Key Points

**Radon Sources – Wherever Uranium 238 or Radium 226 exist**
- Natural Geology and Soils
  - Granites, shale, phosphate deposits, coral deposits and where these materials have eroded to or deposited upon.
- Situations caused by man:
  - Uranium mill tailings used as fill or building materials
    - Very localized and well known as of today.

**Entry Mechanisms**
- **Convective flow of radon laden soil gas through openings in foundation**
  - Caused by pressure differentials (negative pressure in building or positive pressure in soil)
  - Is typically the largest pathway for radon (90%+)
- **Radon from water**
  - Radon can dissolve in groundwater
  - If water is not stored at atmospheric pressure before entering building, radon can be brought into building via water supply.
  - Radon readily degasses from water, causing an additional amount of radon to enter the air beyond that which comes from soil gas.
    - Risk is from inhalation.
    - Little health risk drinking the water
  - On the average, 10,000 pCi/L in water will add 1 pCi/L in air.
  - Be careful testing unoccupied homes on wells in areas known to have radon in water.
- **Diffusion**:
  - Where radon diffuses from soil through slab due to concentration gradients.
  - Typically a small contributor
- **Emanation**:
  - Where a building material within the envelope of a building contains uranium or radium
    - Radon emanates from surface of material
    - Typically a small contributor due to low surface area available for disengagement
Key Points

The following factors influence radon levels in a building in decreasing influence.

- **Source:** Radon potential under building
  - The quantity of radon being generated in the underlying geology or soil (a function of uranium and/or radium content).
  - Regardless of how much vacuum a building applies to soil, if there is no radon being generated under the house, no radon will come in.

- **Driving Forces:** Differential pressure
  - This is the differential pressure between the house and the sub-grade that draws radon laden soil gas into the home.
  - Typically on the order of 0.005-0.020 inches of water column.
  - Generally, capture zone is immediately under and 10 meters around house.
    - Causes adjacent houses to have different radon levels.

- **Pathway:** Means by which soil gases can be drawn into building
  - Permeable native soil, soil disturbed by construction process or aggregate placed beneath slab
  - Drainage systems, especially those connected to interior sumps.
  - Sub-slab duct work, especially that connected to return side of forced air unit (furnace inlet duct)
  - Along trenches in which plumbing lines are laid.

- **Opening:** Portal into structure
  - All foundations have openings
    - Radon moves in with soil air
    - Crawl spaces (crawl space vents do little to help)
    - Slabs (floor-to-wall joints are major openings)
    - Caulking and sealing foundation is not a stand-alone technique for reducing radon.

- **Ventilation Rate:** Exchange of stale indoor air with fresh outdoor air
  - Once radon enters a building, the exchange of air from the outside can help dilute it.
  - Sufficient outdoor air to pressurize building can significantly reduce radon entry, but typically impractical in homes unless designed for (more common in larger buildings).
  - Tight homes do not cause radon! Uranium and radium under the building cause radon.

*Note:* There is no way to predict radon levels in homes from radon potential maps or building features. The only way to know is to test the home. Since variables change from house to house, one cannot predict radon levels in a home based upon the results of a test in an adjacent home.
Key Points

• Radon enters from sub-grade due to vacuums within the home or soil pressures relative to the home.

• Because radon enters through foundation it is typically at its highest concentration in the lower level.

• As air moves up in building, outdoor air that enters through building shell from above grade will dilute radon.
  • Radon is generally 40-60% lower on the first floor relative to the lowest level.
  • If another level exists above first floor the activity levels are very close to outdoor radon levels.

• Exceptions:
  • Where radon from water is significant and water usage is primarily on upper level.
  • Plumbing chases from lower level can provide pathway to upper level that can increase third floor gas concentrations to above those on second floor – but not higher than that found in lowest level.
  • Forced air heating/cooling systems that operate frequently can mix air in home causing radon levels to be pretty much the same on all levels of home.

• Initial Testing Location
  • Lowest portion of the home.
  • If acceptable reading is found in lower level, one can say with reasonable confidence (see exceptions above) that exposures on upper floors of building are also acceptable.
  • Location should either be occupied or occupiable depending upon whether it is a test being done as part of a real estate transaction or not.
Variations within a home:
- Radon activity levels typically decrease as one goes to higher levels within a home.
- On a given level, room-to-room variations are not considered to be significant
  - Select a frequently occupied room on the level for which the test is going to be done.
  - Exceptions:
    - Enclosed rooms where sumps open to soil where radon can be elevated compared to other rooms on same floor. Since these are not frequently occupied. **Do not test there.**
    - Rooms with high humidity such as bathrooms and saunas can affect accuracy of measurements. **Do not test there.**
  - Only one location needs to be selected on floor of choice.

*Note: In schools and commercial buildings, the impact of an unbalanced HVAC system dictates that all frequently occupied rooms in contact with the soil should be tested.*

Test locations:
- Non-Real Estate - Lowest occupied
- Real Estate – Lowest occupiable (regardless if finished or not)
- Frequently occupied room where it is not likely to be disturbed

**Do not test:**
- Crawlspace
- Basements that are only large enough for furnace
- Bathrooms (concern with humidity)
- Garages (infrequently occupied)

**Good places:**
- Bedroom
- Family Room

Follow-up, or diagnostic measurements can be placed in alternate and multiple locations
Key Points

Short-Term Tests
• Identify radon potential independent of living and use patterns of an occupant.
• Provide an indication of radon potential
• Commonly used at time of sale as part of an inspection process
  • All exterior doors and windows closed other than normal entry and exit all during the test and for 12 hours prior to initiation of test.
  • 12-hour pre-test closed house condition not required if test is four days or longer.
  • Test in lowest portion of home where radon levels are likely to be the highest.
  • Minimum 48-hour of data collection after building has come to equilibrium
  • All ventilation systems that exchange air to outside to be off
    • Evaporative (swamp) coolers – OFF
    • Window fans – OFF
    • Whole house fans – OFF
    • Fireplaces should be - OFF
    • Forced air systems - ON as normal (note settings on report)
    • Combustion air and furnace make-up air – ON
    • Air-to-air heat exchangers – ON and noted on report
    • Legitimate mitigation systems - ON and noted on report

Long-Term Tests
• Long-term tests identify radon exposures in locations and under conditions that a specific occupant would maintain in the home under their normal living patterns.
• Provides indication of actual exposure
• Basis of health advisories
• Commonly used outside of sale or as a follow-up to a short-term test
  • Device deployed in lowest occupied portion of home
  • No requirements for closed building conditions
  • Minimum 91-day deployment, up to a full year to account for seasonal variations.

Note: Some states have additional requirements
Key Points

Early Mapping Efforts:
• Looked at known uranium and radium containing areas
• Not effective in estimating indoor radon due to extremely localized impact of varying uranium content and soil permeability as well as climate.

EPA Zone Map:
• Based on both indoor radon measurements, geology and population
• Developed for purpose of identifying where radon resistant techniques would be most cost-effectively incorporated during new home construction.
• Should not be used to determine if a home should be tested
• Each zone indicates probability of a short-term measurement having a result within a given range.
  • It does not mean the average is within a given range.
  • Homes above 4.0 pCi/L can exist in Zones 2 and 3, as well as homes less than 4.0 pCi/L can exist in Zone 1.
• Interesting information from map
• One can see the influence of high uranium content in granites of mountainous areas.
• One can see a higher frequency of Zone 1 areas in northern latitudes due to higher thermal stack effect from colder climates.

Note: Buildings in southern latitudes with high interior vacuums can have very high radon levels!

Other Maps:
• Many state and local agencies have developed more localized maps.
• Be careful with use of any map, since indoor radon levels can be quite different from one house to the next.
  • A case in one state had a home at 2,500 pCi/L of radon and the adjacent house was less than 4.0 pCi/L.
Key Points

- The radon potential of a home is primarily a function of the radium content under the home.
- The primary driving force for pulling radon in are vacuums within the home.
- Vacuums within a home are variable and hence the indoor radon levels can vary from hour-to-hour, day-to-day and season-to-season.
- The longer the duration of the test, the more representative the results will be of the occupants’ exposure.
- **Short-term tests indicate radon potential**
  - Closed building conditions for a minimum of 48 hours
  - Can overestimate or underestimate the year-long exposure.
- **Long-term tests indicate radon exposure**
  - Normal lived in conditions for a minimum of 91 days.
- Maps, although interesting, cannot be used for determining the need to test. All homes should be tested.
- Radon can enter via a water supply and add radon into the air at a rate of 1 pCi/L per 10,000 pCi/L in the water.
- Radon can emanate from building materials or diffuse through concrete in contact with soil, but is typically a minor component of indoor radon.

*Radon levels within a home can vary significantly.*

*Measurements for determining the need for mitigation should not be less than 48 hours.*

*Longer term tests of a minimum 91-day duration to one year are best for characterizing actual exposure if time allows for such a measurement.*
Over a three-month period, short-term real estate style tests varied from 1.9 to 6.0 pCi/L.

Average for entire period was **3.8 pCi/L**

Source: Dr. Dan Steck, Minnesota Radon Project Jan-March 1995

http://www.csbsju.edu/MNradon/