A Brief Review of Indoor Radon Gas

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K-State Radon Programs

**General Radon Entry Pathway**

- 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

- U.S. annual average indoors in homes (living areas)
  - 1.3 pCi/L
  - about 50 Bq/m³

- U.S. annual average outdoors
  - 0.4 pCi/L
  - about 15 Bq/m³

pCi/L is a unit of radon radioactivity (or "activity") concentration
Radon Programs

Current Understanding: Radon Health Effects

- Radon causes lung cancer even **BELOW** EPA's radon action level of 4 pCi/L (150 Bq/m³)
  - North American, European, and Chinese studies report 8 to 16% increase in lung cancer 2.7 pCi/L (100 Bq/m³)
- **MOST** radon-induced lung cancer occurs **BELOW** EPA's action level
  - Protracted radon exposure increases the risk of all types of lung cancer
  - Prevention and mitigation methods reduce the risk
  - Susceptibility to radon-induced lung cancer varies (e.g., smoking, genetics)
- Protracted radon exposure appears to have adverse health effects beyond lung cancer (e.g., leukemia, stomach and liver cancer)

(Ref: Field, RW 2008 “Testimony Before the President's Cancer Panel,” Charleston, SC [December 4])

Sources of Annual Radiation Exposure for the General U.S. Population

- Assumes average indoor radon concentration of **1.3 pCi/L**
- Radon is by far the greatest single source of radiation to the general public.

Lung Cancer Incidence

<table>
<thead>
<tr>
<th>Cancer Type</th>
<th>Estimated U.S. Deaths in 2020</th>
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</thead>
<tbody>
<tr>
<td>Lung and Bronchus</td>
<td>136,700</td>
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<tr>
<td>Colon and Rectum</td>
<td>53,200</td>
</tr>
<tr>
<td>Pancreas</td>
<td>47,090</td>
</tr>
<tr>
<td>Breast</td>
<td>42,690</td>
</tr>
<tr>
<td>Prostate</td>
<td>33,330</td>
</tr>
<tr>
<td>Liver and Intrahepatic Bile Duct</td>
<td>30,160</td>
</tr>
<tr>
<td>Leukemia</td>
<td>25,100</td>
</tr>
<tr>
<td>Radon-Detected Lung Cancer</td>
<td>21,100</td>
</tr>
<tr>
<td>Lymphoma</td>
<td>20,910</td>
</tr>
<tr>
<td>Brain &amp; Other Nervous System</td>
<td>19,020</td>
</tr>
<tr>
<td>Uterine</td>
<td>17,760</td>
</tr>
<tr>
<td>Esophagus</td>
<td>16,170</td>
</tr>
<tr>
<td>Kidney and Renal Fibs</td>
<td>16,030</td>
</tr>
<tr>
<td>Ovary</td>
<td>13,840</td>
</tr>
</tbody>
</table>

Why does Radon migrate into the home?

It's complicated...
Indoor Radon Levels Depend On:

Five Factors
- Source strength of the radon in the soil
- Ease of movement of the radon thru the soil
- Foundation connections between the soil and the indoor environment
- Amount of vacuum the house puts on the soil
- Inflow of outdoor air into the home

What Contributes Radon to Indoor Air?
- The movement of soil gas into a home is the predominant entry route
  - These are averages and a particular home can be different, e.g.,
  - As soil gas entry is reduced, emanation and diffusion can become more important

How Radon Enters Your Home

Entry Points Seen and Unseen
Buildings Generate Vacuum

- Buildings can create vacuums that will draw in soil gas
- These vacuums may be very small and are referred to as air pressure differentials

Air Pressure Variables

- ACH is an acronym for Air Changes per Hour and is a measurement of air infiltration. It is the total volume of air in a home that is turned over in one hour.
  - Tightly constructed homes may have an ACH of 0.25 to 0.35 ACH.
  - A typically built new home may have an ACH of around 1 ACH. Older poorly weather-stripped and sealed homes may have higher than 2 ACH.

The Stack Effect and Negative Pressure

- Is it reasonable to assume climate impacts radon concentrations?
  The answer depends on your definition of ‘reasonable’...
EPA Has Defined Radon Zones

Each of 3100 counties in the U.S. classified as:

**Zone 1** - expect 4.0 pCi/L or greater

**Zone 2** - expect 2.0 to 4.0 pCi/L

**Zone 3** - expect 2.0 pCi/L or less

Zone designations based on five factors: indoor radon measurements, geology, aerial radioactivity, soil parameters, and foundation type.

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U.S. Radon Zone Map

![U.S. Radon Zone Map](image)

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Climate and HVAC Days

![Climate and HVAC Days](image)

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Climate and HVAC Days

![Climate and HVAC Days](image)
Climate and HVAC Days

<table>
<thead>
<tr>
<th>Heating System</th>
<th>Cooling System</th>
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<tbody>
<tr>
<td>Response to radon levels: heating systems will normally be active when indoor temperatures exceed about 70°F (21°C).</td>
<td>Response to radon levels: cooling systems will normally be active when indoor temperatures exceed about 70°F (21°C).</td>
</tr>
</tbody>
</table>

Examples of Heating and Cooling Systems

But, what if?

What If My House Has...?

You CANNOT predict radon levels based on:

- Heating System
- Foundation Type
- Age of Structure
- Air-tightness
- Style of House
- Presence of Sumps, Cracks or Other Features

You just have to TEST to find out!
AARST Radon Measurement Protocols

- AARST Protocol for Conduction Measurements of Radon and Radon Decay Products in Homes
- AARST Protocol for Radon Measurement in Multi-family Buildings
- AARST Standards Website
  - [https://standards.aarst.org/](https://standards.aarst.org/)

Common Testing Durations

How long does radon testing take?

- Long Term - greater than 90 day exposure
  - No behavioral restrictions on building operation
  - Reflects building annualized radon concentrations
- Short Term - typically 2 - 7 day exposure
  - Short Term cannot be less than 2 days
  - Closed building conditions required
  - Reflects building winter radon concentrations
  - 94% of the time Short Term tests provide the same mitigation decision as a Long Term test

Devices

- Charcoal canisters and bags
- Alpha Track detectors
- Electret Ion Chambers
- Continuous Radon Monitors

Test Location Depends On Purpose

**Real Estate**
- Lowest level suitable for occupancy w/o renovation

**Non-Real Estate**
- Lowest lived-in level determined by occupant
Radon Programs

So What do we do?
Rocket Science™!

Radon Mitigation

- **Active Soil Depressurization (ASD)** is the most common approach
- Employs a method for creating a vacuum beneath the foundation greater in strength than the vacuum applied to the soil by the building
- Caulking and sealing has not been shown to be an effective stand-alone radon reduction process
- However, extensive sealing can radically increase the efficiency of ASD systems
- **Ventilation** approaches have proven more costly and less effective

**Mitigation System Design Criteria**

- Lowest indoor radon concentrations
  - Active Soil Depressurization = up to 99% reduction
  - Expect less than 2 pCi/L ~ U.S. EPA’s Citizens Guide
- Safe and does not create other problems
- Durable
- Able to perform system monitoring
- Economical to install and operate
- Quiet and unobtrusive

**Types of ASD Systems**

- Depends on type of house foundation
  - Basement with and without groundwater control systems
    - Drain Tile: Drain Tile Depressurization (DTD)
    - Sump: Sump Depressurization (considered under DTD)
  - Baseline Drains: Baseline Depressurization (rare)
  - Concrete Block Walls: Block Wall Depressurization (rare)
  - None of the above: Subslab Depressurization (SSID)
  - Crawl Space: Submembrane Depressurization (SMD)
  - Slab on grade:
    - Subslab Depressurization (SSID)
    - Stem Wall Depressurization
The Systems Work!

Basic Components of Passive System

- Junction Boxes (to power fan and warning device, if needed)
- Vent pipe running between sub-slab gravel and roof
- Sealing and caulking
- Polyethylene soil-gas retarder between slab and gravel
- Large gravel beneath slab

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

Cost Comparison

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<th>New Home Construction</th>
<th>Mitigate Existing Home</th>
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<tr>
<td></td>
<td>$750-$1,000 per Home</td>
<td>$1,500 - $3,000 per Home</td>
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<tr>
<td></td>
<td>(Labor and Materials)</td>
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</table>
So which states have paid attention?

Radon Disclosure During Real Estate Transactions

State Licensing/National Proficiency Requirements

Radon Resistant New Construction
School & Daycare Testing

Who are these guys?
Why is this bald guy from Kansas State blathering at us?

We’re From the Government, We’re Here to Help

National Radon Program Services
www.sosradon.org
Kansas Radon Program
www.kansasradonprogram.org
K-State Radon Training
https://radoncourses.com/
K-State Radon Chamber
www.ksuradonchamber.org

National Radon Program Services (NRPS)
• https://sosradon.org/
• 800.SOSRADON (800.767.7236)
• NRPS Activities
  • U.S. EPA Cooperative Partner
  • National direct public technical assistance
  • Regional radon stakeholders meeting coordination and training
  • Outreach activities to radon stakeholders
Kansas Radon Program (KRP)
- https://kansasradonprogram.org/home
- 800.693.5343
- State-wide Radon Activities
  - Public education and technical assistance for Kansas residents
  - Professional education for radon stakeholders
  - Outreach activities to radon stakeholders

K-State Radon Training Options
- https://radoncourses.com/
- In-person, Webinar & Online Self-Paced
  - Full measurement/mitigation courses
  - Professional Continuing Education
  - Contract training for organizations
  - EPA Regional Stakeholders meetings

K-State Radon Chamber
- https://ksuradonchamber.org/
- Services
  - Device Performance Testing (DPT)
    - Necessary for initial NRPP certification and an option during recertification
  - Device Spiking Services
    - CAD’s, ATD’s and EIC’s
    - Minimum order of 3 spikes
  - Ecosense Radon Eye Pro Calibration
    - Currently only CRM our lab will calibrate

Questions?
Cause, boy do I have answers...
<table>
<thead>
<tr>
<th>Contact Info</th>
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<tbody>
<tr>
<td>Brian Hanson</td>
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<td>• 785.532.6026 (general office)</td>
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<td>• 785.532.4996 (direct)</td>
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<td>• <a href="mailto:bhanson@ksu.edu">bhanson@ksu.edu</a></td>
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<tr>
<td>NRPS &amp; KRP Contact</td>
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<td>• <a href="mailto:radon@ksu.edu">radon@ksu.edu</a></td>
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<tr>
<td>KSU Radon Training</td>
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<td>• <a href="mailto:radoncourse@ksu.edu">radoncourse@ksu.edu</a></td>
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