

Best Practices to Achieve Radon Resistant New Homes

Conducted by
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Session Objectives

- Understand what factors contribute to the radon concentration in homes
- Increase awareness of current RRNC codes and standards
- Review what works and what doesn't to achieve low radon results in new construction
- Understand radon requirements in Indoor AirPlus

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What is RRNC?

RADON RESISTANT NEW CONSTRUCTION (RRNC) BASICS

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Radon

Periodic Table of the Elements

1	H	2	He	3	Li	4	Be	5	B	6	C	7	N	8	O	9	F	10	Ne	11	Na	12	Mg	13	Al	14	Si	15	P	16	S	17	Cl	18	Ar	19	K	20	Ca	21	Sc	22	Ti	23	V	24	Cr	25	Mn	26	Fe	27	Co	28	Ni	29	Cu	30	Zn	31	Ga	32	Ge	33	As	34	Se	35	Br	36	Kr	37	Rb	38	Sr	39	Y	40	Zr	41	Nb	42	Mo	43	Tc	44	Ru	45	Rh	46	Pd	47	Ag	48	Cd	49	In	50	Sn	51	Sb	52	Te	53	I	54	Xe	55	Cs	56	Ba	57	La	58	Ce	59	Pr	60	Nd	61	Pm	62	Sm	63	Eu	64	Gd	65	Tb	66	Dy	67	Ho	68	Er	69	Tm	70	Yb	71	Lu	72	Hf	73	Ta	74	W	75	Re	76	Os	77	Ir	78	Pt	79	Au	80	Hg	81	Tl	82	Pb	83	Bi	84	Po	85	At	86	Rn	87	Fr	88	Ra	89	Ac	90	Th	91	Pa	92	U	93	Np	94	Pu	95	Am	96	Cm	97	Bk	98	Cf	99	Es	100	Fm	101	Md	102	No	103	Lr
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Rn 86 (222)
Density 9.73 g/L
F.E. Dorn, 1900
Boiling point -62°C
Melting point -71°C
(Xe) 4f¹⁴ 5d¹⁰ 6s² 6p⁶
Radon

- Invisible, odorless, tasteless, colorless, inert, *radioactive* gas
- Occurs from the natural breakdown of Uranium
- Travels through soil
- Enters homes, schools, other buildings
- Elevated indoor levels found in every state



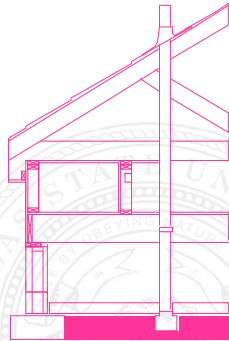
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Radon-Resistant New Construction

- Promote adoption of techniques in national, state and local building codes.
- Encourage voluntary application of the techniques by home builders
- Create consumer demand for radon-resistant new homes.

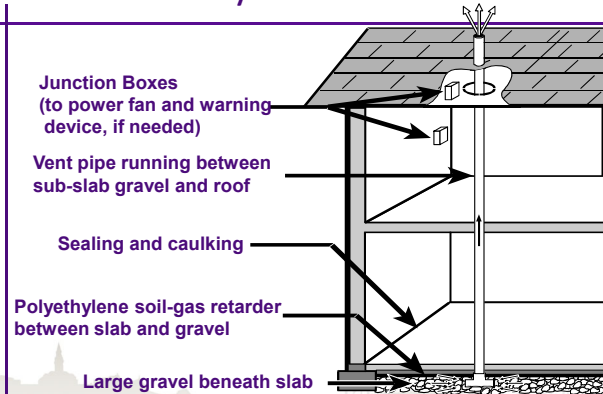


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Basic Components of Passive System



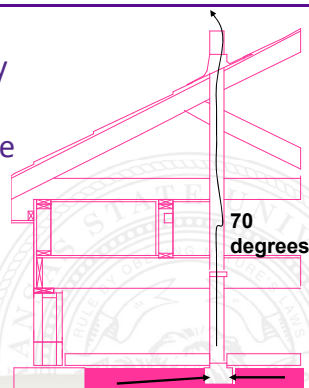
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How Does it Work?

- The pipe is warmed by house air creating a stack effect draft in the pipe.
- The warmed air in the pipe rises, creating a slight vacuum on the cooler soil gas.

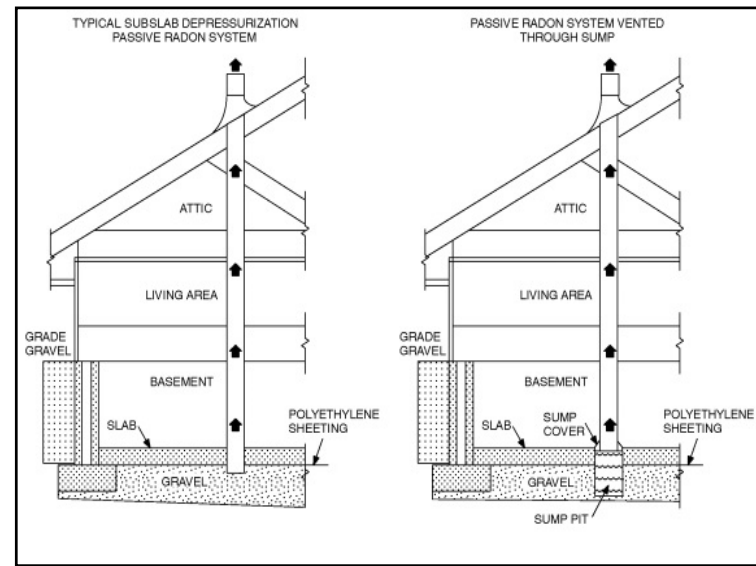


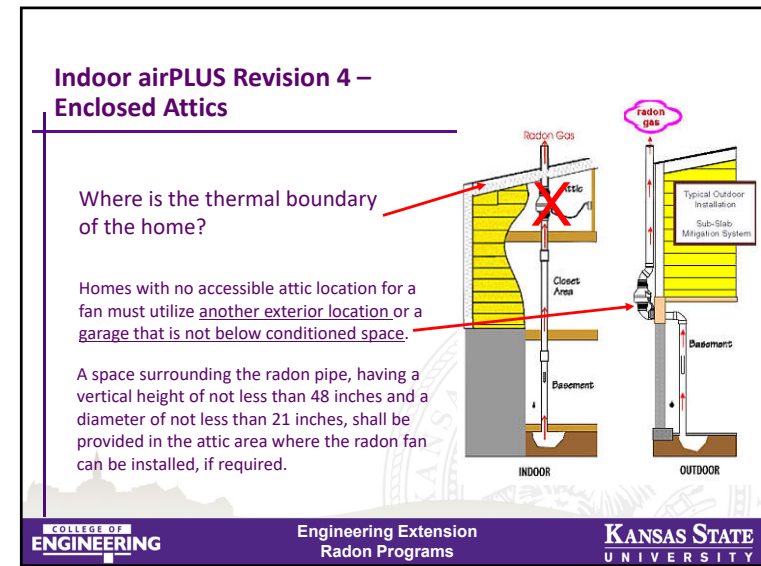
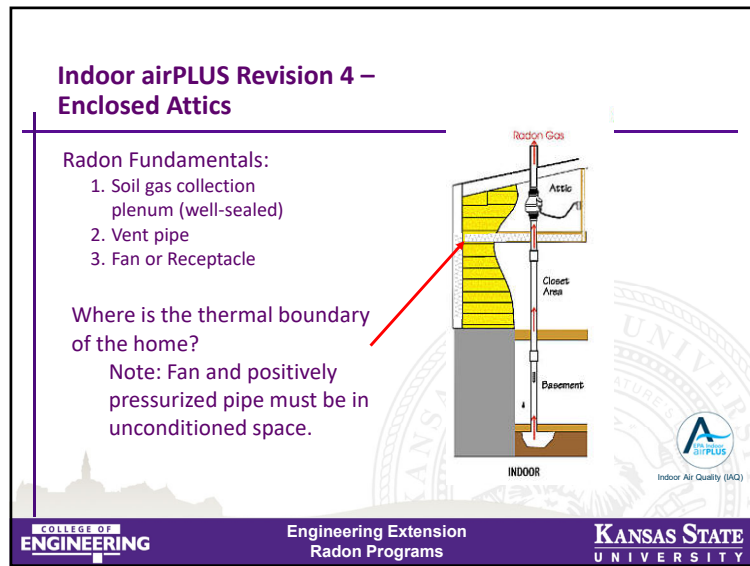
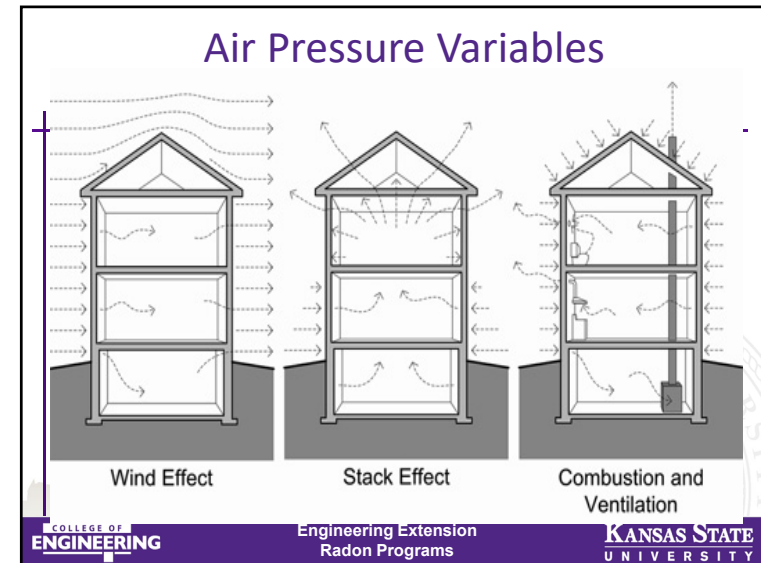
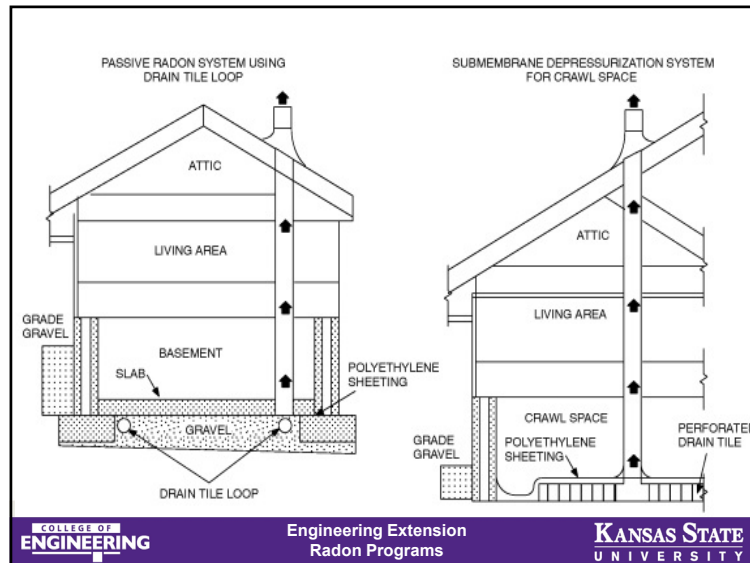
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55 degrees

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Other Building Practices That Help

- Tight Concrete Slab With Control Joints Minimizing Cracks
- Cover and Seal Sump Pumps
- Seal Hollow Block Walls
- Seal Joints in HVAC Ductwork
- Seal Other Potential Radon Entry Routes

Other Issues

- Vent for each separate foundation type
- Reduce building depressurization through duct sealing in unconditioned spaces, air infiltration control and fire-stopping
- Provide electrical supply box in attic for future fan and in anticipated locations of system failure alarms

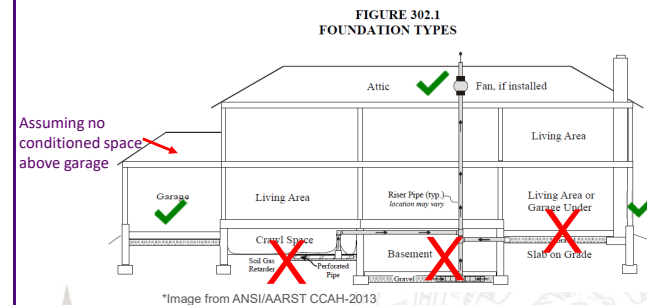
Activating a Passive System

1. Exhaust Fan in the Vent Pipe

- Standard radon control fans consume 70-90 Watts and exhaust 10-40 CFM of conditioned air
- A tiny fan is all that's needed in new construction - 20 CFM at 10 Watts

2. A Visible or Audible Warning System

Possible Fan Locations

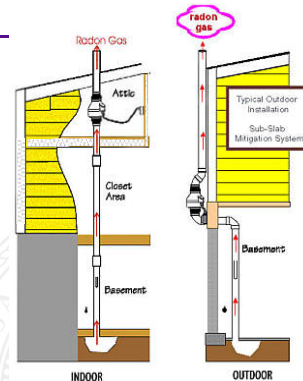


Indoor airPLUS Revision 4 – Gut Rehabs

Can I earn the Indoor airPLUS label in RZ1 if there's an existing slab?

Yes, but . . .

1. Active system must be installed
2. Test out upon final inspection (below 4 pCi/L)



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Benefits of Using Radon-Resistant Techniques

- Low-Cost
- Prevention of Liability
- Marketing Advantage
- Aesthetics
- Changing Building Codes

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Cost Comparison

New Home Construction

\$500 - \$750
per Home
(Labor and Materials)

Mitigate Existing Home

\$1000 - \$2500
per Home
(Labor and Materials)

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Why did it go so wrong?!

RRNC HOMES EVALUATED

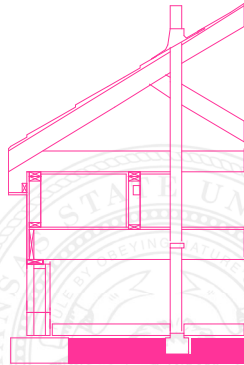
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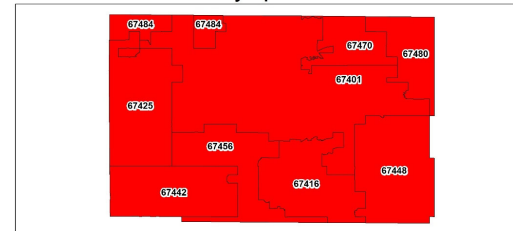
Kansas RRNC Communities

- Known Kansas RRNC Requirements
 - Cities
 - Manhattan
 - Topeka
 - Lawrence
 - Salina
 - Junction City
 - DeSoto
 - Gardner
 - Eudora
 - Counties
 - Shawnee (unincorporated)
 - Douglas (unincorporated)



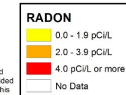
Saline County Radon Potential

2015 Saline County Radon Average Values
by Zipcode



Average Radon Level = 5.7
Maximum Reported Radon Level = 76.9
Total Number of Measurements = 2941
Total Measurements 4 pCi/L or greater = 1564
Total Measurements 20 pCi/L or greater = 63

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Evaluating Salina's RRNC-Built Homes

Project History

- Salina received a Level 1 Community Action for a Renewed Environment (CARE) grant from the U.S. EPA in October 2008 to identify and prioritize local environmental health issues
 - A Level 2 CARE grant awarded in October 2011 funded a broad community outreach program focused on radon awareness, measurement, and mitigation
- March 4, 2013
 - Salina City Commission adopted a modified version of the International Residential Building Code (IRBC) Appendix F
 - Effective as of June 15, 2013
 - Appendix F requires that a passive radon reduction system be installed in all new-built single- and two-family homes

Evaluating Salina's RRNC-Built Homes

Project Timeline

- January 2016
 - Recruitment letters were sent to 130 new-built homes in Salina. Volunteered homes would receive
 - No-cost evaluation of the passive radon reduction system
 - No-cost radon testing of the home
 - Activation of the passive system at no cost if the house tested 4.0 pCi/L or higher (EPA Radon Action Level)
- February 2016
 - 16 houses initially responded
 - 15 houses were evaluated
 - 13 homes evaluated starting week of 3/14
 - 2 homes evaluated started week of 3/21
- March 2016
 - 6 homes that tested at/above 4.0 pCi/L were activated and retested

Radon Test Results for Evaluated Homes

Radon test results in Salina, Kansas, with operational passive radon-reduction systems

Street	Passive test 1	Passive test 2	Passive test Avg.	Post-activation avg.	Floor
House #1	1.6	1.6	1.6		1st floor
House #2	1.7	1.5	1.6		Basement
House #3	2.0	1.4	1.7		1st floor
House #4	1.7	1.9	1.8		1st floor
House #5	1.8	1.9	1.9		Basement
House #6	2.1	2.2	2.2	Provided LT Radon Test	Basement
House #7	2.6	2.5	2.6	Provided LT Radon Test	Basement
House #8	2.6	3.3	3.0	Provided LT Radon Test	Basement
House #9	3.7	2.8	3.3	Provided LT Radon Test	Basement
House #10	4.3	4.0	4.2	0.8	Basement
House #11	4.1	4.7	4.4	1.1	Basement
House #12	5.3	4.8	5.1	1.0	Basement
House #13	5.5	5.7	5.6	1.4	Basement
House #14	6.3	5.2	5.8	1.1	Basement
House #15	14.2	13.4	13.8	1.3	Basement

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Passive Radon System Evaluation Results

Evaluation Process

- All 15 homes had at least a partial passive radon reduction system installed
 - Systems were evaluated for
 - Connection to the sub-slab zone
 - Sealing of any sump pits in the home
 - Ventilation pipe run from the slab thru the roof
 - Ventilation pipe labeling
 - Accessibility in the attic for installing a radon reduction fan

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Passive Radon System Evaluation Results

Evaluation Findings

- Common installation errors included
 - 6 systems had improperly sealed sump pits near the ventilation pipe
 - 7 systems had either no labeling or incomplete labeling
 - 5 systems had insufficient clearance in the attic for a fan installation
 - Several other systems had clearance for a low-wattage fan but nothing larger
 - 2 systems had excessive horizontal pipe runs
 - 2 systems had the ventilation pipe completely enclosed in sheet rock
 - 1 system had the ventilation pipe cut off within the attic
 - None of the systems had electrical junction boxes in the attic near the ventilation pipe
 - Note: The Salina code adoption process voluntarily removed this requirement from the Appendix F when it was adopted

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Passive Radon System Evaluation Results



The ventilation pipe is required by standard to be installed with enough space in the attic to install a radon-reduction fan if necessary. In this example, the evaluator estimated there was just barely room for a low-wattage fan.

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Passive Radon System Evaluation Results

Unsealed sump lids can be a point of loss of suction from the passive stack effect of the radon ventilation pipe. In this example, the homeowner had used electrician's tape to partially seal the lid.



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Passive Radon System Evaluation Results

The ventilation pipe should be installed in a manner allowing for relatively easy access for maintenance or modification. In this example, the ventilation pipe was behind a 7-ft hybrid water heater.



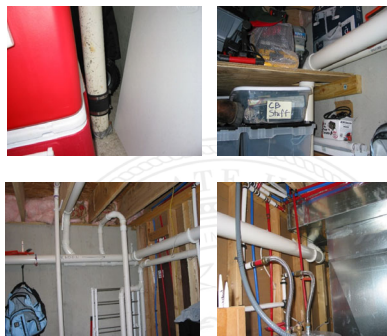
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Passive Radon System Evaluation Results

Excessive horizontal pipe runs can reduce the capacity of the radon ventilation pipe to develop a passive stack effect. In this example, beginning at the floor, the pipe run had multiple lengths of horizontal runs and multiple 90 degree turns, just in the basement of the home.



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Passive Radon System Evaluation Results

The standard for passive radon-reduction systems is for the ventilation pipe to exit through the roof, venting directly to the outside. In this example, the ventilation pipe was cut off and allowed to vent into the attic space.



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Passive Radon System Best Practices

The standard of passive radon system installations does allow for a sump to be used as the point of connection to the sub-slab zone.

In this example, the sump lid is

- 1) sealed with a gasket,
- 2) transparent to allow the homeowner visual access to the sump pit,
- 3) the ventilation pipe is connected to the sump lid with a disconnect coupling, and
- 4) the lid is labeled as being part of the radon-reduction system.



Passive Radon System Best Practices

The standard for passive radon-reduction system installations requires the ventilation pipe to be clearly labeled 1) once per floor and 2) a minimum of once every 10 feet.

In Kansas, the Kansas Radon Program (KRP) provides communities that have adopted passive radon-control system codes with sticker labels; check with your code office to obtain them.



Passive Radon System Best Practices

In homes where the ventilation pipe could be cut to determine the quality of the connection to the sub-slab zone, all cut pipes were connected to sub-slab drain tile systems.

Ventilation pipes connected to sub-slab drain tile will, in general, create better air flow towards the ventilation pipe, which in general increases the amount of radon reduction.




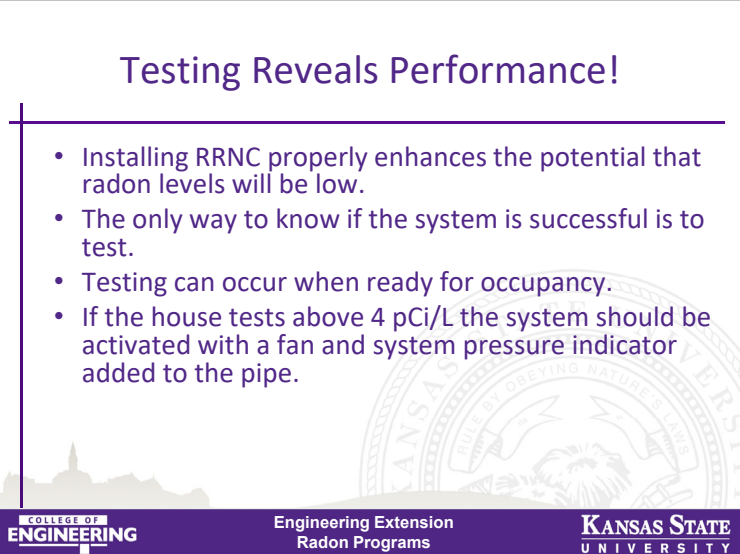


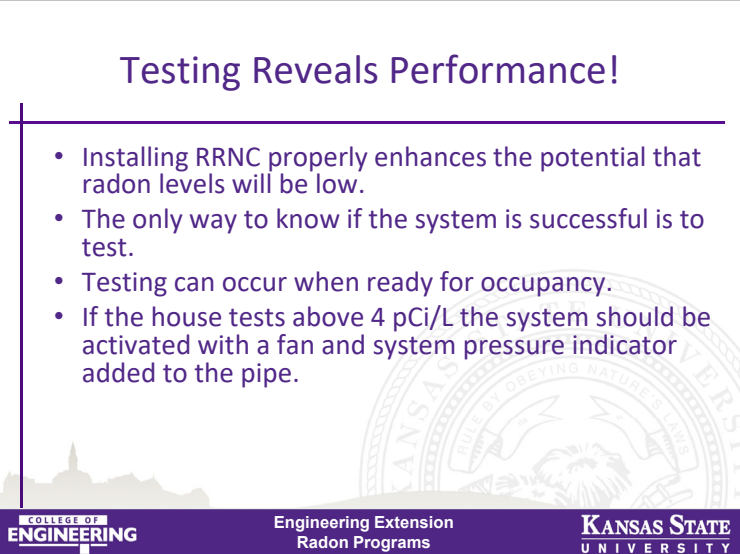



Key Takeaway Points

- A house with a passive radon reduction system IS NOT guaranteed to have an indoor radon under the EPA Action of 4.0 pCi/L
 - All new built homes in Salina should be tested for radon at time of purchase
- If the radon value is elevated, the passive radon reduction should be activated
 - In the vast majority of homes with passive systems, a low wattage suction fan will be sufficient to reduce the radon level to less than 4.0 pCi/L

Testing Reveals Performance!




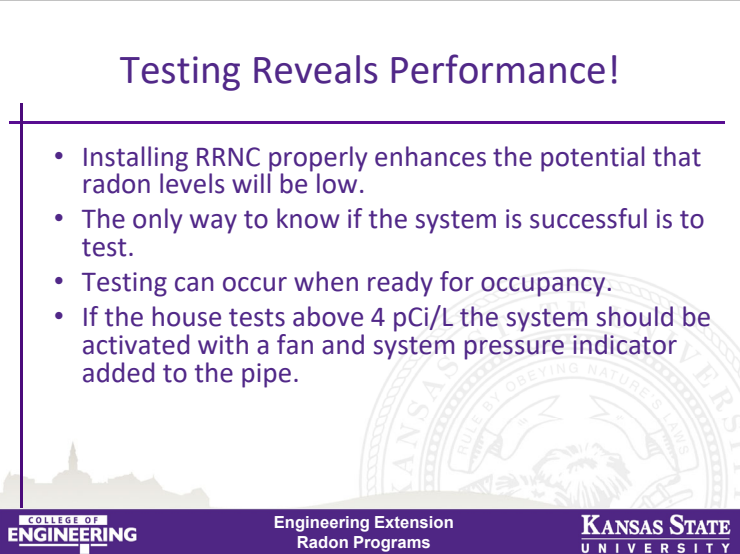
- Installing RRNC properly enhances the potential that radon levels will be low.
- The only way to know if the system is successful is to test.
- Testing can occur when ready for occupancy.
- If the house tests above 4 pCi/L the system should be activated with a fan and system pressure indicator added to the pipe.



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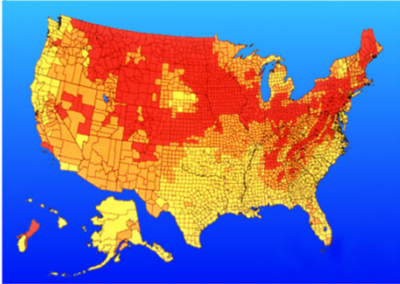


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International Residential Code (IRC) Appendix F: Zone 1 or Locally Determined Data

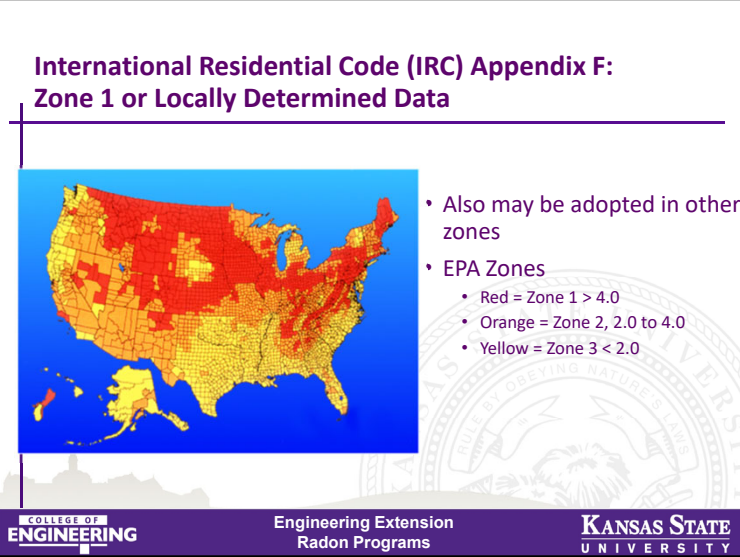


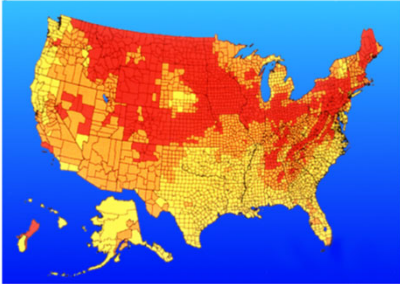
- Also may be adopted in other zones
- EPA Zones
 - Red = Zone 1 > 4.0
 - Orange = Zone 2, 2.0 to 4.0
 - Yellow = Zone 3 < 2.0

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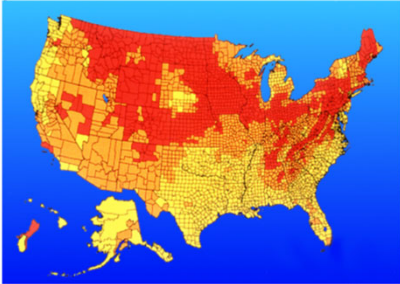
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International Residential Code (IRC) Appendix F: Zone 1 or Locally Determined Data



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Radon Resistant New Construction

The map shows the following states with Statewide Code (teal): Oregon, Washington, Montana, North Dakota, South Dakota, Nebraska, Kansas, Oklahoma, Minnesota, Wisconsin, Illinois, Indiana, Michigan, Ohio, Pennsylvania, New York, Vermont, New Hampshire, Maine, Connecticut, Rhode Island, Massachusetts, New Jersey, Delaware, Maryland, Virginia, North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, Louisiana, Texas, California, Nevada, Arizona, New Mexico, Idaho, Utah, Wyoming, Colorado, New Mexico, and Alaska. The states with Local Code (blue) are: New York, Vermont, New Hampshire, Maine, Connecticut, Rhode Island, Massachusetts, New Jersey, Delaware, Maryland, Virginia, North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, Louisiana, Texas, California, Nevada, Arizona, New Mexico, Idaho, Utah, Wyoming, Colorado, New Mexico, and Alaska. All other states are black.

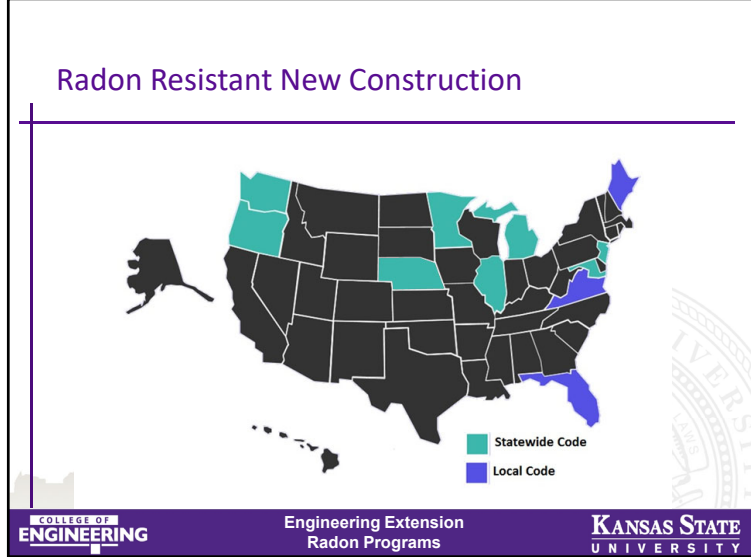
Legend:

- Statewide Code
- Local Code

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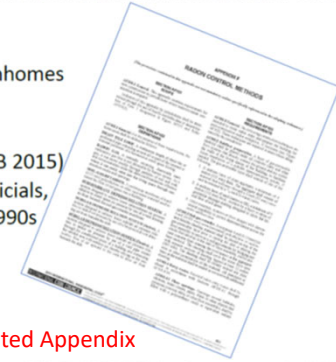
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RRNC and Building Codes

- RRNC provisions must be in a building code for consistency
 - To work across jurisdictions and companies that build homes
- Building codes are adopted by local and state legislative bodies
 - Some legislatures delegate details to advisory group/executive branch
 - Others specify the exact provisions or references in law
 - Jurisdictions adopt codes developed by the International Code Council
- International Code Council (ICC) manages family of codes
 - Updates every three years
 - International Residential Code (IRC): One and two-family, townhomes
 - International Building Code (IBC): Multifamily housing, schools, etc.
- Focused on generic safety/health i.e. imminent death
 - Environmental health ≠ priority

Appendix F of the International Residential Code

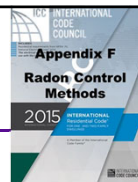
- RRNC code in 7 of 8 states
- 1- and 2- family homes, townhomes
- Basic, passive system only
 - No fan, no testing
 - \$350 average cost* (NAHB 2015)
- Created by builders, code officials, radon industry in the early 1990s
- Updates needed/attempted



IRC 2021 has updated Appendix F adding measurement – see next slides

IRC Appendix F: Section 103 Requirements (Overview)

1. General
2. Subfloor Preparation
3. Soil-Gas Retarder
4. Entry Routes
5. Passive Submembrane Depressurization (PSD) Systems: Crawlspace
6. PSD Systems: Basements and Crawlspace
7. Vent Pipe Drainage
8. Vent Pipe Access
9. Vent Pipe Identification
10. Combination Foundations
11. Building Depressurization
12. Power Source



Trends - RRNC Adoptions

- Required by 11 states (CT IL ME MA MD MI MN NJ OR WA) and more than 100 localities in other states
 - How many localities in your state?
- Geographic scope
 - All counties (CT IL ME MN MA)
 - Zone 1 counties (MA MD MI NJ OR WA)
 - Counties with radon average equal to/above 2.7 pCi/L (NE)
- Type of Occupancy
 - One- and two- family (CT ME MA MI MD; most localities)
 - 1 & 2 family plus apartment buildings (OR)
 - All residential buildings (IL NJ MN NE WA)
- Exceptions: (1) Architect- or PE-designed home exempt; (2) builder can convert to active system, mitigator must test (NE)



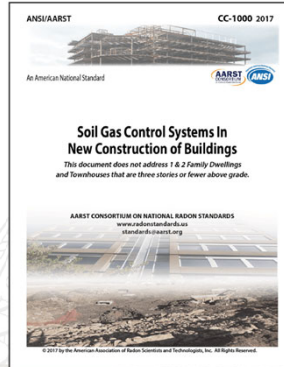
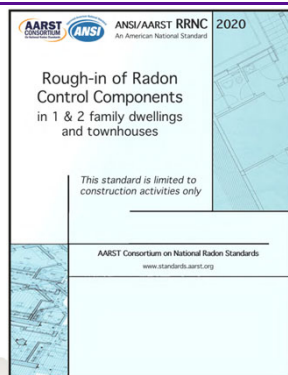
Trends – Which Version of RRNC?

1. Added to code / policy as a state-wide requirement
 - Appendix F as is: MD MI WA
 - Appendix F or ANSI-AARST CCAH: MA
 - Amended Appendix F: CT IL NE MA MN OR
 - ASTM 1465-08: ME (JD > 4,000)
 - Original text: NJ
2. Non-mandatory state-wide approaches
 - Local jurisdictions must use Appendix F if adopting RRNC: FL VA
3. Local adoption – typically Appendix F (exc: Wayne Co OH)
4. ANSI-AARST CC-1000, ANSI-AARST CCAH
 - HUD requires ANSI-AARST CC-1000 / CCAH

AF104 Testing. Where radon-resistant construction is required, radon testing shall be as specified in Items 1 through 11: (added this year)

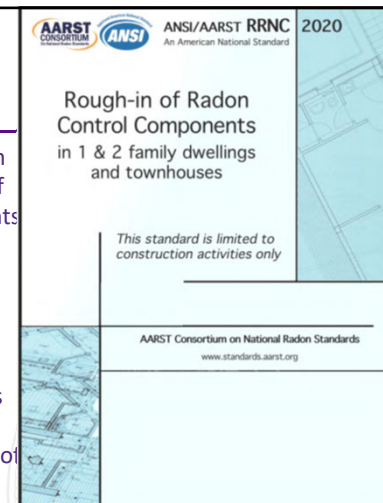
1. **Testing shall be performed ..**
 - after the dwelling passes its air tightness test
 - and HVAC installations are complete
 - different HVAC systems shall be tested separately
 - under closed house conditions
 - by builder, design professional, approved 3rd party
 - not less than 48 hours
 - results less than 4 pCi/L shall be provided to code official.
 - where result is 4 pCi/L or + fan shall be installed
 - where result is 4 pCi/L or + system modified until less than 4 pCi/L.

AARST-ANSI RRNC Standards



RRNC 2020

This standard provides minimum requirements for the rough-in of radon control system components in new dwelling units under construction. This standard is harmonized with ANSI/AARST CCAH, which additionally addresses requirements for verifying if radon concentrations are below the national action level and, if required, activation of radon control systems.



AARST-ANSI New Construction Standards Overview

RRNC (Radon Resistant New Construction) - 2020

- Similar to ICC Appendix F *“Radon Control Methods”*
- Requires Rough-in of ASD System
- No Testing Required (For Now)
- Performance Option for Testing less than 4 pCi/L

CCAH 2020

This standard provides **minimum requirements for the rough-in** of radon control system components in new dwelling units under construction. CCAH also includes **minimum requirements for verifying if radon concentrations are below** the national action level and, if required, activation of radon control systems. This standard is harmonized to compliment the standard designated as ANSI/AARST RRNC, which replicates construction activities for rough-in components only.



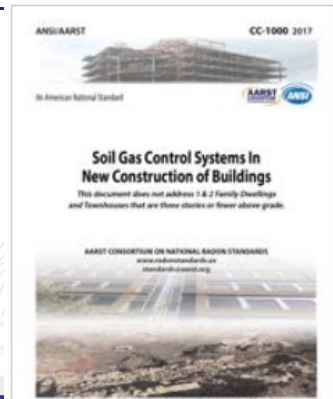
AARST-ANSI New Construction Standards Overview

CCAH – (Construction Code Applicable to Homes) -2020

- Model Building Code for New Construction
- Adopted as an alternative code to Appendix F in Mass.
- ICC Appendix F code adoption proposals unsuccessful
- HUD adopted for 1 & 2 Family New Construction in 2018

Large Buildings – CC-1000-2018

This standard provides minimum requirements for the construction of any building intended for human occupancy, except for 1 and 2 family dwellings, in order to reduce occupant exposure to radon and other hazardous soil gases. It addresses the construction of buildings to be utilized for multifamily or congregate residential, educational or commercial occupancies.



ANSI-AARST Standards Access

ANSI/AARST national consensus standards are utilized by numerous federal and state agencies, such as the Department of Housing and Urban Development (HUD) and the Environmental Protection Agency (EPA). A national consensus standard is available for every building type.

Standards are available for public viewing here:

<https://standards.aarst.org/#pb>



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VERSION 2 Indoor airPLUS

November 10, 2020

EPA United States
Environmental Protection
Agency

Indoor Air Quality (IAQ)

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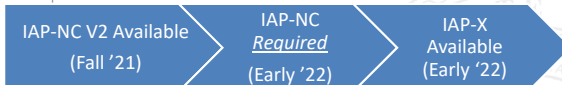
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Indoor airPLUS Version 2 Timeline

- Public Comment & Final Development



- Implementation



*Caveat - Does anyone really know what 2021 holds?

Public Comment Open Through March 17, 2021



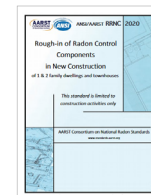
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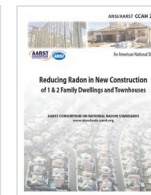
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2. Radon

Following ANSI/AARST standards is recommended



"RRNC" - Passive Systems



"CAAH" - Active Systems



Available for web view - <https://standards.aarst.org/>



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2. Radon

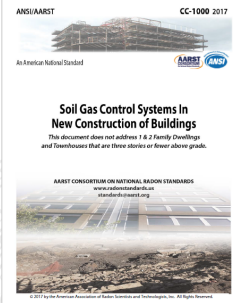
Following ANSI/AARST standards is recommended

ANSI/AARST CC-1000 provides design detail for buildings 4+ stories above grade

Exceptions for some buildings with ventilated garages that meet IMC Section 404

Key Takeaway:

Some exceptions apply to multifamily--use consensus-based standards for design guidance.



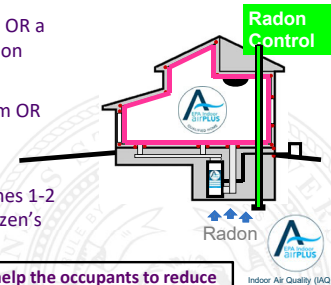
"CC-1000" - Active Systems for Large Buildings

Available for web view - <https://standards.aarst.org/>

2.1 Radon Zone Identification and Strategy

Radon strategies outlined for ALL ZONES

- In EPA Radon Zone 1
Include active radon mitigation system OR a passive system and test upon completion
- In EPA Radon Zone 2
Install a passive radon reduction system OR test upon completion
- In EPA Radon Zone 3
Comply with one of the options for Zones 1-2
OR provide the occupants with the Citizen's Guide to Radon



Key takeaway: Identify your radon zone and help the occupants to reduce their risk of exposure.

Questions?

Kansas State University

National Radon Program Services

— increasing public knowledge of radon and the need to test and fix homes

MAIN PAGE	ORDER KIT	EPA PUBS	FAQ	BUY & SELL
Who is certified to fix my home? \$1,500 average cost to fix	Can I build Radon-Resistant? Yes. When done properly	How do I find a test kit? 21,000 deaths from lung cancer	Do I, or my family have lung cancer? #1 cause of lung cancer in non-smokers	I'm buying/selling. Who tests? 1 in 15 homes test high for radon

Bruce Snead – bsnead@ksu.edu 785-532-4992
 Brian Hanson – bhanson@ksu.edu 785-532-4996

<https://sosradon.org/Resources-for-RRNC-Code-Adoption>

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