



Myth Busters: Addressing RADON Protections for High Performance Homes

Indoor airPLUS a PHIUS Partner

Gary Hodgden and Paul H. Raymer
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Indoor airPLUS Program Overview



- Non-regulatory home label; currently for new homes.
- Assists home builders, trade contractors & renovators
- Concrete way for builders to sell health benefits to customers
- Independent, 3rd-party verification
- Construction Specs, technical support, marketing resources

ENERGY STAR + Indoor airPLUS



- Envelope
- HVAC
- Moisture
- CO

+



- Radon
- Pests
- Materials
- HVAC +
- Moisture +
- CO +

=



- 1. Better durability**
- 2. Less long-term maintenance**
- 3. Comprehensive indoor air quality protection**
- 4. A safer, healthier home**

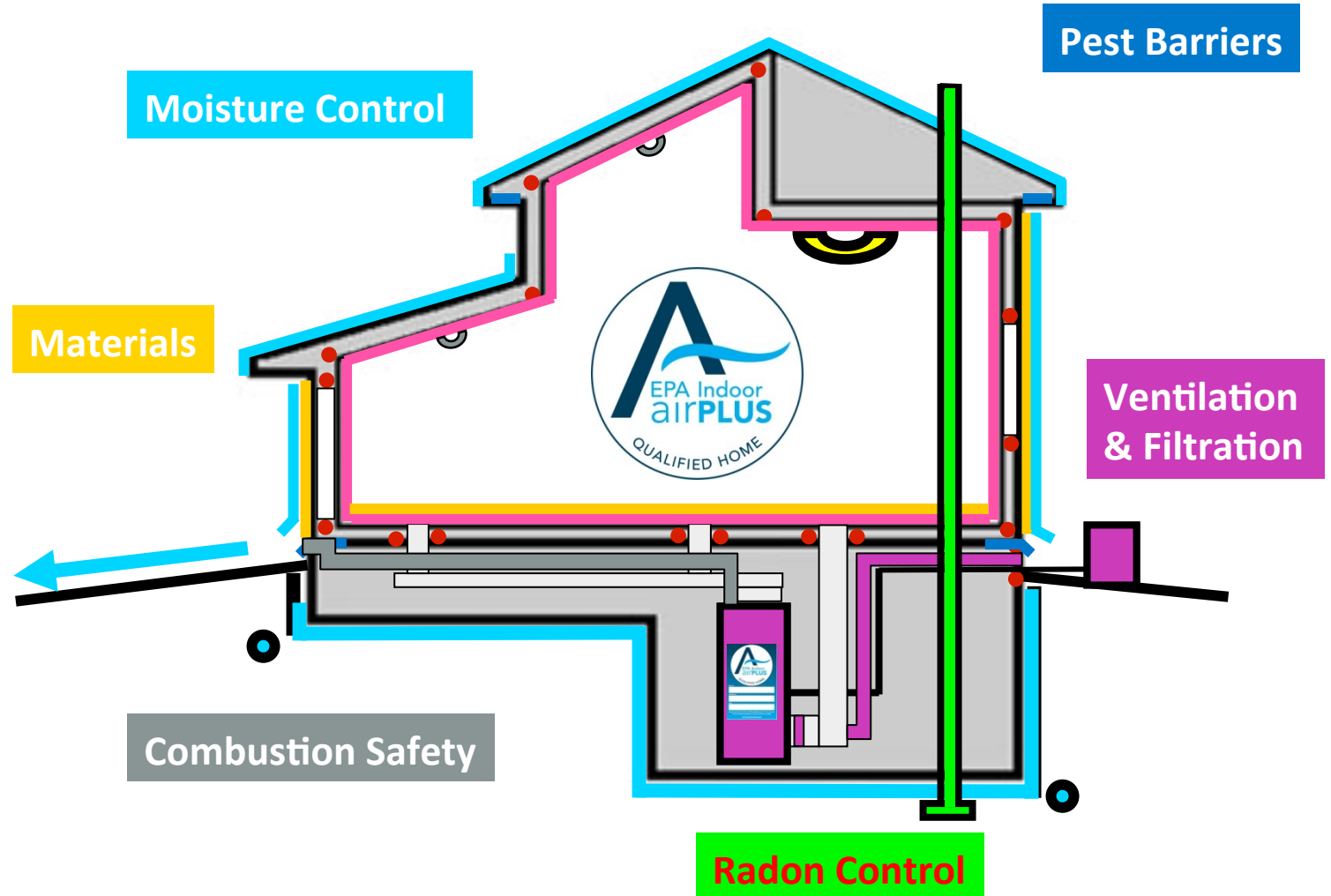
Indoor airPLUS as a Health Benchmark for High-Performance Homes

- IAP is respected as a benchmark for IAQ to protect occupant health in new homes.
- IAP is required by other labeling programs (Zero Energy Ready, PHIUS) as a pre-requisite.
- IAP is also referenced by LEED for Homes and the National Green Building Standard.



How to Use the Construction Specifications

- Seven sections:
 - Moisture Control
 - Radon
 - Pests
 - HVAC Systems
 - Combustion Pollutants
 - Materials
 - Home Commissioning
 - Homeowner Education



Myth Busters

Addressing Radon Protections for High-Performance Homes

Gary E. Hodgden, Secretariat

ANSI/AARST Consortium on National Radon Standards

www.RadonStandards.US

Introduction

- Radon gas is responsible for about 21,000 lung cancer deaths every year in the US and is the number one cause of lung cancer among non-smokers
- Other soil gases and excessive moisture can lead to a host of other issues in tight homes, even when whole-house ventilation is part of the design

Introduction

- As such, radon-resistant new construction (RRNC) is important for high-performance buildings
- Fortunately, RRNC construction techniques are simple, affordable and effective if correctly designed and installed

But there is a lot of misinformation out there.

The Radon Hazard

Myth 1

“Radon precautions are unwarranted. There is no evidence that anyone has died from radon”

The question: **Is the risk from radon real?**

Yes

Risk estimates are based on studies of lung cancers in human beings.

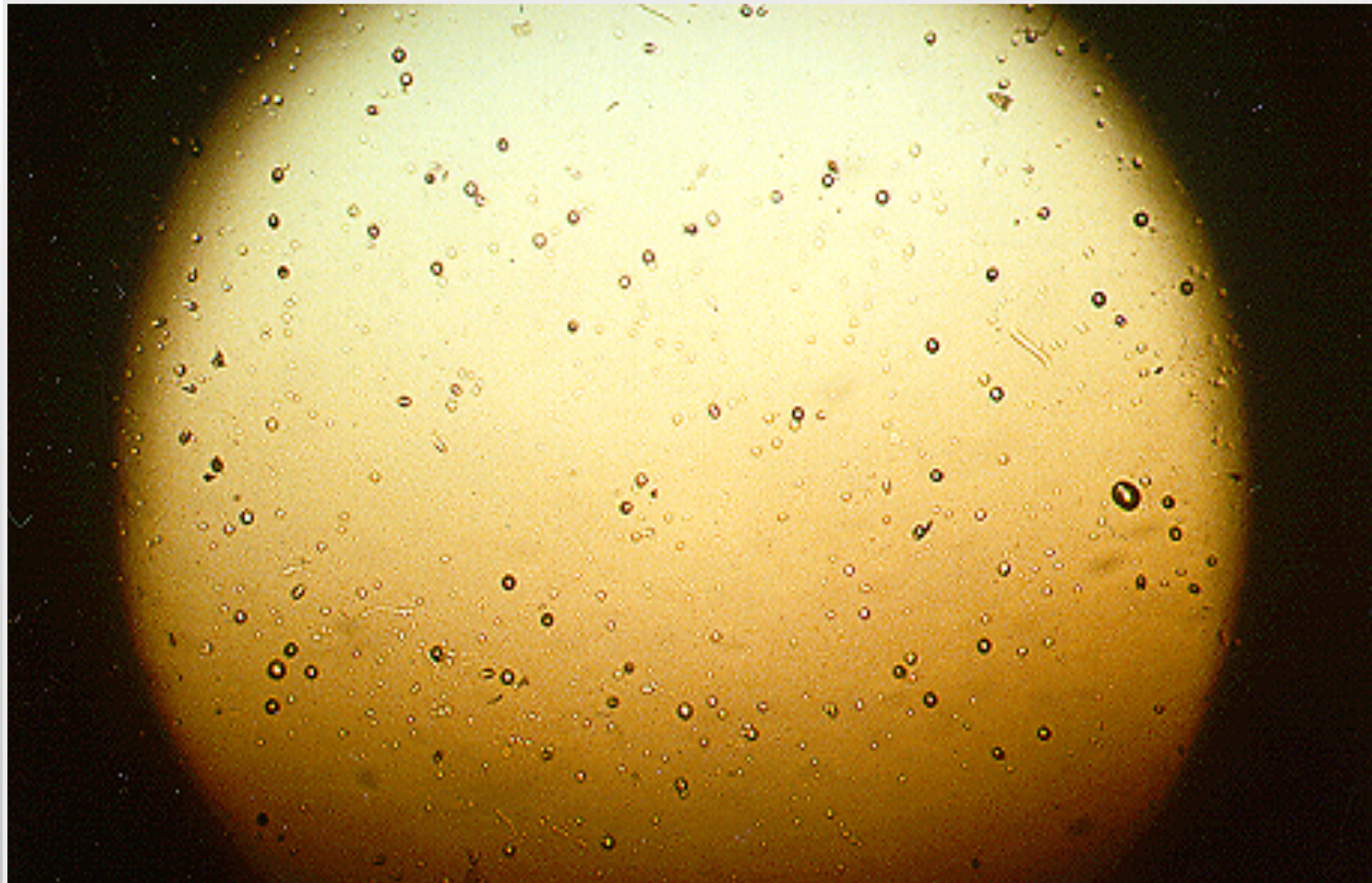
The Radon Hazard

Visible in a laboratory cloud chamber



The Radon Hazard

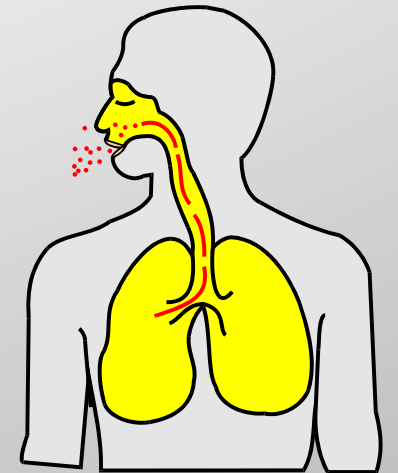
Dents in plastic caused by radon can be seen with a cheap microscope.



The Radon Hazard

The Science

- Fortunately, the liquid lining of the lungs serves to shield tissue.
- Fortunately, individual cells struck by an alpha particle most often die rather than turn cancerous
- However, **any single alpha particle strike to a cell is capable of causing lung cancer**



Myth 2

“Radon hazards do not exist in my area”

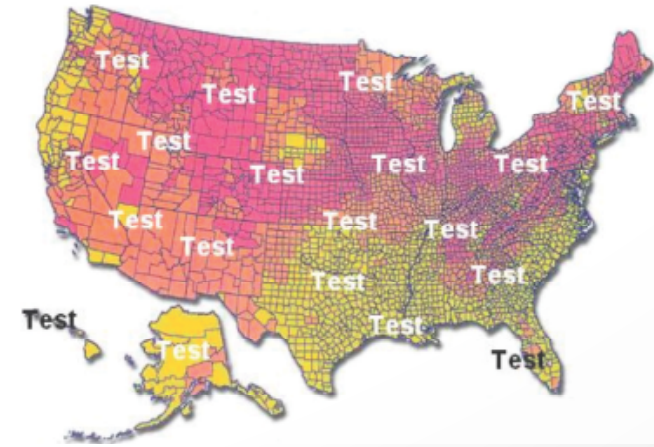
**Is it only in locations that have
“certain specific” geological conditions?**

Yes, but those conditions have been found in virtually every county in the U.S.

- Radium (that produces radon) is salt-and-peppered across soils everywhere on earth
- Radium distribution can be vastly different across each parcel of land

Myth 2

“Radon hazards do not exist in my area”



Published survey maps

- In Zone 1 counties (i.e., mean average ≥ 4 pCi/L), nearly **50%** of the homes exceed the action level
- In Zone 2 counties (i.e., mean average 2-4 pCi/L), **20-30%** of homes typically exceed the action level
- **All zones** are witnessed to have pockets of homes or portions of a city show up with radon hazards

Myths 3 **Radon hazards are ...**

- only in homes with basements or crawl spaces?
- not in well ventilated homes?
- not in slab-on-grade buildings?
- only if there is a sump hole?
- only in older homes?
- only in newer homes?

None of these myths are true

No one component about building design allows a person to confidently predict levels of radon.

Myth 4

“Sealing cracks and holes in the floor will fix radon problems”

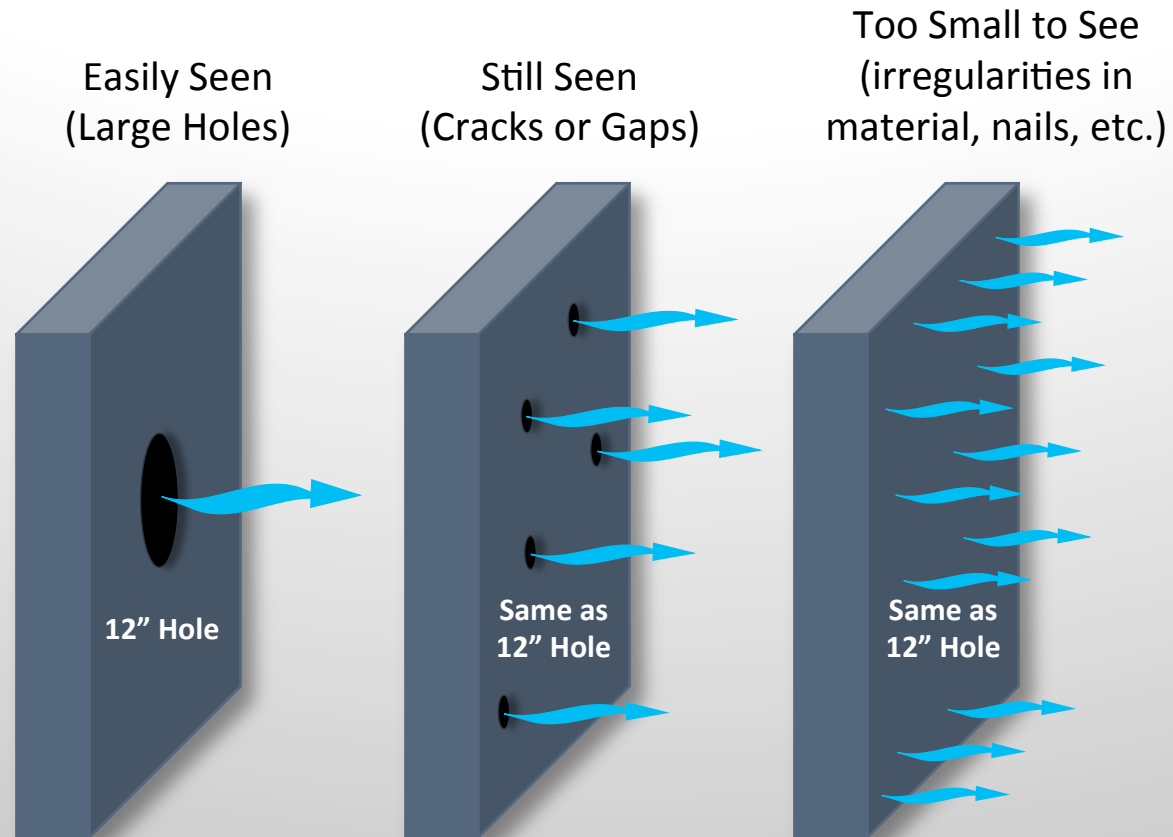
The question: **Does sealing fix radon?**

Rarely

- Soil-gas is pressure-driven into homes through the smallest gaps and those not visually identifiable
- Sealing is an integral part of any mitigation method.
- But no foundation is completely airtight or stays airtight over years to stop pressure-driven air.

Myth 4

“Sealing cracks and holes in the floor will fix radon problems”



Myth 5

“I don't live in a basement. So, I am not exposed to radon hazards”

Not a true assumption

Air exchange rates (dilution) are different for each given room or floor-level in a home. However:

- *Passively:* A car running in an enclosed garage will set off carbon monoxide alarms within the home after about 5 minutes
- *Actively:* HVAC air handlers distribute radon laden soil gas throughout the home whenever blowers are active

Myth 6

“Passive radon features are in place. I’m safe”

Incorrect assumption

- Be it passive or active systems ... **there is no way to know without testing**
- Particularly without a fan, passive energy sources that might control radon gas are intermittent
- For passive efforts, it is important to verify effectiveness by testing in no less than two seasons, to include the heating season.

Myth 7

“Tests are unreliable. They indicate dangerous radon readings one day and safe readings the next day”

The question: **Are radon tests reliable?**

- 1. It is wise to assume each test result is reasonably accurate**
 - Side-by-side testing under the same test conditions will almost always produce similar results from two devices

The question: **Are radon tests reliable?**

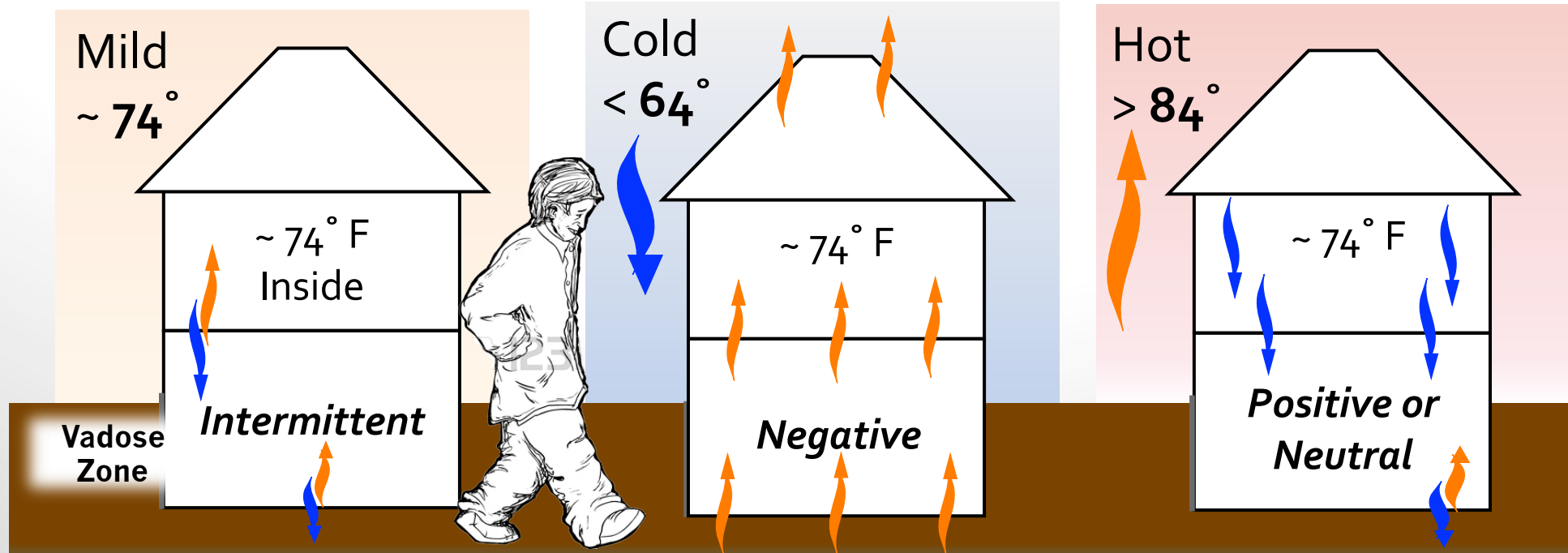
2. Risks are associated with a range

- Folks imagine 3.8 pCi/L is safe and 4.2 pCi/L is dangerous
But the health hazards of 3-5 pCi/L are identical
- It's not about decimal digit accuracy
It about the range of occupant risk

2. Seasonal Variations

- As buildings respond to changes in outside temperature, the magnitude of driving forces for radon entry vary.

Propensity of Negative Pressure



24 Hour Temp Averages		Annual	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
ZONE		Avg												
1 Very Hot	Miami, FL	76	82	79	74	69	68	69	72	75	79	82	83	83
2 Hot	New Orleans, LA	69	79	70	61	55	52	55	62	69	76	81	82	82
3 Warm	Atlanta, GA	62	73	63	53	45	43	46	53	62	70	77	79	79
4 Mixed	Phillidelpia, PA	55	68	57	47	36	32	34	42	53	63	72	77	76
5 Cool	Chicago, IL	49	65	53	40	27	22	26	37	49	59	69	74	72
6 Cold	Minneapolis, MN	45	61	50	33	19	13	18	31	46	59	68	73	71
7-Very cold	Minot, ND	39	56	45	26	14	6	11	21	41	53	61	68	67
8 SubArctic	Fairbanks, AK	27	45	25	4	-6	-8	-2	11	31	49	60	62	57
8 SubArctic	Cambridge Bay	6	32	11	-9	-21	-27	-27	-22	-7	15	36	47	44

The question: **Are radon tests reliable?**

RRNC, if optimized, can make seasonal differences to provide lower annual exposures

1. Venting with a vent pipe that is open to permeable aggregates allows soil gas to migrate to the outdoors above the roof;
2. Sealing the building shell where it meets soil serves to create a barrier between soil gas and indoor air; and
3. Using tighter building shells to help minimize building pressures that drive soil gas entry.

Myth 8

“It is not justifiable to install radon reduction features when only a few homes will have a radon hazard”

Are there benefits for virtually all structures?

Yes

1. Radon

- Compared to 4 pCi/L, guidance from the World Health Organization (< 2.7 pCi/L) and EPA (< 2.0 pCi/L) definitively correlate to less hazard.

RRNC might often make that difference.

- If tests indicate results above the action level, that difference is virtually assured when adding a fan.

Are there benefits for virtually all structures?

2. Vapor control

- Soil gas is an overwhelmingly contributor of moisture in the form of vapor that causes smells, biological hazards and energy penalties
- Radon systems reduce vapor entry
 - Except they can't prevent high humidity that comes in from outside around windows, door frames, etc.

Are there benefits for virtually all structures?

3. Other soil gas hazards (chemical vapors)

- Chemicals intentionally applied such as for termite treatment or with lawn care
- Chemicals in nearby landfills or industrial sites and even from agricultural herbicides and fertilizers

Myth 9

“Spending money on tightening up the building will increase radon concentrations”

Does a tighter home increase radon?

It Depends

Indoor air quality is a “whole building” issue.

- If failing to reduce both air that exits the upper building and soil gas entry, you will likely see higher radon concentrations.
- But some studies indicate little effect. While lower air change rates reduce dilution, a tighter building can mean less stack effect that drives radon entry.

Myth 10

“Increased ventilation will eliminate radon hazards”

Is the solution to radon pollution ... dilution?

Not for radon in homes

Rarely is it a viable solution

- Energy penalties: To dilute radon by 50% requires doubling the existing air change rate.
- For commonly found concentrations like 10 pCi/L, you must increase outside air entry by more than 4 times the home's original air change rate.

Myth 10

“Increased ventilation will eliminate radon hazards”

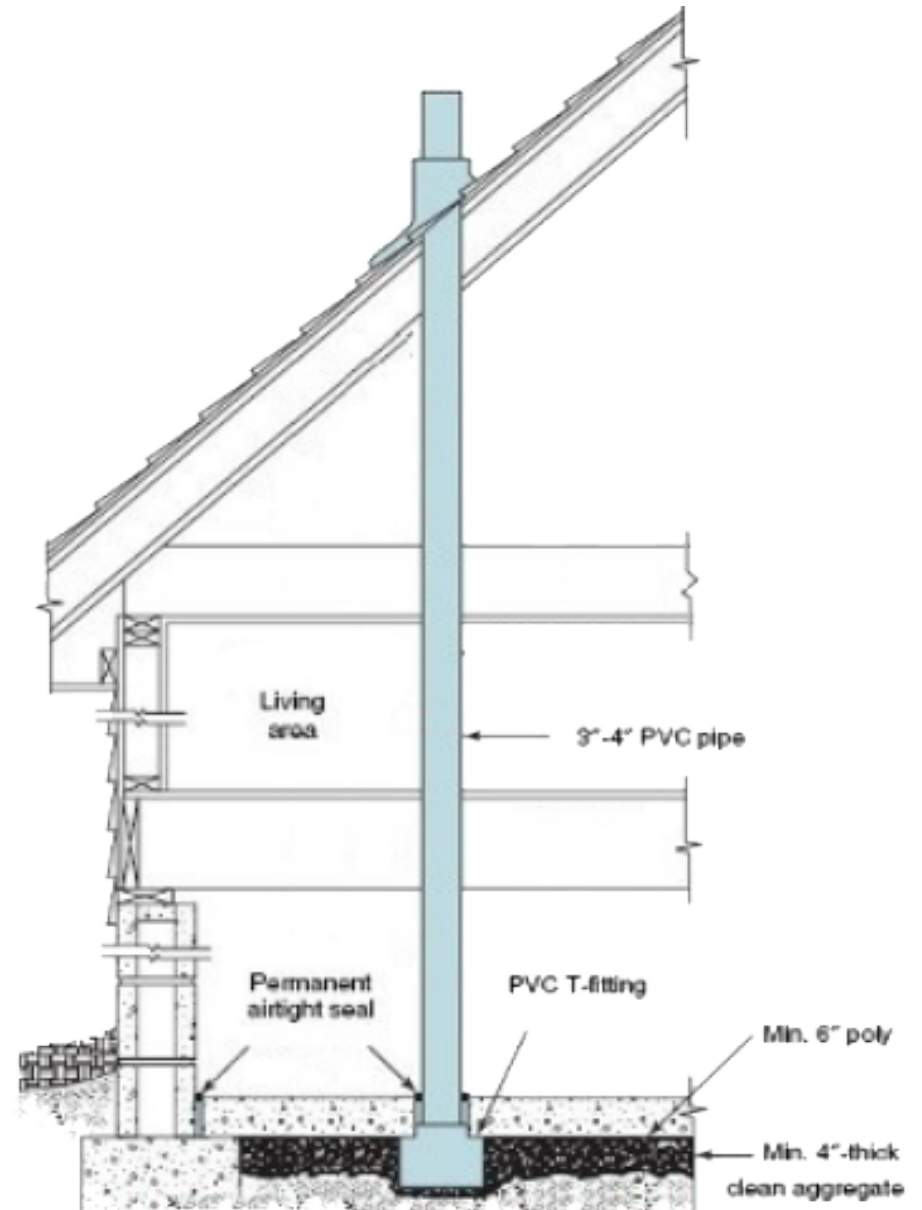
**What about causing systems to pressurize
airspace in contact with ground?**

Compared to controlling soil gas before it enters, **not reliable**

- Maintaining a pressurized airspace is a volatile situation across the life of a building and there are energy penalties
- In addition, soil gas can be merely pushed under the floor to enter in a different area

*What Are The
Viable Options?*

*and How Do
They Work?*



Myth 11

“Passive radon features have demonstrated such poor success that it’s hardly worth the expense”

The degree of reduction in soil gas entry is directly attributable to the degree achieved for:

1. Providing permeable conditions under the home to easily control the destination of soil gas,
2. Breaking the connection between soil air and occupied spaces, and
3. Soil gas venting while countering or minimizing air pressures that drive soil gas into a building.

Optimizing Effectiveness



1. Hydraulic conductivity below the slab

- To manipulate the destination of soil gas, we need soil gasses to move freely under the building
- Ground water control using a layer of highly permeable gravel or crushed stone under the building are the same practices that allow passive and active control of radon

Optimizing Effectiveness

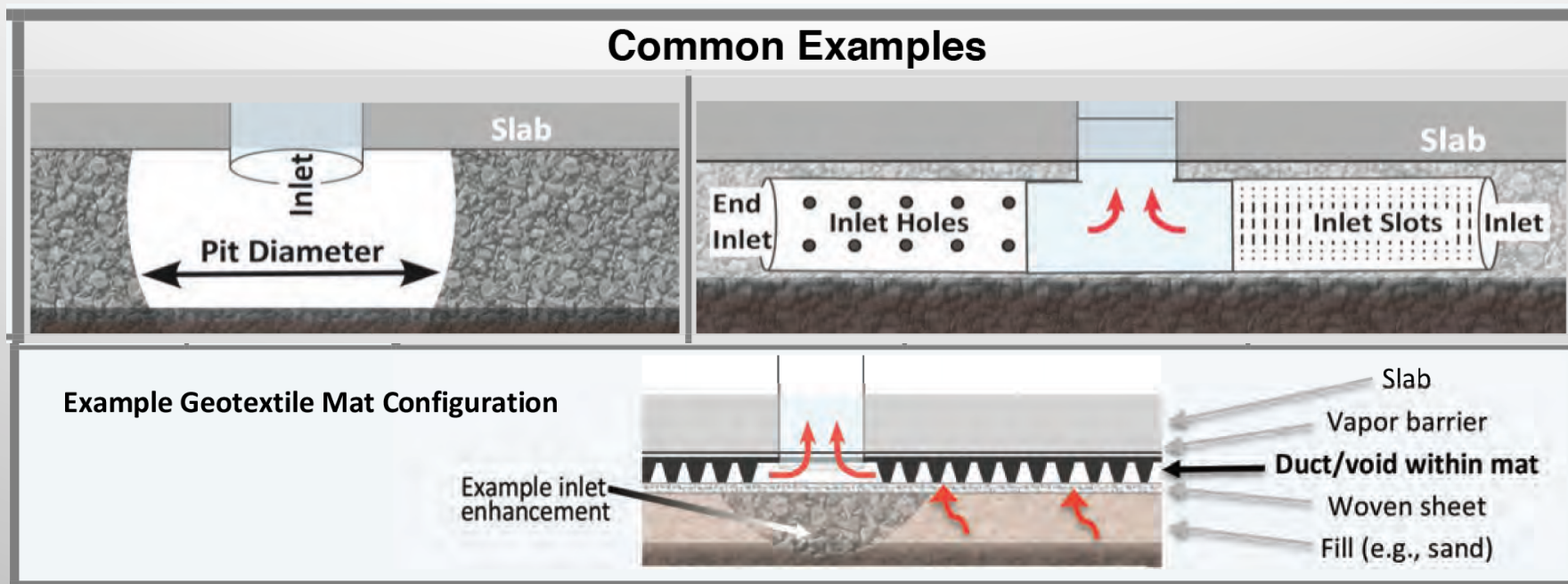
A complete hollow void under a building would require the least amount of energy for controlling the destiny of soil gas. Inversely, the amount of energy required to move air within solid clay is excessive to the point of impossible.

Range of Hydraulic Conductivity of Natural Soils			
USCS class	Soil Type	Hydraulic Conductivity Range gallons per day/ft ²	Permeability Description
GP	Uniform gravel	4,000 to 20,000	High
GW	Well-graded gravel	1,000 to 6,000	Moderate to high
SP	Uniform sand	100 to 4,000	Moderate to high
SW	Well-graded sand	20 to 2,000	Low to moderate
SM	Silty sand	20 to 100	Low
SC	Clayey sand	20	Low to very low
ML	Silt	1 to 2	Very low
CL	Clay	0.02 to 0.2	Very low to impermeable

Optimizing Effectiveness

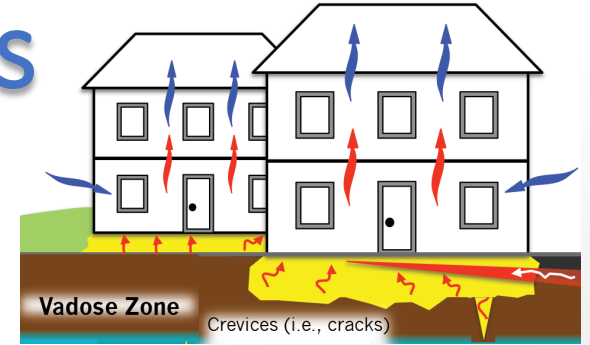
Hydraulic conductivity between soils and vent pipes (air inlets)

Pits, perforated pipe or geotextile matting where aggregates are not clogging the vent pipe.



Optimizing Effectiveness

Limit the size of the soil gas collection area

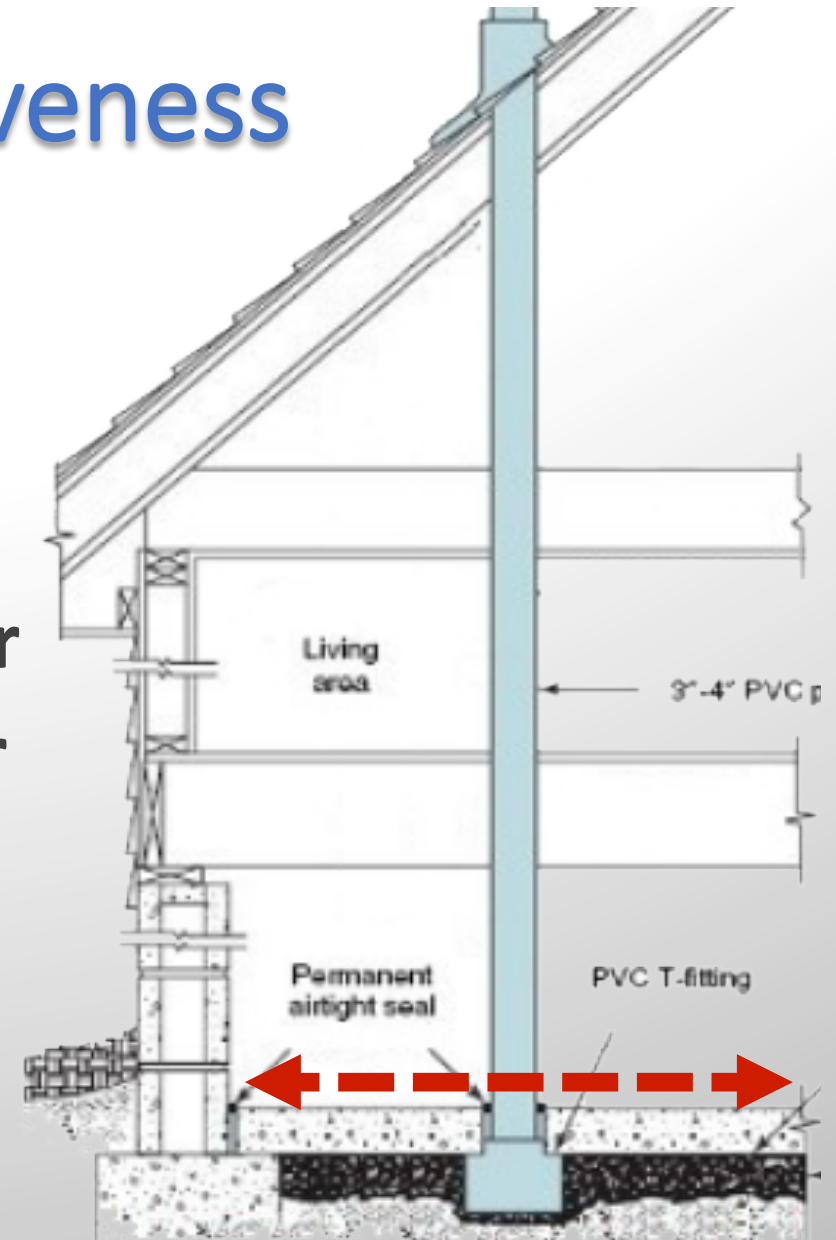


- You can't expect to influence the destination of soil gas if the airspace under a building is endless (e.g., highly permeable soils) or open to outside air
- Design to isolate the gas permeable airspace. Common practices include vapor retarders, closure of drain tiles exposed to outside air and even placing low permeable soils around foundations as an air block to isolate the airspace of interest under the home

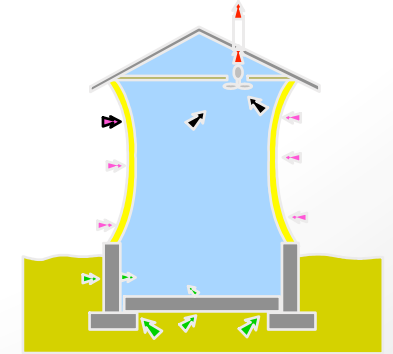
Optimizing Effectiveness

2. Sealing

Extend the concept of building shell closure to include a **complete closed air barrier between soil gas and indoor air**



Optimizing Effectiveness



3. Building tightness that minimizes stack effect

- Include minimized capacity for air to escape the top of the building and enter from the below the building.
- Combined, these serve to reduce the magnitude of air volumes flowing upward.

Optimizing Effectiveness

4. Energy Sources

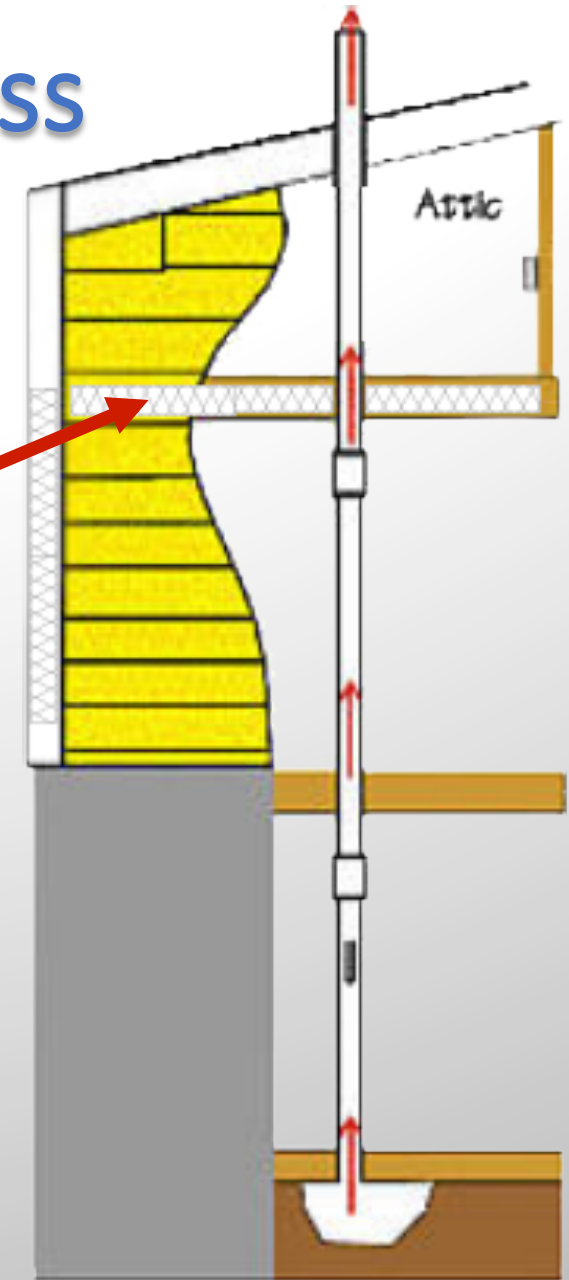
- Extend vent piping through areas that will remain warm throughout the year to encourage the stack effect
- When the air inside the pipe is warmer than outside air, soil gas will flow upward and exhaust to the outside



Optimizing Effectiveness

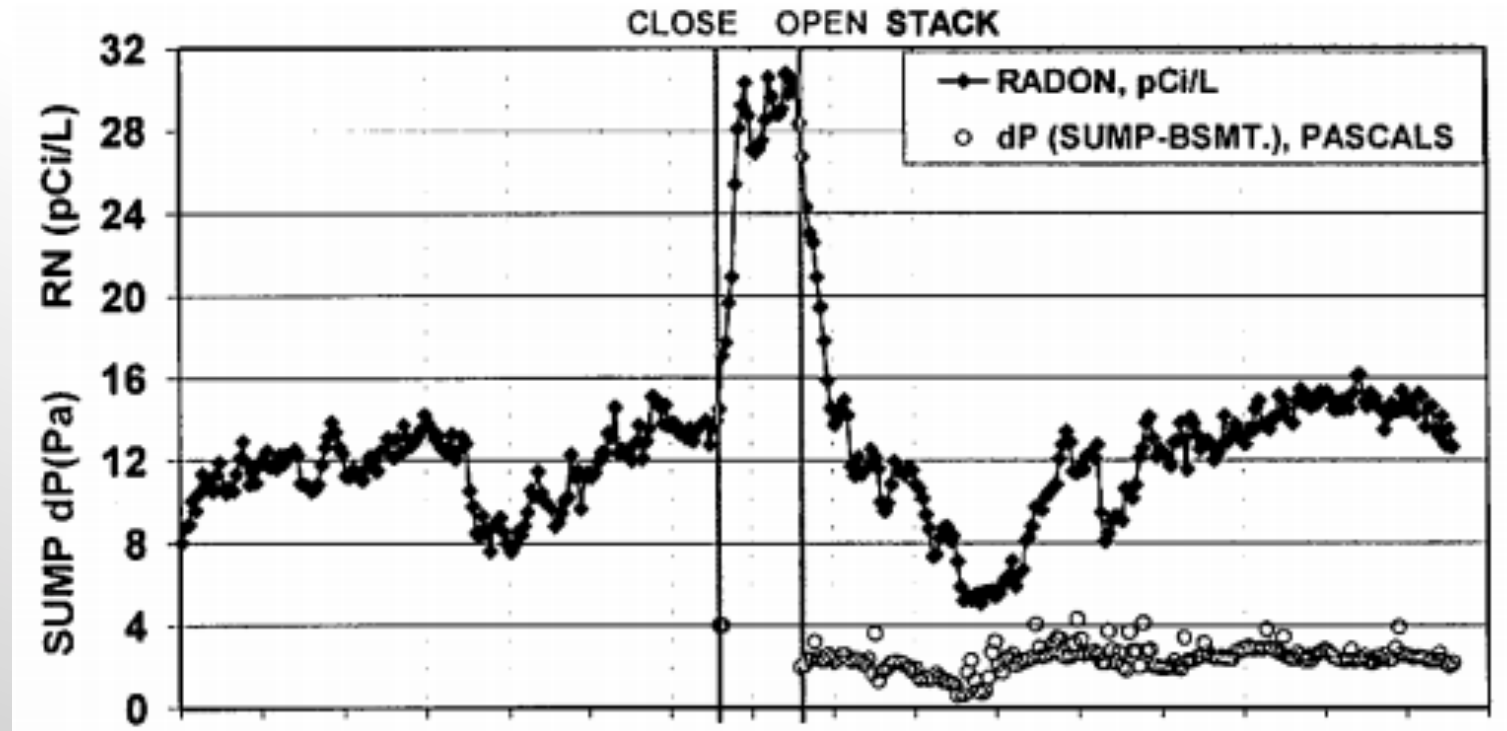
4. Energy Sources

- Where is the thermal boundary of the home?
- Attic heat can warm the pipe to enhance passive effectiveness.



Optimizing Effectiveness

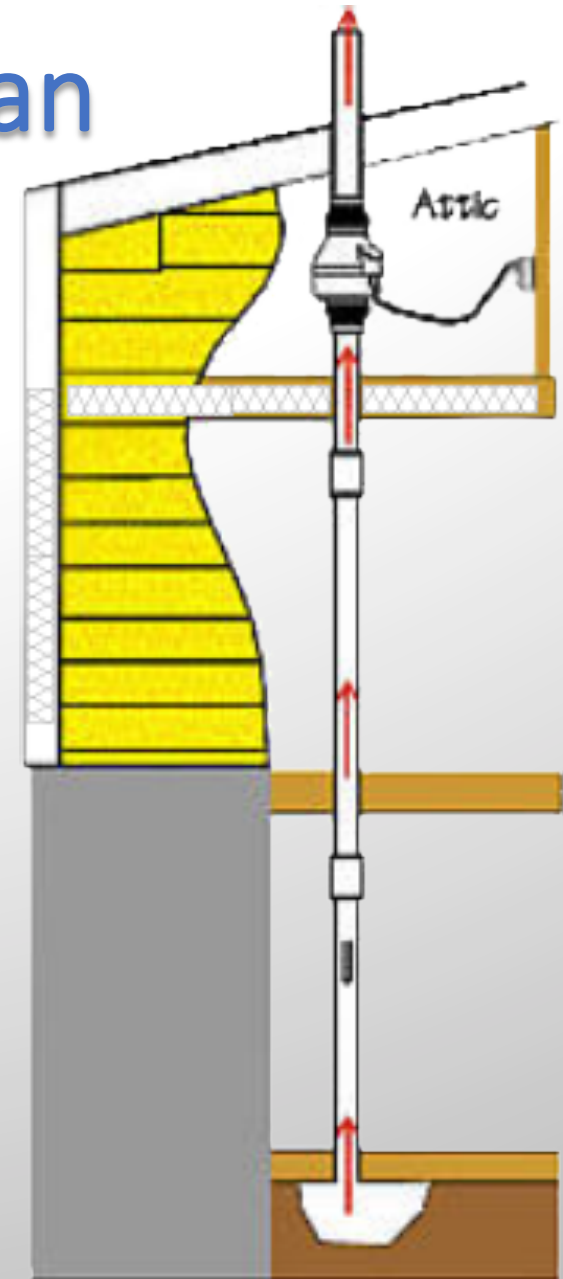
Example of higher radon when capping the pipe



BUT THIS DOES NOT HAPPEN if without permeable gravel and with all gaps and holes in the slab closed.

Provision for possible fan

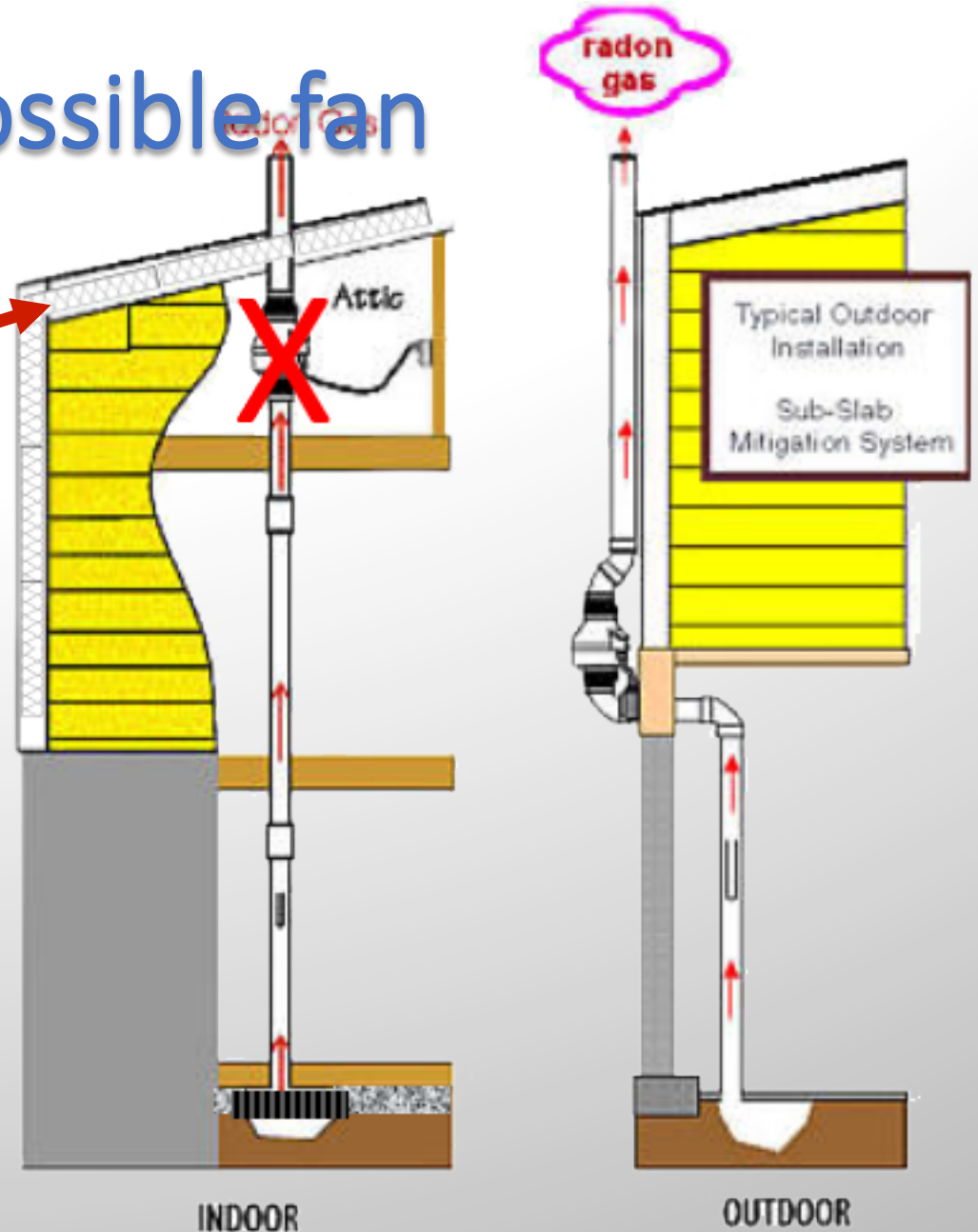
- Fan installation is optional with Indoor airPLUS
- But designs **must** allow for the possible need to create a fan driven system
- The space must allow manual access (e.g., 48" tall) with room for a fan (e.g., unobstructed airspace of 21" diameter around the pipe)



Provision for possible fan

Fan Locations

- Where is the thermal boundary?
- If accessible attic space is not provided, choices for fan locations are limited to the exterior or in a garage that is not below conditioned spaces.
- The fan cannot be within or under the heated and cooled envelope of the home.



A word to the wise

- **Soil gas is highly humid.** Wind turbines placed at the top of exterior piping freeze up with ice or lock-up with rust.

Problems ..



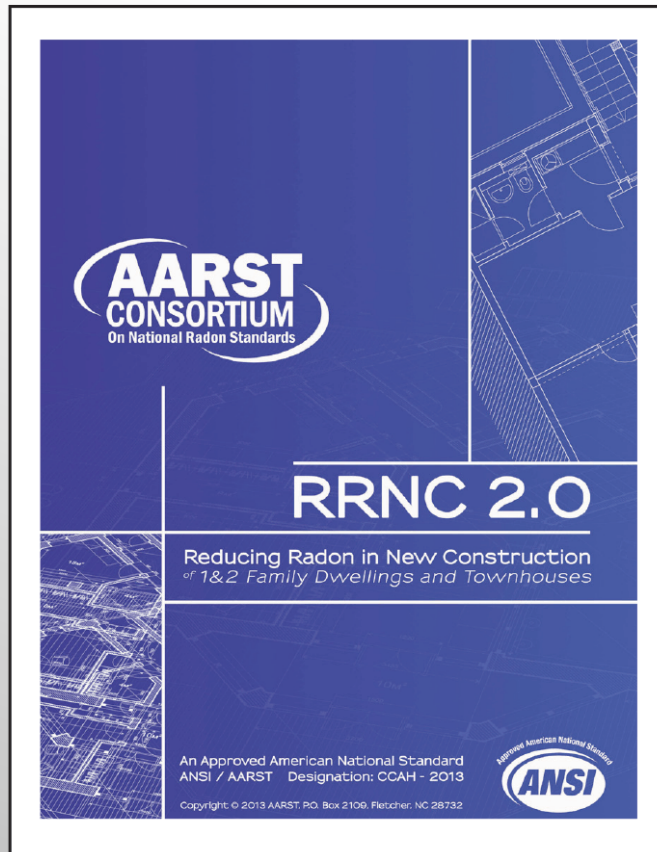
(Passive vortex alternative)

- Solar driven fans that are capable of withstanding outdoor conditions and not fail due to consistent condensation inside the fan are currently not readily available.

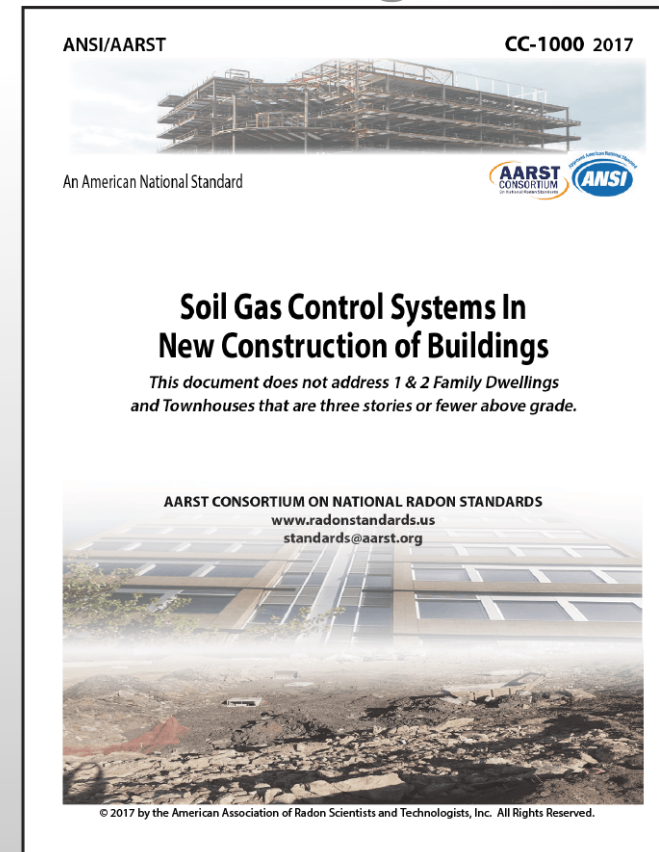
Standards Resources — ANSI/AARST

www.RadonStandards.US

CCAH for homes





CC-1000 larger buildings



SUMMARY

Remember

The degree of reduction in soil gas entry is directly attributable to the degree achieved for:

1. Appropriate gas permeable layers 
2. A closed barrier between soil gas and indoor air 
3. Soil gas venting while countering or minimizing air pressures that drive soil gas into a building

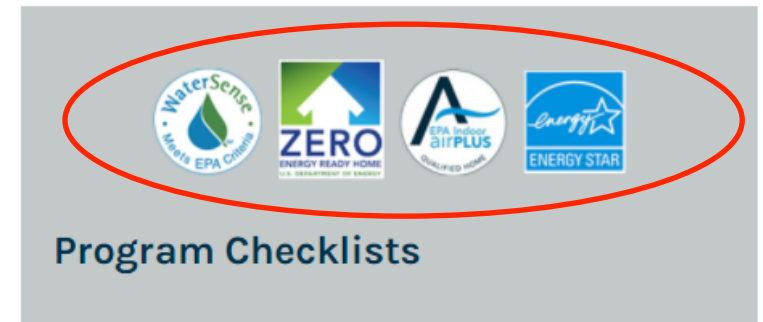
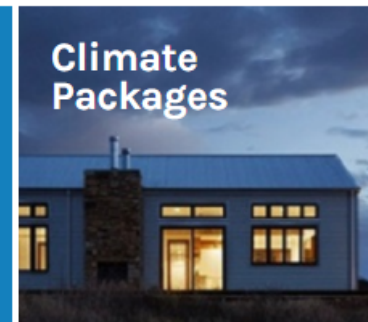
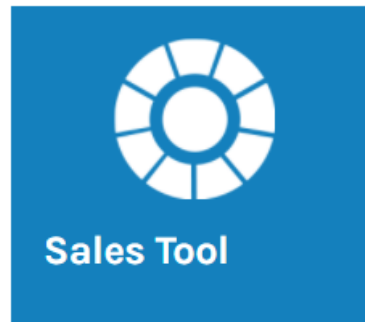
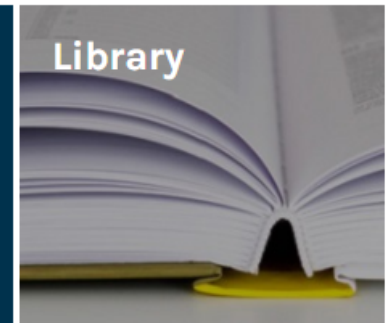
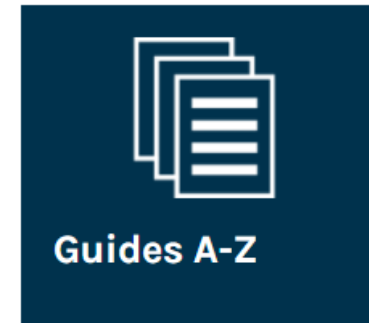
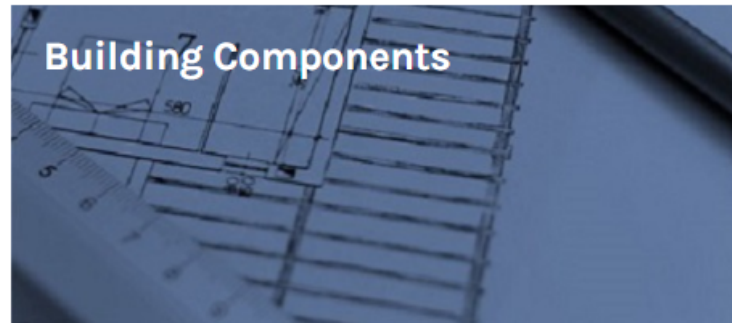
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Paul H. Raymer, ICF representing EPA Indoor airPLUS

Technical Assistance

- Specifications
- Webinars
- Online Resources and Tools
- Integration with DOE Building America Solution Center



2018 Indoor airPLUS Leader Awards

The [Indoor airPLUS Leader Awards](#) were created to recognize leading program partners who build or verify IAP homes and effectively educate homebuyers using the IAP brand and tools.

New this year:

- *“Indoor airPLUS Leader of the Year”*
- *Announced during Award Ceremony at:*
[EEBA Summit – Oct 16-18, 2018 – San Diego](#)



Homes that do more.





Indoor airPLUS

A new opportunity for leading builders to create better environments inside and out.

Learn more at:

www.epa.gov/indoorairplus

OR contact the Indoor airPLUS Team at:

indoor_airPLUS@epa.gov

