sub-slab diagnostics". **Just drill some holes through the slab and suck hard on one of them with a vacuum cleaner** to see if pressure beneath the slab can be reversed at the perimeter.

Objections raised are:

1. The vacuum curve does not fit the system fan curve
2. The call back rate without diagnostics is only 10%
3. Familiarity with local soil types and construction techniques
4. It takes too much time.

The vacuum can be adjusted to emulate a radon system fan. A 2.5 hp shop vac can move 90 CFM at 0" static and create well over 10" of pressure at a reduced CFM. Sump pressure is a function of CFM and vice versa. To create X pressure you need to move Y CFM. It doesn't matter that the fan is capable of 100" of pressure if it cannot move enough air to create 2" of pressure in the sump, so therefore the argument that a vac is too much fan does not hold up. It is the capability of the vac to move air that is the important factor in sub-slab diagnostics, and not many systems will require more than 70 CFM to create an adequate sump pressure. If more soil air needs to be exhausted, then a radon system fan should be used to test sump performance and pressure field extension.

Call backs are reduced to below 1%, and most of the diagnostic test holes need to be drilled if the system and sub-slab pressure field extension are to be commissioned.

A big plus to sub-slab diagnostics is the determination of sump location. During the bid inspection a location for the sump(s) may have been "eyeballed" that gives the system the best chance of creating an adequate negative pressure field under the slab, but routing the vent pipe out of the house may be difficult. Diagnostics will determine if the easy route is possible and if just one sump will provide an adequate negative pressure field, saving time and material.

It is helpful to test pressure field extension before, during, and after installation.

Before installation to assess communication, size the system fan, and determine the location and number of sumps.

During installation to see if the sump is large enough to provide adequate pressure field extension.

After installation is complete to assess the system performance.

Measurements made are the sump pressure, system CFM, and the pilot hole pressures.

Main test hole and sump pressure holes are used to apply suction under the slab and to test the proposed sump pressure. The pilot test holes are for testing pressure field extension.

The main test hole is drilled in the desired location for the system sump. It is a 1.25" hole to fit the vac tube, and is usually drilled next to a footing (interior or exterior) or plumbing pipe. Be careful not to punch a hole in any plumbing or sub-slab heating system.

The sump pressure hole is 0.5" in diameter and is drilled 1 to 1.5 feet from the main test hole. This distance should equal the radius of a sump that would be dug under the floor at that location. Pressure measured at this hole

indicates the installed sump pressure needed to create the change observed at the pilot holes, and can be used to measure the sump pressure with the completed system.

The pilot test holes are 0.5" in diameter, and are drilled at the perimeter, and along interior footings (usually at least 4 holes, one in each corner farthest from the main test hole).

THE PROCESS

1. Draw a floor plan of the slab if it hasn't been done.
2. Place the shop vac outside the building and route the vac hose into the house. Vacuum cleaners are not airtight and will spill dust and radon back into the house. This configuration keeps from re-entraining dust and radon into the house. No dust makes a lot of sense to the homeowner, and low radon makes a lot of sense from a worker health standpoint. It also gets the noise of the vacuum outside.
3. Drill all the test holes, note their locations and label them on the plans. This is where the pressure and flow data will be kept track of.

At this time sub-slab sniffs should be made if desired, before sub-slab radon characteristics have been changed by diagnostics, and noted on the plans.

4. Measure the "as is" pressure difference across the slab at the pilot holes with the vac off and on. Record the data on the plans. Usually there will be a 1 to 2 pascal positive pressure difference from the soil to the basement and sometimes more (4 to 15 pa). If it hasn't already been done, this might be a good time to cycle the forced air furnace fan on and off and record its effect on basement pressures. Make sure all window and exterior doors are closed for this test, and tape the opening the vac hose comes in through. Closed house conditions. Any open windows and doors will result in misleading pressure readings across the slab. A windy day can raise havoc with these measurements.
5. Connect the vac to the 1.25" main test hole, and duct tape around the flow tube to make it tight. Turn on the vac.
6. Check the furthest pilot hole for smoke reversal. If there is no smoke reversal, check pilot test holes closer to the main test hole for reversal. At this time check the floor for cracks that may short circuit the pressure field extension.
7. Measure the sump pressure and adjust the vac, if needed, to emulate the desired sump pressure.

<u>Fan Model</u>	<u>Max Pres @ 0 CFM</u>	<u>Max Flow @ 0" Static</u>
FR 100	0.85" WC (212pa)	120 CFM
FR 150	1.50" WC (375pa)	245 CFM
FR 160	2.10" WC (525pa)	380 CFM
FR 175	2.40" WC (600pa)	400 CFM

When choosing which fan to install, consider the amount of air to be exhausted, sump pressure needed, and the static loss through the radon vent pipe. Fan performance curves will help in the selection as will a duct friction loss calculator. The complete fan performance curves and not the 4 or 5 data points usually given are necessary for this procedure. Included with this paper are fan curves for Kanalflakt fans, the F-4, F-6, F-8M, and F-8L. These come reasonably close to the FR-100, FR-150, FR-160, and FR-175 respectively. These curves are at the end of this paper.

8. Measure the flow (CFM) on the vacuum side of the shop vac and not the exhaust side. As was noted before, shop vacs are not tight and the CFM on the vacuum side does not necessarily equal the CFM on the exhaust side.

9. Measure the pilot hole pressure changes and record the data on the floor plans. Ideally there will now be negative pressure under the floor, but it won't always be the case. Positive pressures under the slab indicate the need for crack sealing, a larger sump, another sump location, more sumps, and or a higher suction fan.

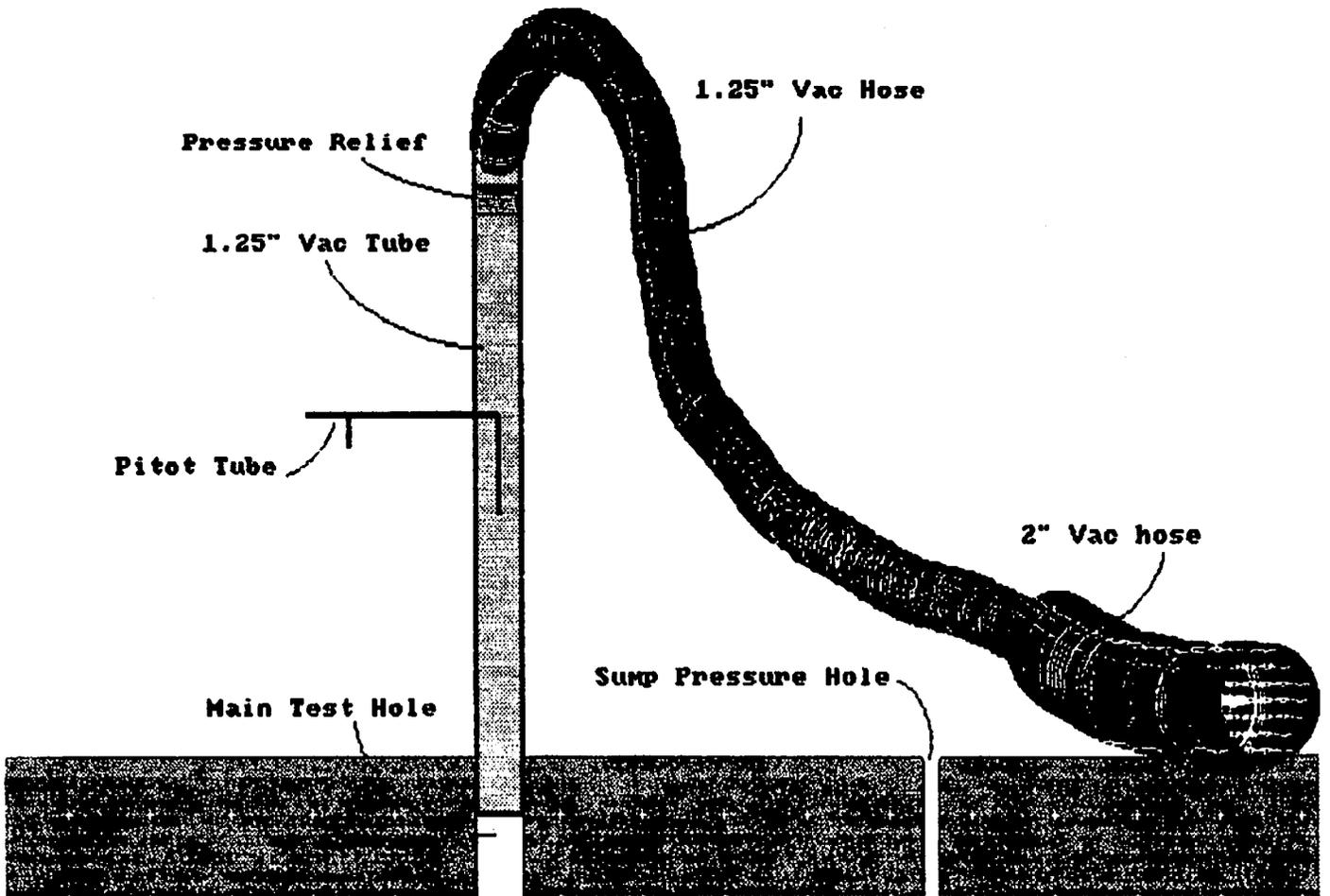
It is helpful in this test to cycle the shop vac on and off at each pilot hole especially if the diagnostics are being done when it is windy outside. It has been noted with some sub-slab tests that there may be a lag-time in pressure reach when cycling the shop vac on and off, and it is necessary to let the pressure field acquire equilibrium.

It may not be necessary to achieve a strong negative pressure field under the slab. If 90% of the slab has a good negative pressure field extension beneath it, that may be enough. Radon entry in houses has been effectively controlled with as little as -0.5 pa (-0.002" WC) pressure difference at remote pilot holes, however -2.5 pa (-0.01" WC) and greater should instill confidence the system will control radon.

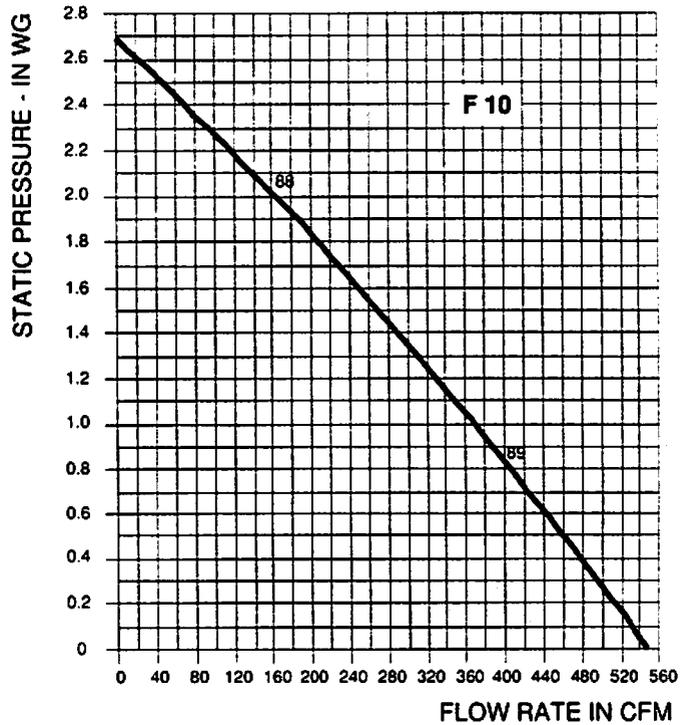
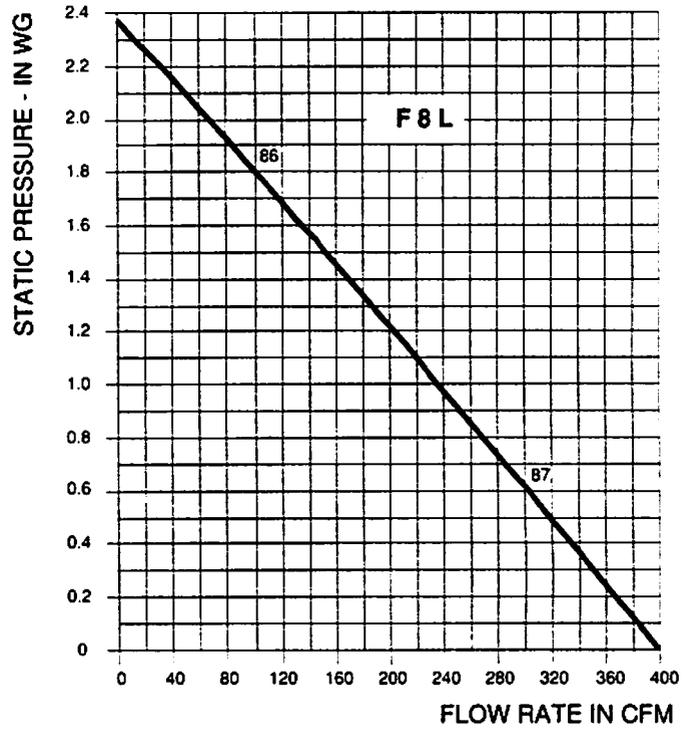
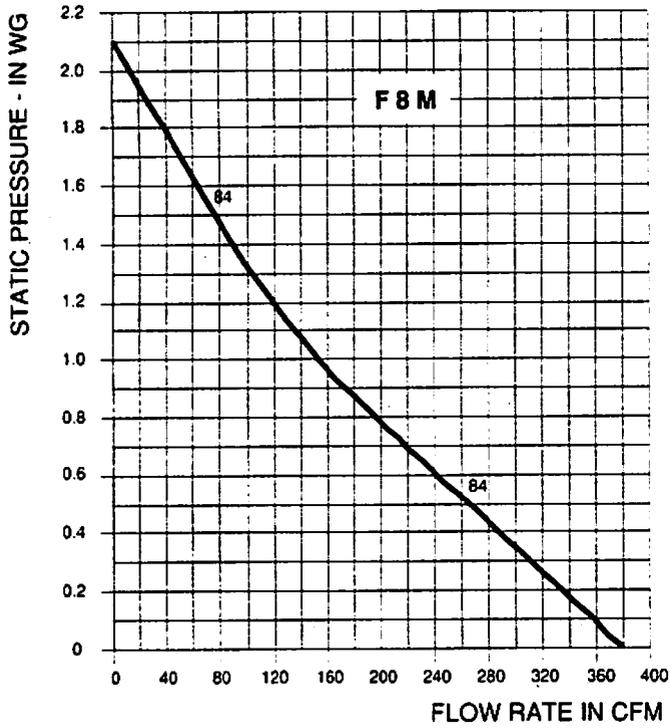
10. Once the main test hole, or excavated sump, creates the desired effect at the edges of the slab, measure the CFM exhausted by the vac and the pressure created in the sump. Calculate the static loss for the CFM in the vent pipe and add to the sump pressure. This will indicate what pressure the fan will need to achieve and the amount of air it will have to move at that pressure. It now becomes a matter of looking at the fan curves and choosing the one that fits best. If it's close, the next larger fan might be chosen.
11. Intuition gained from doing a lot of diagnostics can streamline the process and measuring the CFM may become unnecessary in most cases except where documentation is required.

Tools needed:

1. Eye protection
2. Ear protection
3. Roto hammer with 1.25" capacity
4. 1.25" concrete drill bit
5. 0.5" concrete drill bit
6. Electronic digital manometer with 0.001" resolution
7. 6" pitot tube to measure flow through the 1.25" vacuum extension (the equation for measuring the CFM once the flow in feet per minute is known is, assuming an inside flow tube diameter of 1.14":
 $(1.14 \cdot .5)^2 \cdot 3.14 / 144 = \text{CFM}$)
8. 1.25" OD vacuum extension with small hole drilled for pitot tube
9. 2.5hp or greater shop vac (90 CFM capacity preferred)
10. 75' of vacuum hose
11. 6' of vacuum hose (comes with vac)
12. Chemical smoke gun
13. Flashlight
14. Ductape
15. Floral clay (sticky)
16. 2/50' extension cords



Performance Curves



Performance Curves

