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Radon Diagnostics

Workshop Proceedings

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OVERVIEW OF SELECTING RADON MITIGATION METHODS

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Over the past several years a growing number of researchers and contractors have been lowering elevated radon levels in residences by a number of techniques. All of them fit into one of the following categories:

1) Prevent radon entry

- preventing radon entry by soil depressurization or pressurization
- preventing radon entry by basement pressurization
- preventing radon entry by sealing of entries

2) Dilution of radon by introducing outside air (It is important that this does not increase soil entry by putting negative pressure on the basement)

- heat recovery balanced flow
- non-heat recovery flow (Blowing in or powered by negative pressure on the basement)

There are perhaps a dozen specific methods that have been tried with varying degrees of success in lowering radon concentrations and no doubt several more that are experimental, untried or undreamed of. The advantage to having a number of techniques available to choose from is that it gives flexibility - an opportunity to use a method that has a greater chance of success.

The problem of course is to select the one or two from amoung the multitude that gives you greater chance of success or is most appropriate for the situation.

Here are my thoughts on selecting a mitigation technique, based on experience, feelings, the work of many others and of course analysis of the physics involved. Please keep them in perspective. In many ways they are incomplete or tentative. They are certainly open to new thought and modification. I would be very distressed if they interfered with new insight or discouraged asking questions by appearing to provide answers when they are really ideas.

Begin at the House

Probably 80% of the information I use to decide on a

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mitigation technique is gathered by using my eyes and brain while visiting the house. First thing I do is see what state of mind the homeowner's in. I may be the first semi-knowledgeable person to come in contact with them and they may have a number of fears concerning thier health, thier families health (will this affect my daughters ability to have children ?) and the impact on the value of the property. I want to keep them from undue panic but not calm them down so much that they don't do something about a real problem.

The second thing I do is get a feeling for the house by walking around it keeping my mind clear and paying attention to my peripheral vision. I'm looking for how the building's put together, are there any unaccounted for volumes in the house, exhaust fans, furnaces, ways to get pipes around. But most importantly I'm looking for ways that radon can enter the building, how does the building hit the ground, sumps, footer drains, crawlspaces any place there is a large soil surface that has good airflow connection to the house.

I am always asking "What is going on here ?" Where is radon coming in ? Why is it coming in at all ?

Then I make a floorplan and fill out the site form. This is nothing more than a way to get the information most critical to selection of a mitigation plan together in one spot. The homeowner may know if there are exterior footer drains, perhaps there are gutters emptying into risers from the footer drains and you can see them. The homeowner may have photographs of the building under construction from which you can learn a great deal. Once again it is physical inspection that tells you most.

Look and see !!

The key things I look for when simply observing are:

For soil depressurization

- soil gas entry points using eyes and smoke sticks
- anything that is like a cavity that has a large contact with soil surface
  - hollow core block walls, cored and reinforced ?
  - interior or exterior footer drains
  - sump holes (drains or no ?)

For basement pressurization

- basement that seems tight and is easily isolated from the upstairs
- no combustion appliances upstairs
- basement that is hard to apply soil depressurization to (finished, hard to seal wall or slab openings)

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For dilution with outside air

- crawlspace or basement that is easy to isolate (no freeze problems, few penetrations)
- tight house
- lack of other options

Measurements

Soil Depressurization Tests

Drill at least two holes through the slab (basement floor, slab on grade or crawlspace floor). One of these is 1-1/4" diameter (coincidentally the O.D. of the hose for a Eureka Mighty Mite vacuum cleaner), the other 3/8".

Use smoke sticks to see if soil gas is entering from the holes (if it is then the make up air must be coming from somewhere, eh?

Look in the large hole. What do you see ? #2 stone, sand and gravel, silt, clay, bedrock ? A good bed of stone everywhere and you can easily depressurize the entire sub-slab soil surface (maybe 1800 square feet or so in one fell suction point).If it is clay it will be hard to get any pressure field to develop under the slab. If the soil has settled away from the slab (most likely near the edge) you may have good access to a large soil surface even if the sub-slab soil is clay.

If the basement wall is concrete block drill at least one 3/8" hole in it. If there is a wall that has a slab on grade next to it (like a garage floor, a patio or living area as in a split level design) then drill a 3'8" hole in that and one hole in another wall.

Take a grab sample under the slab and in holes in the block walls (or better yet do a sniff with a scintilation flask). Are they higher than the basement air ? Are they higher because it is a major source or because the air under the slab is very stagnant ? This is one of the tests I'm not sure how to interpret. Does it really make a difference if I depressurize the soil in the location with the highest concentration ? I am sort of using that as a guideline right now, but I wish someone would do some research to help me understand grab sample results better.

Use the vacuum cleaner to put a suction on the large hole in the slab and check with smoke sticks at the other holes that you've drilled through the slab and walls or at floor cracks, sump holes and other openings through the slab that were already present to see how easily air will move beneath the slab. If there is #2 stone or a cavity under the slab this will probably be quite far. If it is sand under the slab you can expect a pressure field to develop only 5

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to 15 feet away from the suction point. Sometimes in a very fine, tightly packed soil (fine sand or silt) you will get no airflow with this test, but if you release some Freon under the slab at one of the smaller holes it will quickly move to the vacuum where it can be detected in the vacuum exhaust with a halogen detector of the type used by refrigeration and air conditioning technicians. With the vacuum cleaner not running you can inject Freon under the slab and find locations where it leaks back into the basement, identifying soil gas entry routes, and if exterior footer drains are present you can sometimes find where they drain away to daylight by sniffing around outside and finding Freon exiting to the open air.

The purpose of these tests are to decide whether soil depressurization can be effectively employed as a mitigation technique. If it is easy to develop a pressure field in the sub-slab agregate or block wall then this will be a preferred method. If the vacuum cleaner test results show no airflow but Freon will move or if the vacuum cleaner suction test ios marginal (spotty or only a few feet) then sub-slab suction might be possible but should be considered with other possibilities.

Basement Pressurization

A fan door test between the basement and upstairs is done with particular attention paid to the 10 Pascals or less delta P range. The test should be run so that air is being blown from the upstairs into the basement. In the basement another person is checking with smoke sticks to see when soil gas stops entering the building, reverses and is actually leaving the basement and being blown back out into the soil creating a sort of air pressure shield that forces soil gas away from and around the building. If this can be accomplished using a small enough airflow (I'd say less than 300 cfm at 10 Pascals) then basement pressuriztion may be considered as a mitigation tehcnique. In this method air would be drawn from the upstairs house putting some negative pressure on the upper part of the building and blown into the basement to pressurize it and prevent soil gas entry. The fan door test will give you some idea of what performance characteristics a fan would need to do the job. If the airflow rate can be lowered from 300 cfm to 200 cfm by sealing the floor between the basement and the upstairs then this should not greatly add to the energy load from infiltration because it is just reversing the normal stack effect airflow found in cool climates in the winter time. Another precondition for this mehtod would be the absence of a fireplace, woodstove or other vented combustion device in the upstairs where the pressurization air would be drawn from.

Dilution of Radon Test

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A fan door test is done on the whole house to get an idea of how tight the building is. This will aid in deciding if introducing dilution air is a possibilty for controlloing radon levels. Armed with some simple infiltration models and assuming that dilutionair can be added without putting a negative pressure on the house that would increase soil gas entry an estimate can be made of the expected reductions in radon concentrations for varying increases in ventilation air.

If there is a crawlspace or basement that would be easy to isolate from livingspace and does not contain things that would need freeze protection (or are easily protected from freezing) then I would consider isolation of the space and passive ventilation (followed by active ventilation if passive didn't quite do it).

Selecting The Mitigation Technique

When it comes to selecting a mitigation method I am currently using the following order of preference.

- soil depressurization (or pressurization)
- basement pressurization
- isolate and ventilate (crawlspace or basement)
- ventilate house

For deciding on what do do within each of these categories I am using logic shown in the decision charts for each of these categories at the end of this paper.

All of this is just used as guidelines and the final selection will involve aesthetics, noise, homeowner preference, budget, insight from the mitigation contractor, permanence of installation, power consumption, longevity and a variety of other more or less subjective factors that may overide the logic outlined above.

Selecting Mitigation Method

Investigate Building by looking, filling out site forms, doing qualitative and quantitative tests.

Use Results of Tests and Flowcharts to make a List of Mitigation Techniques to be Considered

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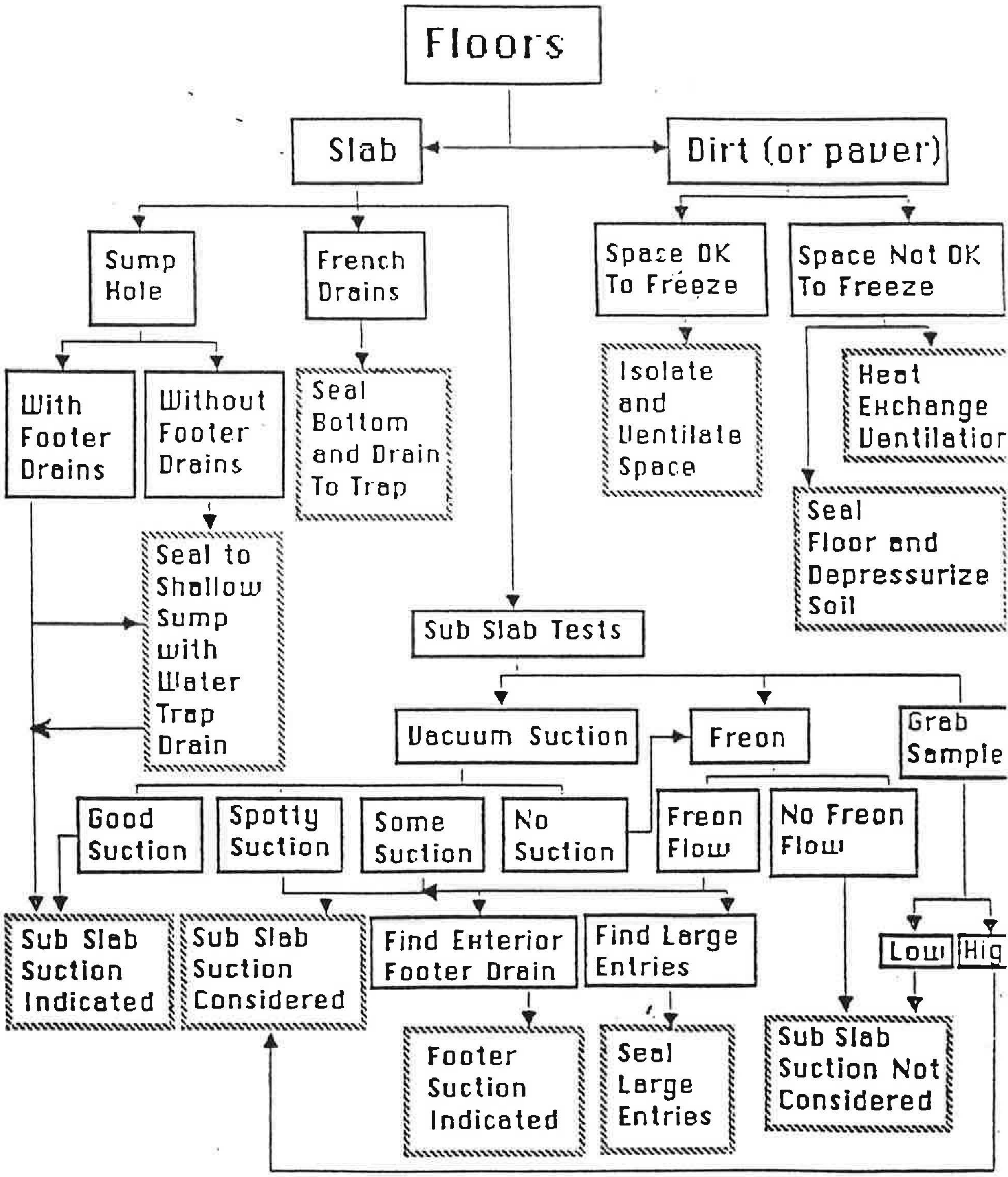
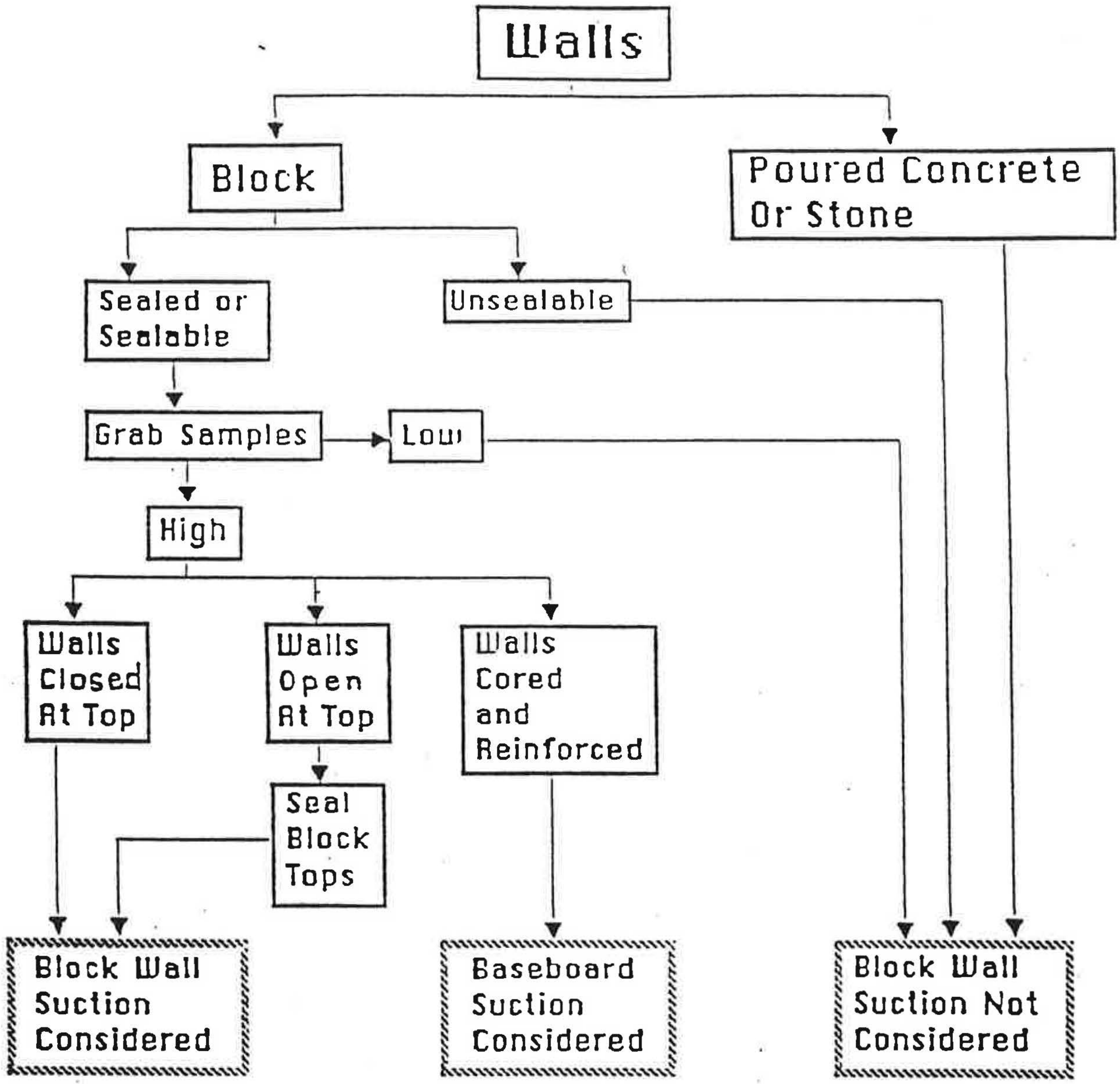
Make the Final Selection Based on Your Current Method Prioritization List and all Those Important Factors That Flowcharts Don't Accomodate Aesthetics, Noise, Homeowner Preference, Contractor Input, Combinations of House Features That the Charts Don't Allow.



Floors
Slab
Dirt (or paver)
Sump Hole
French Drains
Space OK To Freeze
Space Not OK To Freeze
With Footer Drains
Without Footer Drains
Seal Bottom and Drain To Trap
Isolate and Ventilate Space
Heat Exchange Ventilation
Seal Floor and Depressurize Soil
Seal to Shallow Sump with Water Trap Drain
Sub Slab Tests
Vacuum Suction
Freon
Grab Sample
Good Suction
Spotty Suction
Some Suction
No Suction
Freon Flow
No Freon Flow
Low
Sub Slab Suction Indicated
Sub Slab Suction Considered
Find Exterior Footer Drain
Find Large Entries
Footer Suction Indicated
Seal Large Entries
Sub Slab Suction Not Considered


Walls
Block
Poured Concrete Or Stone
Sealed or Sealable
Unsealable
Grab Samples
Low
High
Walls Closed At Top
Walls Open At Top
Walls Cored and Reinforced
Seal Block Tops
Block Wall Suction Considered
Baseboard Suction Considered
Block Wall Suction Not Considered

Current Prioritization List

My current order of preference for mitigation techniques is as follows :

- Depressurize soil or isolate and vent non-living spaces (use flowcharts for Walls and Floors to find which methods should be considered for the house)

- Pressurize basement (Do a fan pressurization test on the basement using the basement door to decide if this is appropriate and if so what fan flow at what pressure drop is needed. Currently, I'm using 300 cfm as the decision point)

- Add ventilation air to dilute the radon (Use a fan door test on the whole house to help decide if adding dilution air will provide the reductions needed assuming that it can be done with balanced or positive pressure flow.

HOUSE SUMMARY SHEET

HOUSE ID ______________ PHONE NUMBER ____________________________

NAME ____

ADDRESS ____

____

____

HOUSE TYPE ____

HOUSE AGE ______________________

TIGHTNESS DATA

AIR CHANGES AT 50 PA __________________________ ELA ________

EARTH CONTACT AREAS

_____ PIERS ____

_____ SLAB ____

_____ CRAWLSPACE ____

_____ BASEMENT ____

SOIL GAS ENTRY ROUTES

_____ CRACKS IN WALL _____ SUMP HOLE w/DRAIN TILE

_____ CRACKS IN SLAB _____ AIR DUCTS UNDER SLAB

_____ EXPOSED EARTH _____ OPEN CONCRETE BLOCKS

OTHER ENTRIES

____

____

____

____

HOUSE SUMMARY SHEET - PAGE 2

NEGATIVE PRESSURE DATA

Exhaust Devices

CFM

_____ Bath Fans _____ __________

_____ Dryer _____ __________

_____ Range Fans _____ __________

_____ Kitchen Fans _____ __________

_____ Whole House Fan _____ __________

Heating System Type

Fuel _____ Distribution __________

Thermal Bypasses

_____ Around Chimney _____ Plumbing Chase

_____ Balloon Walls _____ Recessed Lights

_____ Soffits _____ Bath Fans

_____ Attic Scuttle _____ Pocket Doors

Other Bypasses __________

____

____

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RADON MEASUREMENT HISTORY

Time Integrated

Date	Location	Results	Units

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HOUSE SUMMARY SHEET - PAGE 3

Grab Samples

Date	Location	Results	Units

Suggested Mitigation Strategies: