RADON MEASUREMENT COURSE FOR SCHOOL DISTRICTS ELECTING TO PERFORM RADON MEASUREMENTS

REFERENCE MANUAL / STUDY GUIDE

ILLINOIS EMERGENCY MANAGEMENT AGENCY

AMERICAN LUNG ASSOCIATION® of Illinois

NOTICE

ACKNOWLEDGMENT

The Radon Measurement Course for School Districts was prepared in accordance with 32 Illinois Administrative Code 422 – Regulations for Radon Service Providers regulated by the Illinois Emergency Management Agency (IEMA). We would like to acknowledge the efforts of American Lung Association of Illinois (ALAIL) Environmental Staff members in reviewing, revising and creating this course.

Any comments regarding this document can be sent to the Illinois Emergency Management Agency, 1035 Outer Park Drive, Springfield, Illinois 62704. Phone: (800) 325-1245. Internet: www.radon.illinois.gov.

The State of Illinois is providing this Radon Measurement Course for School Districts as an on-line course for school districts that elect to perform their own school radon screening measurements. This course is intended for use by the school districts when performing their own radon testing, in lieu of hiring a licensed measurement professional. Careful study of this course will increase knowledge about radon and provide information for radon measurement.

The course is intended to help you learn the required information as well as prepare and conduct radon screening measurements; furthermore, this information hopes to convince schools that the need for radon testing is an important part of public health, welfare, and safety in the community.

What to Study

The objective of this guide is to insure that an individual: (a) learns and understands each of the elements of the knowledge base; (b) values and is able to apply (practice) each of these knowledge base elements, in terms of why it is necessary to know such material thoroughly; and, (c) prepares (the learner) for the testing process that will ultimately decide if the learner is exempted from the license requirements to practice the knowledge learned in the school districts buildings for whom they are employed.

Radon Measurement Course Objectives

This guide addresses learning objectives for radon screening measurements in schools. Each successful candidate will have the ability and utility to address each of the following objectives:

1. To define the elements and components of radon and radon measurement, using appropriate labels, terms, and wording, as well as possessing the ability to communicate effectively such definitions to others.
2. To understand the relevant laws and elements of physical science to the radon measurement process, as well as understanding the role of physical science in both the introduction and presence of radon in the environment.
3. To forecast how radon occurs, when and where, and why, as well as predicting how this element will behave at different times, in different places, and/or under different circumstances.
4. To measure relevant properties of radon, utilizing appropriate scales of measurement, interpreting both status and progression (change), as well as possessing the ability to interpret such measurements validly and reliably.
5. To understand and utilize the standard devices and/or instrumentation approved for radon measurement, their calibration and servicing, as well as the potential for errors associated with the misuse or misplacement of such devices.
6. To model the required elements of quality control and quality assurance throughout the measurement process as a continuous part of the measurement protocol, as well as the inherent values of a quality controlled approach to measurement.

7. To comply with existing laws, regulations, and other established procedural requirements associated with radon measurement, as well as emulate the importance of legal oversight of radon-related activities.
8. To understand the processes associated with basic radon mitigation.

Note: Not all terms defined below are in the course, but all terms relate to radon.

ACCURACY- The correlation between the measured value and the original target or "true" value.

ACT – Means the Radon Industry Licensing Act [420 ILCS 44].

ACTIVE SOIL DEPRESSURIZATION OR ASD – A family of radon mitigation systems involving mechanically driven soil depressurization, including sub-slab depressurization (SSD), drain tile depressurization (DTD), block wall depressurization (BWD), and sub-membrane depressurization (SMD).

ACTIVATED CARBON- When fibrous material as coconut shells or wood is burned in low oxygen conditions, activated carbon is produced. This combustion product allows radon to be absorbed within pore spaces. Activated carbon can be used to remove radon from water and for radon measurement devices.

ACTIVITY- related to RADIOACTIVITY

ACUTE EFFECT- Effect that occurs immediately after exposure.

AIR EXCHANGE RATE- Rate at which the outdoor air replaces the building air (can be expressed in air changes per hour).

AIR PRESSURE DIFFERENTIAL- Differences in air pressure in spaces that are close to each other (air between inside and outside the building shell). Air movement that is caused by pressure differentials is a large force for radon entry into buildings. Air movement occurs from higher pressured areas to lower ones.

ALPHA DECAY- The loss of two protons and two neutrons by an atom in a radioactive decay.

ALPHA PARTICLE- A positively charged particle, indistinguishable from a helium atom nucleus and consisting of two protons and two neutrons.

ALPHA TRACK DETECTOR- Long term test for radon in which the detector is a small piece of special plastic or film inside a small container. Air being tested diffuses through a filter covering a hole in the container. When alpha particles from radon and its decay products strike the detector, they cause damage tracks. The plastic or film detector is treated to enhance the damage tracks and then the tracks over a predetermined area are counted using a microscope or optical reader.

ATOM- A unit of matter, the smallest unit of an element, having all the same chemical properties of that element and consisting of a dense, central, positively charged nucleus surrounded by a system of electrons.

ATOMIC NUMBER- a number representing the positive charge or the number of protons in the nucleus of the atom of an element: isotopes have the same atomic number but different mass numbers.

ATOMIC WEIGHT- The average mass of an atom of an element, usually expressed relative to the mass of carbon 12, which is assigned 12 atomic mass units.

BACKGROUND MEASUREMENTS- Such are made with tools that are exposed to very low radon concentrations as the outdoor air. Background levels are subtracted from samples before calculating sample concentrations.

BACKGROUND RADIATION- Radiation that is produced from radioactive material that might come off from building materials, etc.

BASEMENT- The substructure or foundation of a building. The lowest habitable story of a building, usually below ground level.

BETA DECAY- Is a type of radioactive decay in which a beta particle (an electron or a positron) is emitted. In both instances, the atomic number increases or decreases by 1, while the atomic mass number remains unchanged.

BIAS- is a term used to describe a tendency or preference towards a particular perspective, ideology or result, especially when the tendency interferes with the ability to be impartial, unprejudiced, or objective. In terms of a Quality Assurance Program, bias will be represented by the difference between the average value of duplicate measurements and the true value.

BLIND SPIKES-Used in evaluation of laboratorial accuracy in which detectors are exposed to known conditions and submitted to the lab without identification.

CALIBRATION- In the quality assurance process is the determination of deviation from standards of measurement in order to address necessary correction features. A set of gradations that show positions or values.

CHRONIC EFFECT- An effect that takes time to develop after exposure or with prolonged exposure.

COEFFICIENT OF VARIATION- The ratio of the standard deviation of a distribution to its arithmetic mean. Used in expressing the overall error, the combination of bias and lack of precision.

COMBINATION FOUNDATION- Buildings constructed with more than one foundation type, e.g., basement/crawlspace or basement/slab on grade.

COMMERCAIL BUILDING- A type of building that is designed for commercial use, including, but not limited to office buildings, warehouses, retail facilities, schools, recreational facilities, assisted living facilities and buildings that combine these uses.

CONCENTRATION GRADIENT DIFFUSION- One of the ways that radon moves through soil through diffusion (from higher concentrations to lower).

CONFIDENCE- The level of assurance for a method to successfully reduce radon amount present.

CONVECTIVE MOVEMENT- As the result of the pressure difference between the building and the soil, the flow of radon gas into the building. Temperature differences can affect convective movement.

CRAWL SPACE- An area beneath the living space in some homes, where the lowest livable area is above grade. A shallow space located below the ground floor of a building and surrounded by the foundation wall.

CRAWLSPACE DEPRESSURIZATION- A radon control technique designed to achieve lower air pressure in the crawlspace relative to indoor pressure by use of a fan-powered vent drawing air from within the crawlspace. (See also Mechanically Ventilated Crawlspace System)

CUBIC FEET PER MINUTE (cfm)-Is a unit of measurement of gasflow (most often airflow) that indicates how many cubic feet of gas (most often air) pass by a stationary point in one minute. In other words, it is a unit for measuring the rate of flow of a gas or air volume into or out of a space at a given temperature.

CURIE (Ci)- A unit of radioactivity, equal to the amount of a radioactive isotope that decays at the rate of 3.7×10^{10} disintegrations per second.

DECAY PRODUCT- is a nuclide resulting from the radioactive decay of a parent isotope or precursor nuclide.

DECAY SERIES- Also referred to as a decay chain involves consecutive members of a family of radionuclides formed by sequential transformation from one element to the next. A succession of nuclides, each of which transforms by radioactive disintegration into the next until a stable nuclide results.

DEPRESSURIZATION- The result of air pressure inside the building being slightly lower than the air pressure outside or the soil gas pressure.

DIFFUSION- The process by which molecules spread from areas of high concentration, to areas of low concentration.

DRAIN-TILE DEPRESSURIZATION (DTD)- A type of active soil depressurization system where the suction point piping attaches to a drain tile or is located in the gas-permeable material near the drain tile. The drain tile may be inside or outside the footings of the building.

DUCTWORK- A system of ducts used fro ventilation or heating system, also includes pipes, vents, etc, belonging to such a system.

DUPLICATES- Two measurements made under same conditions and at the same time in order to identify the precision of the result.

DYNAMIC EQUILIBRIUM-Occurs when two opposing processes proceed at the same rate. A reversible chemical reaction will be at dynamic equilibrium when the rate of forward reaction is equal to the rate of the reverse reaction. While at dynamic equilibrium there is no change in the concentration of either the forward or reverse reactions. The overall concentration of radon decay products (RDPs) present divided by the concentration that would exist if the RDPs were in radioactive equilibrium with the radon gas concentration that is present.

EAVE- The lower border of a roof that overhangs any wall.

ELECTRET ION CHAMBER- A tool to measure amounts of radon. The electrets is an electrostatically charged piece, usually a disk of Teflon, located inside an electrically conducting plastic chamber of a known air volume. The electret serves as a source of high voltage needed for the changer to operate as an ion chamber. It also serves as sensor for the measurement of ionization in air. The ions produced inside the sensitive volume of the chamber are collected by the electrets causing a depleted charge. The measurement of the depleted charge during the exposure period is a measure of integrated ionization during the measurement period. The electrets charge is read before and after exposure using a specially built non-contact electrets voltage reader.

ELECTRON- Is a fundamental subatomic particle that carries a negative electric charge.

ELECTRON VOLT (ev)- A unit of energy equal to the energy acquired by an electron falling through a potential difference of one volt, approximately 1.602×10^{-19} joules.

ENTRY ROUTES- Openings in structures that allow for pathways for soil gases to get into the building.

EPITHELIUM- Is a tissue composed of a layer of cells. Epithelium lines both the outside (skin) and the inside cavities and lumen of bodies.

EXHAUST FAN- A fan that blows indoor air out of the building.

FIELD BLANK- The use of a detector that has never been exposed to radon in order to identify the correctness of results and determine the effects of shipping and storing radon measuring devices.

FLOOR PLAN- in architecture and building engineering is a diagram, usually to scale, of the relationships between rooms, spaces and other physical features at one level of a structure.

FOLLOW-UP MEASUREMENTS- Measurements taken after an initial one to evaluate the long term differences and changes.

FOOTING(S)- The supporting base or groundwork of a structure, as for a monument or wall.

FOOTPRINT- Each foundation type in direct contact with soil or other material.

FORCED-AIR FURNACE (or HEAT PUMP)- A device for cooling or warming an enclosed space by removing heat from interior air and transferring it out, or by absorbing heat from outdoor air, or from a hot-water source, and transferring it in.

FOUNDATION- The base on which something rests; specif., the supporting part of a wall, building, etc., usually of masonry, concrete, etc., and at least partially underground.

FOUNDATION TYPE- The basement, crawlspace, slab-on-grade or any other construction technique approved by local building code.

GAMMA RADIATION- Electromagnetic radiation of high energy. Gamma rays are the most penetrating type of radiation and represent the major external hazard. Gamma radiation has relatively small mass, moves at the speed of light and has no charge.

GEIGER COUNTER- An instrument used to detect and measure radiation.

HVAC- Heating, ventilation and air conditioning.

HALF-LIFE- The time required for half the nuclei in a sample of a specific isotopic species to undergo radioactive decay.

HOME ENVIRONMENT MEASUREMENT- A short term or long term measurement of radon in a single family home, duplex or condominium.

IEMA- Illinois Emergency Management Agency

INFILTRATION- The seepage or flow of air into a room or space through cracks around windows, under doors, etc.

INDOOR RADON ABAEMENT ACT- Legislation, signed in 1988, which establishes a long-term goal that indoor air be as free from radon as the ambient air outside buildings.

INTEFERE- To adversely or potentially adversely impact the successful completion of an indoor radon measurement by changing the radon or radon progeny concentrations or altering the performance of measurement equipment or an indoor radon mitigation system installation or operation.

ION- An atom or a group of atoms that has acquired a net electric charge by gaining or losing one or more electrons.

IONIZATION- The formation of or separation into ions by heat, electrical discharge, radiation, or chemical reaction.

IONIZING RADIATION- High-energy radiation capable of producing ionization in substances through which it passes. It includes nonparticulate radiation, such as x-rays, and radiation produced by energetic charged particles, such as alpha and beta rays, and by neutrons, as from a nuclear reaction.

ISOTOPE- One of two or more atoms having the same atomic number but different mass numbers.

LAB BLANK- A control measure that aids in determining the counts that would be reported by an analytical system when the detector hasn't been exposed.

LABORATORY- Any organization that analyzes or calibrates radon or radon progeny measurement devices or detectors.

LABORATORY ANALYSIS- The act of analyzing radon (or radon progeny concentration with passive devices, or the act of calibrating radon (or radon progeny) measurement devices, or the act of exposing radon (or radon progeny) devices to known concentrations or radon or radon progeny as a compensated service.

LIFETIME RISK- The risk over lifetime of dying of a specific disease.

LINEAR DOSE MODEL- The dose-risk model that presupposes that the excess risk is linearly proportional to the dose.

LITER (L)- A metric unit of volume equal to approximately 1.056 liquid quarts, 0.908 dry quart, or 0.264 gallon.

LIVING AREA- Any area in a building that is, or could be, adapted for human habitation whether the area is located in a basement, over a crawlspace, or situation on a slab-on-grade.

LONG TERM MEASUREMENT- Measurements conducted for more than 90 days.

LOWER LIMIT OF DETECTION- The minimum amount of a particular component that can be determined by a single measurement with a stated confidence level.

MAKE-UP AIR- Outdoor source of draft air (to address combustion appliance back-drafting)- the amount or percentage of fresh air delivered or mixed with recirculating air on a normal cycle of air by volume.

MATERIAL SAFETY DATA SHEETS- is a form containing data regarding the properties of a particular substance.

MANOMETER- An instrument used for measuring the pressure of liquids and gases.

MASS NUMBER- The sum of the number of neutrons and protons in an atomic nucleus.

MECHANICALLY VENTILLATED CRAWLSPACE SYSTEM- A radon control technique designed to increase ventilation within a crawlspace, achieve higher pressure in the crawlspace relative to air pressure in the soil beneath the crawlspace, or achieve lower air pressure in the crawlspace relative to air pressure in the living space, by use of a fan. (See also CRAWLSPACE DEPRESSURIZATION)

MICROMANOMETER- Any manometer that is designed to measure very small pressure differences.

MICROREM- Is one millionth of a rem, is a unit for measuring “dose equivalence” of the health risk of an absorbed dose of radiation.

MITIGATION- The act of repairing or altering a building or building design for the purpose in whole or in part of reducing the concentration of radon in the indoor atmosphere.

MULTI-FAMILY BUILDING- A building, three stories or less, designed to building more than four families in separate units that do not have a common HVAC system for multiple units.

NEUTRAL PRESSURE PLANE- A horizontal line through a building that shows the level at which the pressure indoors equals the pressure outside. Also considered

NEUTRON- An elementary particle having approximately the same mass as the proton but lacking a net electric charge.

NUCLEUS- the central part of an atom, the fundamental particles of which are the proton and neutron, except for hydrogen, which is usually composed of one proton only: it carries a positive charge and constitutes almost all of the mass of the atom.

NUCLIDE- A type of atom specified by its atomic number, atomic mass, and energy state, such as carbon 14.

PARTITION- Something that divides or separates, as a wall dividing one room or cubicle from another.

PASSIVE MONITOR- A measurement tool that does not require external power or batteries to operate, such as charcoal detectors or alpha track detectors.

PASSIVE NEW CONSTRUCTION SYSTEM- A system installed in new construction that relies solely on the convective flow of air upward in the vent pipe for sub-slab depressurization and consists of a vertical pipe routed through conditioned space from the suction pit to at least 12 inches above the roof.

PERCENT DIFFERENCE- the amount by which one quantity is greater or less than another expressed as a percent.

PERMEABILITY (sub-slab)- The rate of flow of a liquid or gas through a porous material. Sub-slab references the flow underneath a concrete slab.

PICOCURIE (pCi)- A measure of radioactive energy equivalent to that released by one-trillionth of a gram of radium. One pCi represents 2.2 radioactive disintegrations per minute.

PICOCURIE PER LITER (pCi/L)- Represents 2.2 radioactive disintegrations per minute per liter of air.

PLENUM- A condition, space, or enclosure in which air or other gas is at a pressure greater than that of the outside atmosphere.

PRECISION- The ability of a measurement to be consistently reproduced.

PRECISION ERROR- Lack of clarity in measurements to produce consistent data.

PRESSURE DRIVEN AIRFLOW (CONVECTIVE MOVEMENT)- Heat transfer in a gas or liquid by the circulation of currents from one region to another, from areas of higher concentration to lower.

POLYVINYL CHLORIDE (PVC)- Polymer of vinyl chloride; tasteless, odorless; insoluble in most organic solvents; a member of the family of vinyl resins; used in soft flexible films for food packaging and in molded rigid products such as pipes, fibers, upholstery, and bristles.

PROTON- A stable, positively charged subatomic particle in the baryon family having a mass 1,836 times that of the electron.

QUALITY ASSURANCE- A system for evaluating performance, as in the delivery of services or the quality of products provided to consumers, customers, or patients.

QUALITY ASSURANCE PROGRAM (QAP)- Quality Assurance Program.

QUALITY CONTROL- The operational techniques and the activities that sustain the quality of a product or service in order to satisfy given requirements. It consists of quality planning, data collection, data analysis, and implementation, and is applicable to all phases of the product life cycle: design, development, manufacturing, delivery and installation, and operation and maintenance.

RADIANT HEATING- A method of heating a space by means of radiation, as from electric coils, hot-water or steam pipes, etc. installed in the floor or walls.

RADIOACTIVE DECAY SERIES- A group of isotopes representing various stages of radioactive decay in which the heavier members of the group are transformed into successively lighter ones, the lightest being stable.

RADIOACTIVITY- Spontaneous emission of radiation, either directly from unstable atomic nuclei or as a consequence of a nuclear reaction or the radiation, including alpha particles, nucleons, electrons, and gamma rays, emitted by a radioactive substance

RADIONUCLIDE- A nuclide, an atom with an unstable nucleus, that exhibits radioactivity.

RADIUM- A rare, brilliant white, luminescent, highly radioactive metallic element.

RADON- A gaseous radioactive decay product of uranium or thorium.

RADON CHAMBER- A facility in which radon measurement devices or detectors are exposed to known radon concentrations.

RADON CONTRACTOR- A person licensed to perform radon (or radon progeny) mitigation or to perform measurements of radon (or radon progeny) in an open atmosphere.

RADON DECAY PRODUCTS- A colorless, odorless, tasteless, naturally occurring radioactive, inert gaseous element formed by the radioactive decay of radium.

RADON PROGENY- Any combination of the radioactive decay products of radon.

RADON RESISTANT NEW CONSTRUCTION (RRNC)- Construction techniques that have been demonstrated to limit the amount of radon gas that enters from surrounding soil into the indoor environment. These techniques include passive and skeletal new construction systems.

RADON SOURCE STRENGTH- Point of origin of concentration of radon.

RE-ENTRAINMENT- The unintended re-entry into a building of radon that is being exhausted from the vent of a radon mitigation system.

RELATIVE BIAS- The estimated bias divided by the true or reference value and expressed as a percentage.

RELATIVE MEASUREMENT ERROR- Relative error is the ratio of the absolute error of the measurement to the accepted measurement. The relative error expresses the "relative size of the error" of the measurement in relation to the measurement itself.

RELATIVE PRECISION- term which is frequently used to denote the ratio of the error variances of two sample designs which are different but which are based upon the same sampling unit and the same size of sample.

RELATIVE HUMIDITY- The amount of water vapor in the air at any given time is usually less than that required to saturate the air. The relative humidity is the percent of saturation humidity, generally calculated in relation to saturated vapor density.

SCHEDULE- Is the thickness of a pipe.

SCREENING MEASUREMENT- A screening test is a procedure that is performed to detect the presence of a particular substance.

SEALING AND CAULKING- Means to plug and make tight to reduce the passage of gas. Sealing and caulking enhances radon reduction techniques; however, sealing and caulking alone has not been shown to lower radon levels significantly.

SECULAR EQUILIBRIUM-Occurs when the quantity of a radioactive isotope remains constant because its production rate (due, e.g., to decay of a parent isotope) is equal to its decay rate. Radioactive equilibrium in which the parent has such a small decay constant that there has been no appreciable change in the quantity of parent present by the time the decay products have reached radioactive equilibrium.

SENSITIVITY CHECKS-Are used in determining the lowest limits of detection for a particular measurement system.

SHORT TERM MEASUREMENT- Measurements conducted for at least 48 hours and up to 90 days; closed building conditions are required for measurements lasting seven days or less and recommended throughout.

SKELETAL NEW CONSTRUCTION SYSTEM- A system installed in new construction that is designed for the installation of a vent van and may consist of multiple vent pipes, including vertical an angled runs not necessarily routed through conditioned space, that may be joined to a single termination above the roof or may terminate separately above the roof.

SLAB-ON-GRADE- Is a type of foundation which transfers building loads to the earth very near the surface, rather than to a subsurface layer or a range of depths as does a deep foundation.

SOIL GAS- The gas mixture that is present in soil, that may contain radon.

SOIL GAS RETARDER- A continuous membrane or other comparable material used to retard the flow of soil gases into a building.

SPIKED SAMPLES- see BLIND SPIKES

SPLIT LEVEL BUILDING- is a style of building in which the floor level of one part of the building is about half way between a floor and its ceiling of the other part of the building.

STACK- A vertical pipe.

STACK EFFECT- The overall upward movement of air inside a building that results from heated air rising and escaping through openings in the building envelope, thus causing indoor air pressure in the lower portions of the building to be lower than the pressure in the soil beneath or surrounding the building foundation.

STANDARD DEVIATION- Is a measure of the dispersion of a collection of values.

SUBFLOOR- A wood floor which is laid over the floor joists and on which the finished floor is laid.

SUB-MEMBRANE DEPRESSURIZATION (SMD)- A radon control technique designed to achieve lower air pressure in the space under a soil gas retarder membrane which is laid on the crawlspace floor and sealed, relative to air pressure in the crawlspace, by use of a fan-powered vent drawing air from beneath the membrane.

SUB-SLAB DEPRESSURIZATION (Active) or (SSD- Active)- A radon control technique designed to achieve lower sub-slab pressure relative to indoor air pressure by use of a fan-powered vent drawing air from beneath the concrete slab.

SUB-SLAB DEPRESSURIZATION (Passive) or (SSD- Passive)- A radon control technique designed to achieve lower sub-slab air pressure relative to indoor air pressure by use of a vent pipe (without a fan) routed through the conditioned space of a building and connecting the sub-slab area to the outdoor air. This system relies primarily on the convective flow of warmed air upward in the vent to draw air from beneath the concrete slab.

SUCTION HOLE/POINT- The absorption of soil gases possessed by a plastered surface concentrated in one point or space.

SUITABLE FOR OCCUPANCY- A structural area in a home currently lived in or an area not currently suitable for occupancy, such as a basement, that an occupant or homeowner could use for living space without renovations. This includes an unfinished basement that could be used regularly as a playroom, recreation room, exercise room or workshop.

SUMP- A sump is a specially made receiving tank to receive wastes or sewage by gravity; from the sump the wastes or sewage is lifted by pump or ejectors to be discharged into the building drain or building sewer.

SUMP PUMP- A small capacity pump that empties pits receiving groundwater, sewage, or liquid waste.

SUB MEMBRANE DEPRESSURIZATION- A way to create a vacuum under the floor under the sidewalls to contain radon, often made from polyester.

THERMAL BYPASS- Facilitation of the upward movement of air because of the stack effect through any opening in the floors or common chases such as recessed lighting fixtures, plumbing chases and air gaps around the chimney.

THERMAL RESISTANCE- An index of a materials resistance to heat flow; it is the reciprocal of thermal conductivity (k) or thermal conductance (C). The formula for thermal resistance is.

TIGHT BUILDING- A building in which the air exchange rate is low.

TIME INTEGRATED SAMPLING- Sampling done over a period of time and then reported as an average number for that period.

USEPA- the United States Environmental Protection Agency.

UNATTACHED FRACTION-Radon decay products that are in the air and have not yet attached to larger dust particles. Unattached fractions are more dangerous to cause lung cancer because they are able to travel further within a lung.

URANIUM-238- The most common isotope of uranium, having mass number 238 and half-life 4.46×10^9 years, nonfissionable but irradiated with neutrons to produce fissionable plutonium 239.

VAPOR BARRIER- A material with a high resistance to vapor movement, such as foil, plastic film, or specially coated paper, that is used in combination with insulation to control condensation and limit the passage of gas.

VENTILATION RATE- The rate at which fresh air brought into the system from the outdoors.

WARM AIR SUPPLY- Any heating system which sends out warm air to circulate the building.

WATER COLUMN (WC)- Hydrostatic pressure can be analyzed by the height of a water column, which effectively yields the pressure at a given depth of the column.

WEATHERSTRIP- A ribbon of resilient material used to reduce air infiltration through the crack around a sash or door.

WIND INDUCED AIRFLOW- Changes in air pressure around and inside a building that results in air movement.

WORKING LEVEL (WL)- Any combination of short-lived radon decay products in one liter of air that will result in the ultimate emission of 1.3×10^5 MeV of potential alpha energy. The short-lived radon progeny for radon-22 are: polonium-218, lead-214, bismuth-214 and polonium-214. The number 1.3×10^5 MeV was chosen because it is approximately the alpha energy released from the decay products in equilibrium with 100 pCi of Ra-222. Exposures are measured in working level months (WLM).

WORKING LEVEL MONTH- Exposures of working level (WL) are measured in working level months (WLM). Working level months (WLM): (working level x hours or exposure)/(170 hours/working month). In SI units, 1 WLM = 6×10^5 Bq-h/M^3 (EEC).

RADON MEASUREMENT IN SCHOOL BUILDINGS

Summary of Public Act 96-0417 (PA96-0417) – January 2010

- ❖ Recommendation that every occupied school building in a school district be tested every 5 years for radon.

- ❖ Recommendation that new schools in a school district be built using radon resistant new construction techniques.

- ❖ A licensed Radon Professional (from the list of IEMA approved professionals) may be selected to perform the measurement test. Alternatively, a school district may perform its own measurements by having a staff member successfully complete an IEMA approved measurement course.

The purpose of this training is to serve as the school district measurement course. If you are reviewing this course, as the school district, you are taking the first step toward conducting your own radon testing.

- ❖ Test Results: Each school district may maintain, make available for review, and notify parents and faculty of the test results.

- ❖ Reporting: The school district shall report radon test results to the State Board of Education, which shall prepare a report every 2 years. This report will include results from all the schools that have performed testing. The report will be submitted to the General Assembly and the Governor.

- ❖ Test Results Above Action Levels: The school district may hire a licensed radon professional to take additional measurements before any mitigation decisions are made. If the additional measurements are above the action level, it is recommended that mitigation be performed by a licensed radon professional.

Overview of Course

The course, presented in this Module 1, will cover radon testing in schools and will also include some introductory materials that are important to have a full understanding of radon testing in schools. After completion of the course, the school district will have an understanding of the basics of radon, how to place the radon test devices, and how to understand the test results. This module will serve as a reference guide and provide the necessary elements to decision making for school building testing.

The other Modules, reading material, and references are provided as supplementary material that will help answer questions from the public, parents, and school administration. It is also important to have a thorough understanding of radon to be able to make prudent decisions for radon mitigation, if mitigation is necessary.

The Radon Measurement Exam will focus on the radon school testing requirements.

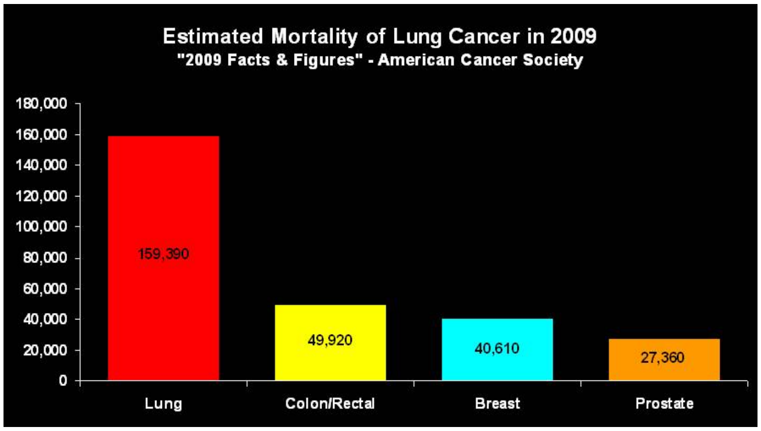
Why is Radon a Problem?

Radon is a naturally occurring colorless, odorless, tasteless and radioactive gas. It comes from the natural breakdown (decay) of uranium which is found in soil and rock all over the United States. Radon travels through the soil and enters buildings through cracks and openings in the foundation. Eventually, radon decays into radioactive particles (decay products) that can be trapped in the lungs when you breathe. As these particles in turn decay further, they release small bursts of radiation. This radiation can damage lung tissue and lead to lung cancer over the course of a lifetime.

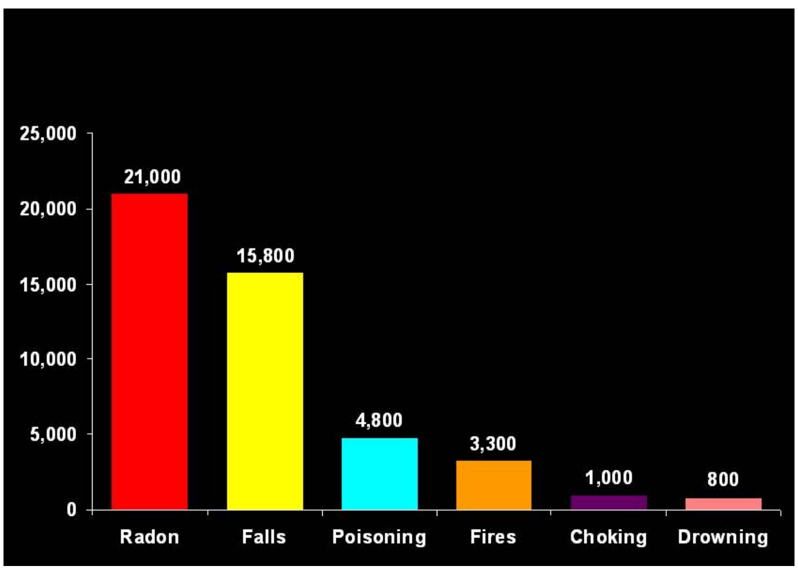
Radon is a human carcinogen. Prolonged exposure to elevated radon concentrations causes an increased risk of lung cancer. Like other environmental pollutants, there is some uncertainty about the magnitude of radon health risk; however, scientists are more certain about radon risks than from other cancer-causing environmental pollutants. This is because estimates of radon risk are based on studies of cancer in humans (underground miners and other more current epidemiological studies).

The Surgeon General, in 2005, warned Americans about the health risk from exposure to radon in indoor air. Because radon is the leading cause of lung cancer for non-smokers in the U.S. and breathing radon over prolonged periods can present a significant health risk, the Surgeon General urged Americans to perform radon testing.

The figure below shows that there are more incidences of lung cancer than colon/rectal, breast or prostate cancer. The survival rate for Lung Cancer is one of the lowest for those with cancer; from the time of diagnosis, between 11 and 15% of those afflicted will live beyond 5 years.



The United States Environmental Protection Agency (USEPA) estimates that 21,000 lung cancer related deaths occur annually in the U.S. with 1,160 of those in Illinois. The bar chart below is from the 2009 National Safety Council Report.



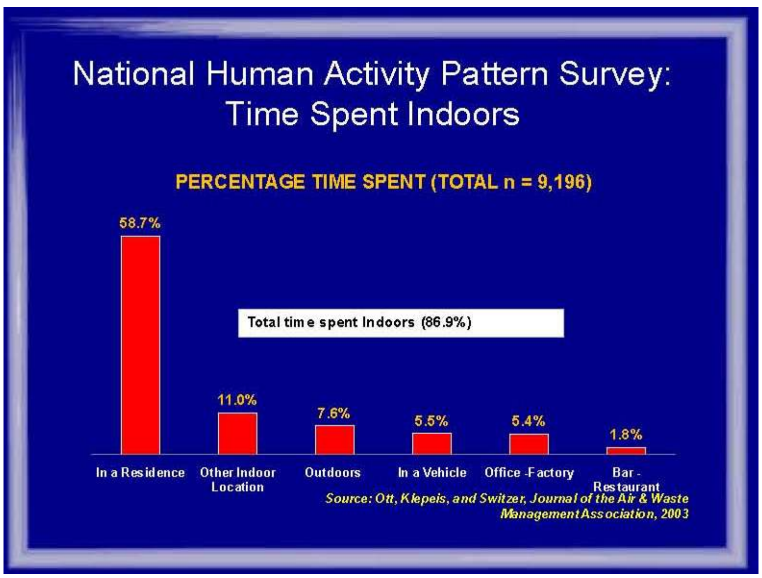
Not everyone who breathes in radon (or radon decay products) will develop lung cancer. An individual's risk of lung cancer depends mostly on the concentration of radon, the duration of exposure and genetic and health disposition. Smoking combined with radon is an especially serious health risk. The risk of dying from lung cancer caused by radon is much greater for smokers than non-smokers.

Children (who have higher respiration rates than adults) have been reported to have greater risk than adults for certain types of cancer from radiation, but there is no conclusive data at this time on whether children are at greater risk than adults from radon.

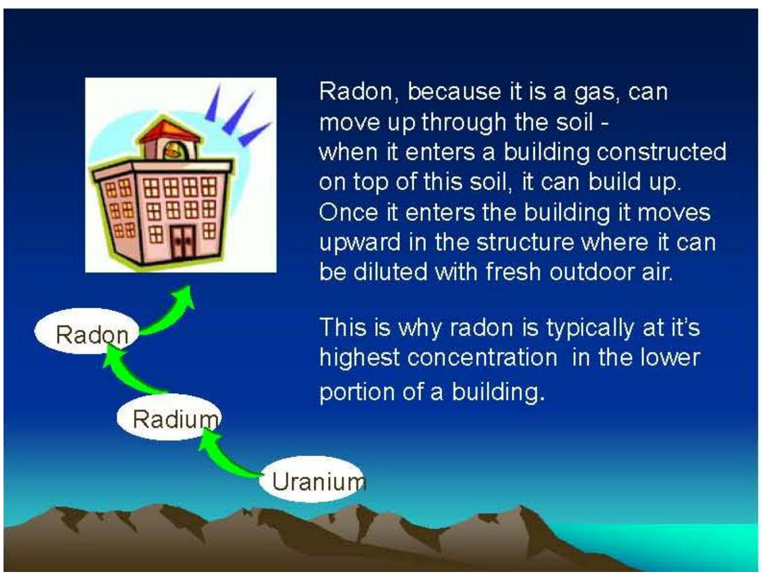
Where Do We Spend Our Time?

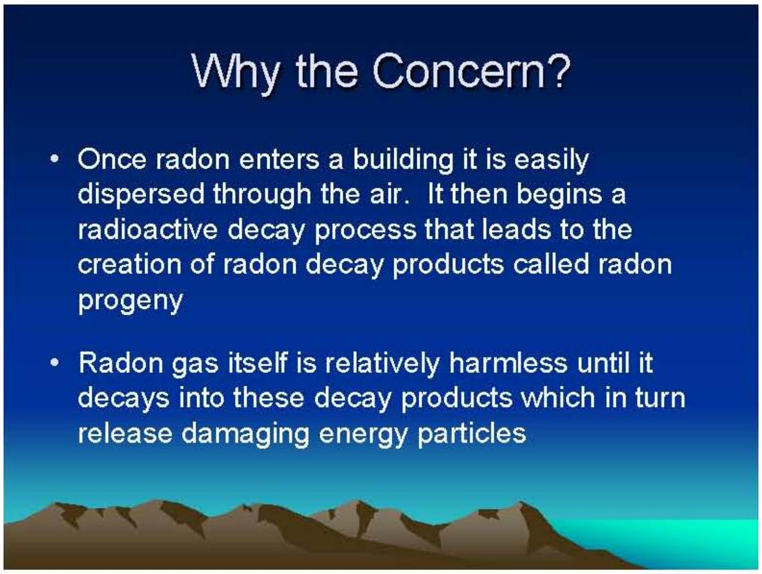
Studies show that we spend 86.9% of our time indoors on a daily basis. Because many people, particularly children, spend much of their time at home, the home is likely to be the most significant source of radon exposure. The Illinois Emergency Management Agency (IEMA) has collected measurements of 104,884 homes in Illinois. This data from licensed radon professionals has been collected starting in 2003 and continues today. This data shows that over thirty-six percent (36%) of the homes in the state have radon test levels above the **USEPA Action Level**.

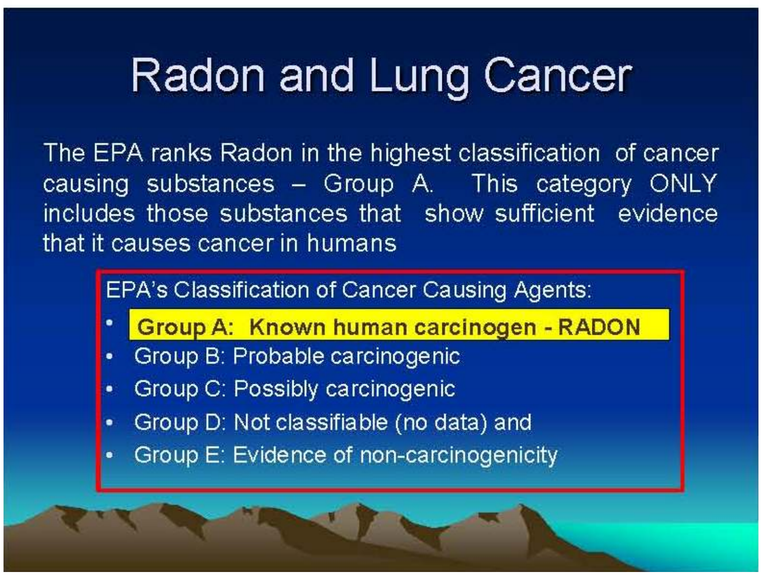
For most school children and staff, the second largest contributor to their radon exposure is likely to be their school. As a result both USEPA and IEMA recommend that buildings as well as homes be tested for radon.

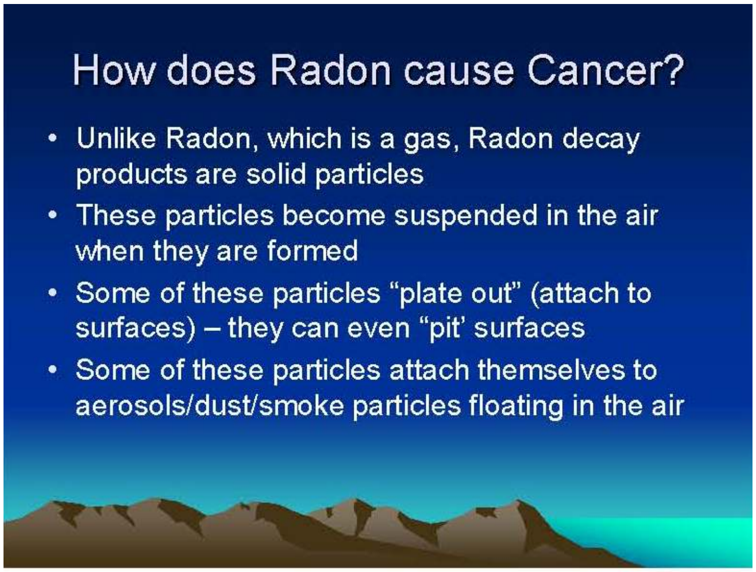


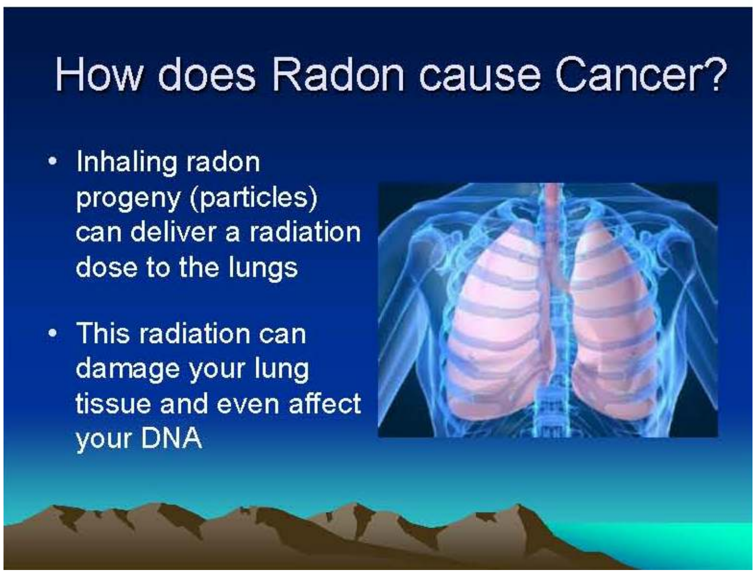
What is Radon?

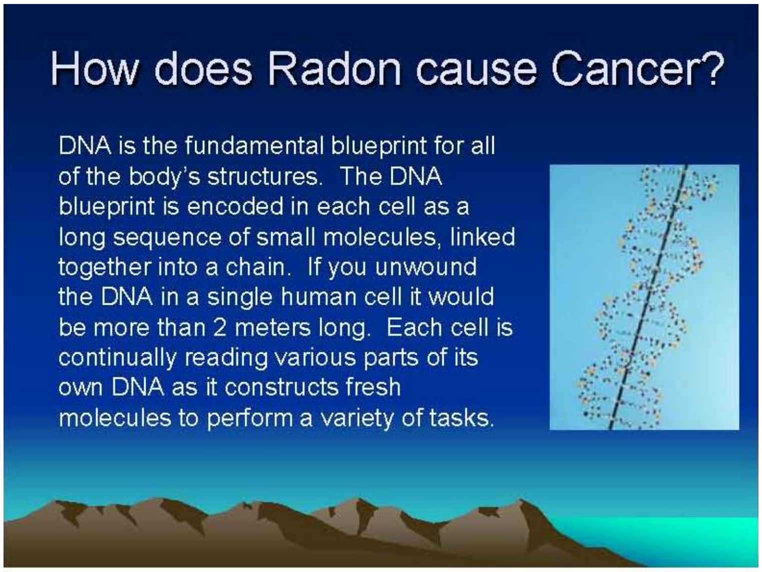


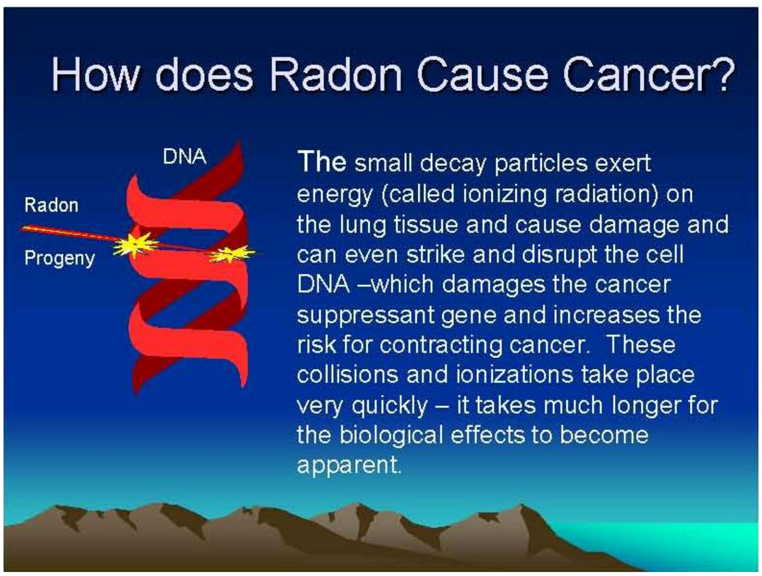

Why the Concern?
• Once radon enters a building it is easily dispersed through the air. It then begins a radioactive decay process that leads to the creation of radon decay products called radon progeny
• Radon gas itself is relatively harmless until it decays into these decay products which in turn release damaging energy particles

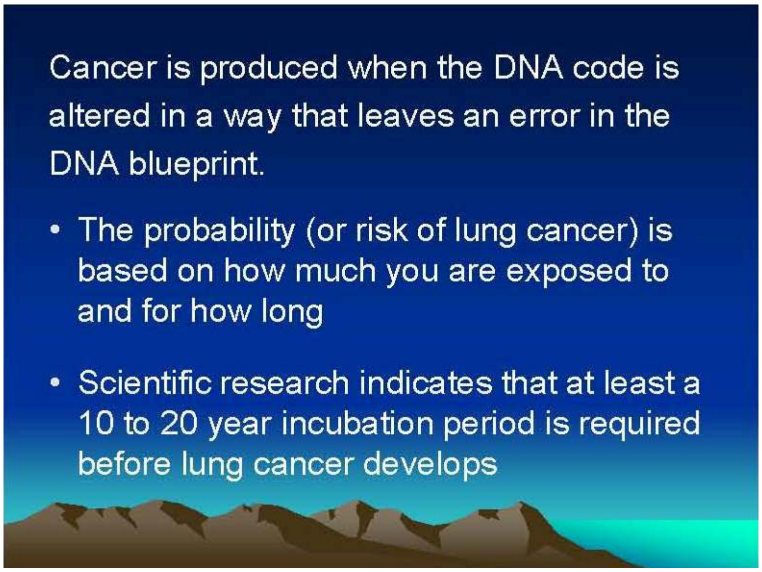

Radon and Lung Cancer
The EPA ranks Radon in the highest classification of cancer causing substances – Group A. This category ONLY includes those substances that show sufficient evidence that it causes cancer in humans
EPA's Classification of Cancer Causing Agents:
• Group A: Known human carcinogen - RADON
• Group B: Probable carcinogenic
• Group C: Possibly carcinogenic
• Group D: Not classifiable (no data) and
• Group E: Evidence of non-carcinogenicity


How does Radon cause Cancer?
• Unlike Radon, which is a gas, Radon decay products are solid particles
• These particles become suspended in the air when they are formed
• Some of these particles “plate out” (attach to surfaces) – they can even “pit’ surfaces
• Some of these particles attach themselves to aerosols/dust/smoke particles floating in the air


How does Radon cause Cancer?
• Inhaling radon progeny (particles) can deliver a radiation dose to the lungs
• This radiation can damage your lung tissue and even affect your DNA


How does Radon cause Cancer?
DNA is the fundamental blueprint for all of the body's structures. The DNA blueprint is encoded in each cell as a long sequence of small molecules, linked together into a chain. If you unwound the DNA in a single human cell it would be more than 2 meters long. Each cell is continually reading various parts of its own DNA as it constructs fresh molecules to perform a variety of tasks.

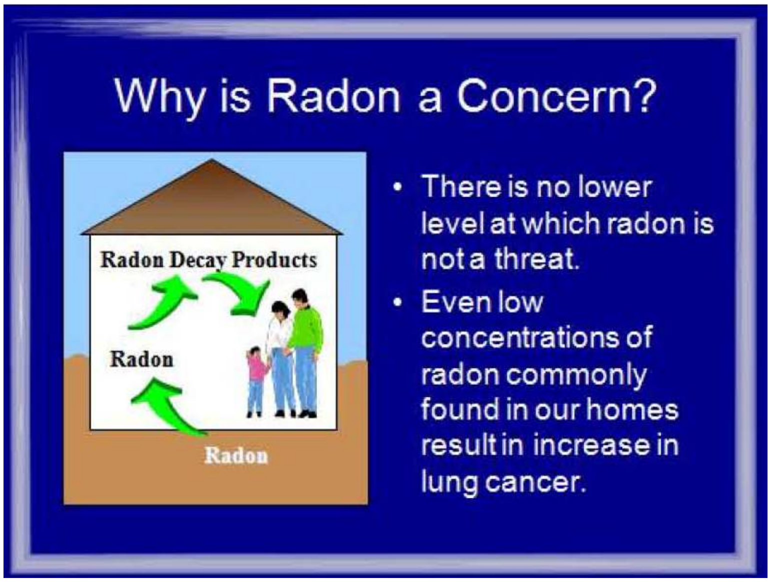

How does Radon Cause Cancer?
DNA
Radon
Progeny
The small decay particles exert energy (called ionizing radiation) on the lung tissue and cause damage and can even strike and disrupt the cell DNA –which damages the cancer suppressant gene and increases the risk for contracting cancer. These collisions and ionizations take place very quickly – it takes much longer for the biological effects to become apparent.



What is the USEPA Action Level?

USEPA recommends reducing the concentration of radon in indoor environments to below the Radon Action Level of 4 pCi/L. This action level is based on the ability of current mitigation technologies to reduce elevated radon levels below 4 pCi/L. Depending upon the building characteristics, it may (or may not) be possible to reduce levels well below the Action Level.

It must be noted that any level of radon carries some risk and no concentration of radon is ever safe.



What Radon Studies Have Been Completed in Schools?

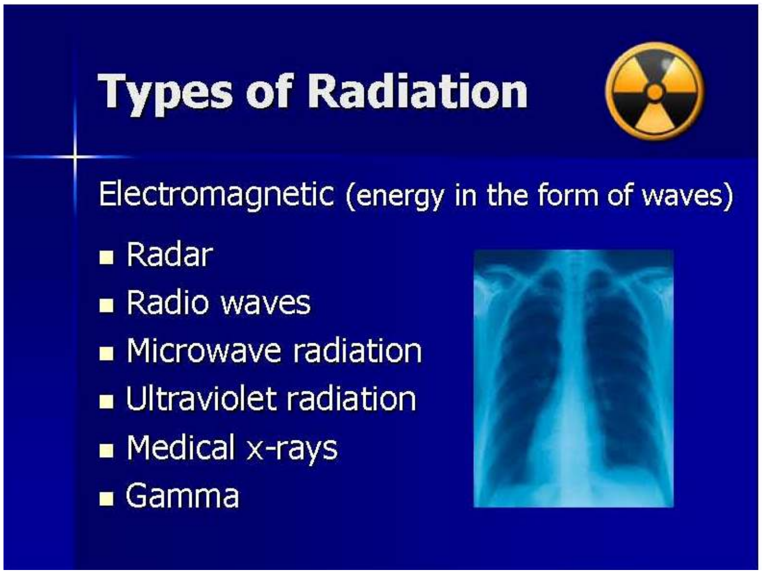
USEPA began investigating radon in schools in 1988. The initial studies show that there were elevated levels of radon in schools in every state.

A further study called the *National School Radon Survey* showed that 19.3% of all U.S. schools (nearly one in five) have at least one frequently occupied room with short-term radon levels above the **USEPA Action Level**. In total USEPA estimates that there are over 70,000 schoolrooms that are impacted by radon.

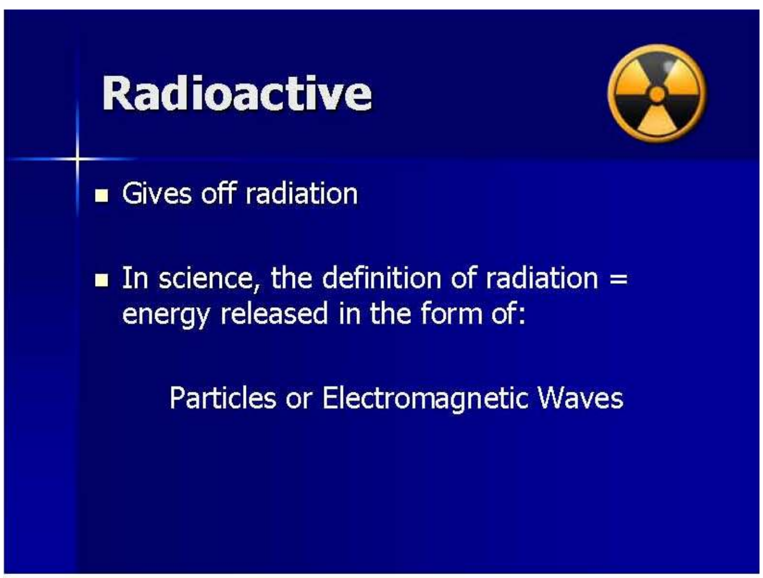
What is the Basis of Radiation?

In nature, atoms are generally stable and their structure doesn't change. A piece of gold will remain a piece of gold. Radioactive materials, on the other hand, are unstable and the atoms change constantly until all the atoms become stable.

Radioactive materials are said to emit radiation. Radiation can be classified as *ionizing* or *non-ionizing radiation*. The most common type of radiation is ionizing radiation, for example, *radioactive material* give off ionizing radiation. An atom of a radioactive material gives off ionizing radiation because the inherent energy within itself causes the atom to change in structure. Radiation is energy in the form of particle or waves emitted by an atom as it changes in structure from a higher energy state to a lower energy state.



As mentioned above, when an atom changes in structure due it's radioactive properties, it is called radioactive decay. **Radioactive decay is the disintegration of the nuclei of atoms in a radioactive element.** These disintegrations are usually accompanied by the release of parts of the nucleus (called decay products) which are sometimes accompanied by the release of energy. Radioactive decay occurs spontaneously. The atom is changed due to the decay products that are released.



There are three principal types of radioactive decay products: alpha, beta and gamma radiation. They are all emitted from the nucleus of the unstable atom.

Alpha Radiation (α)

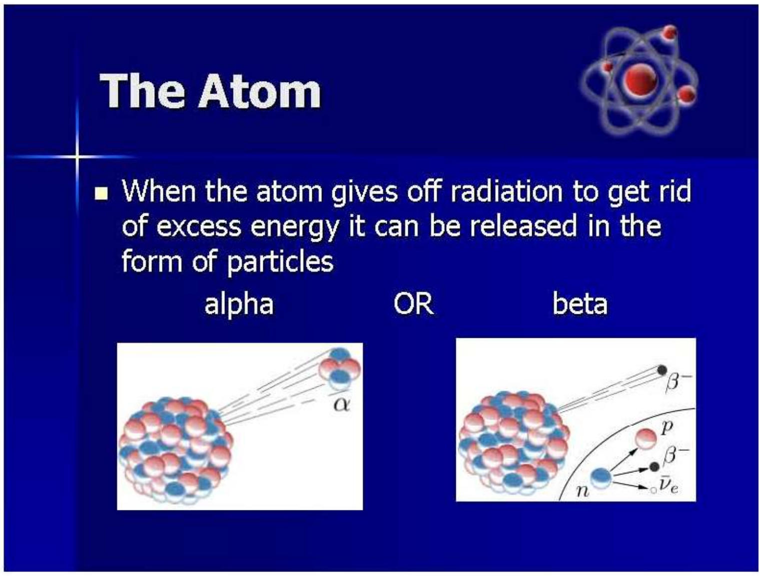
- Alpha radiation or alpha decay is a type of radioactive decay in which an atomic nucleus emits an alpha particle (two protons and two neutrons – which is the same thing as a helium nucleus)
- In the decay process, the atomic mass number changes by 4 and the atomic number changes by 2.
- Alpha particles are relatively massive, relatively slow, and have a total charge of +2.
- Alpha particles are strong enough to pit plastic.

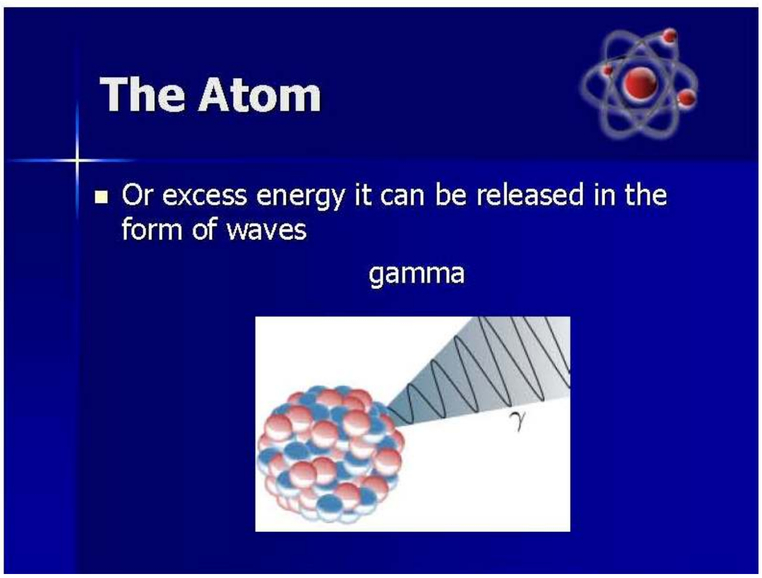
Beta Radiation (ß)

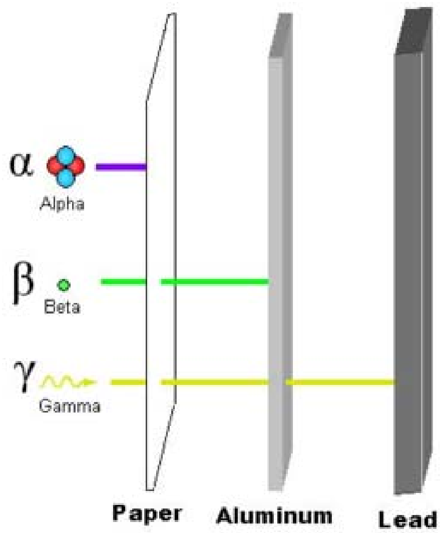
- Beta radiation or beta decay releases a particle which is an electron.
- In the decay process, the atomic mass number remains unchanged.
- Beta particles are relatively small in mass, relatively fast moving, and have a total charge of -1.

Gamma Radiation (γ)

- Gamma radiation is pure energy. It is released from the nucleus whenever an alpha or beta is emitted.
- Gamma rays have no mass, move at the speed of light and have no charge.


The Atom
When the atom gives off radiation to get rid of excess energy it can be released in the form of particles
alpha OR beta
α
β−
p
β−
ν̄e
n


The Atom
Or excess energy it can be released in the form of waves
gamma
γ



This shows three different types of radiation and their penetration levels.

When alpha and beta particles are emitted from an atom they are traveling at varying speeds. When they collide with something they deposit some or all of that energy in the thing with which they have collided.

Alpha particles collide readily with matter and lose their energy quickly. Therefore they have little penetrating power and can be stopped by the first layer of skin or a sheet of paper. However, if alpha particles are inhaled this can affect the cellular tissue – because they give up their energy over a relatively short distance, alpha particles inside the body can inflict more severe biological damage than other types of radiation. Alpha radiation presents the greatest risk associated with radon. Some alpha particles are also dangerous when swallowed, but generally, the most risk is to the lungs.

Beta particles are fast-moving, but much smaller that alpha particles. Beta particles have medium penetrating power and can travel several feet in the air. They can penetrate up to 1 to 2 centimeters of water or human flesh. They can be stopped by a sheet of aluminum a few millimeters thick. Even though beta particles can travel farther into the body, the damage done by alpha particles is about 20 times greater.

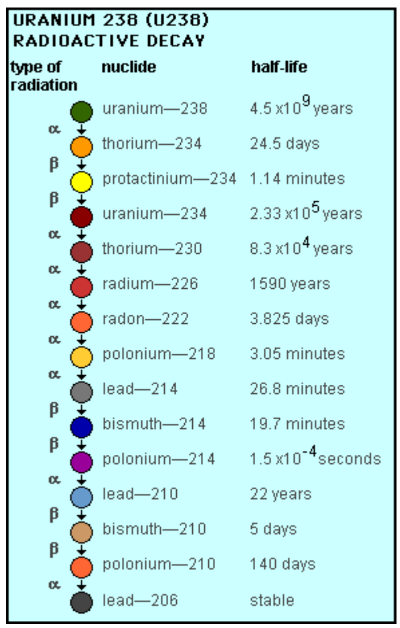
Gamma radiation is similar to medical X-rays. Gamma radiation is transmitted in a wave without movement of material, just as heat and light from a fire or sun travels through space. But unlike light, these rays have great penetrating power and can pass through the human body. Physical mass in the form of concrete, lead or water is used as a shield from gamma rays. As above, even though gamma radiation can penetrate the body, the damage called by alpha particles is greater.

Most atoms are not radioactive; since their nuclei are stable (i.e., they do not decay). This is why an ordinary object, such as a diamond or gold with millions and millions of atoms with stable nuclei, always remains the same.

What is the Source of Radon?

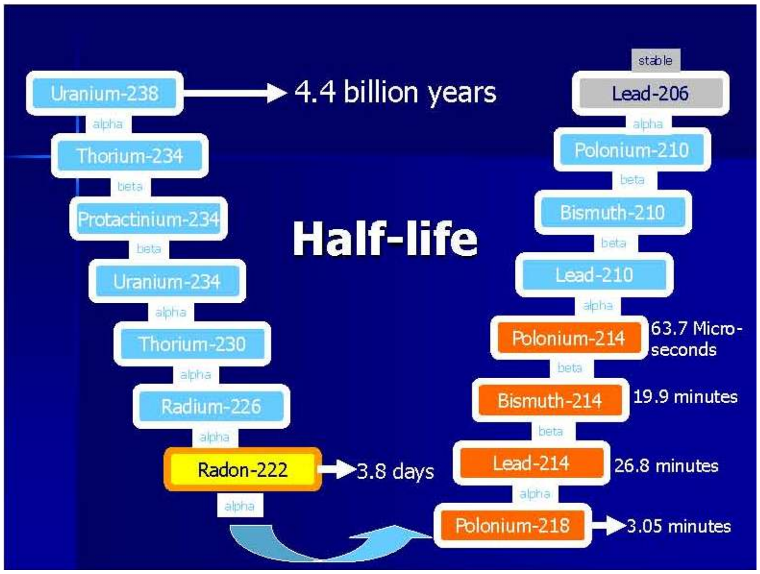
It was mentioned earlier, that Radon comes from the natural deposits of uranium in soil, rock or water. Uranium is an unstable radioactive material that undergoes radioactive decay through a series of changes in its natural state called the Uranium Decay Chain. Other unstable materials go through similar Decay Chains.

In the case of Uranium the elements in the series change (through decay), after a sufficiently long time, from radioactive elements into the final form of lead which is stable and will not change.

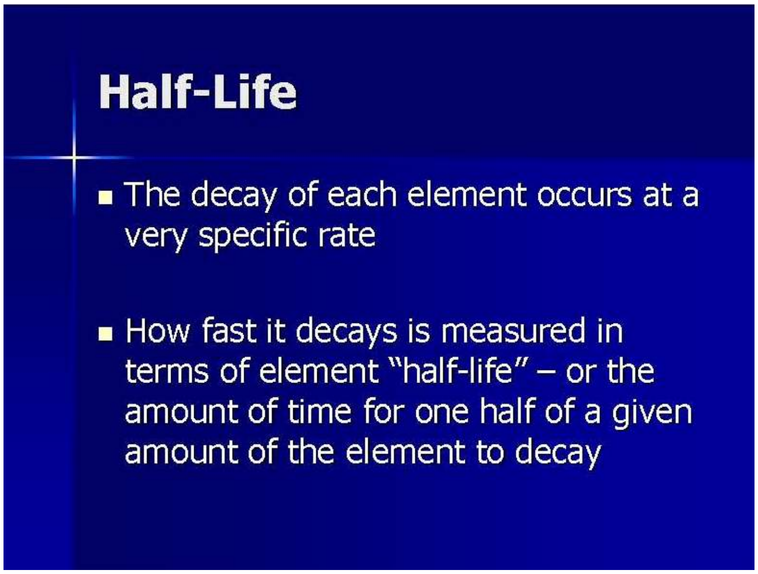


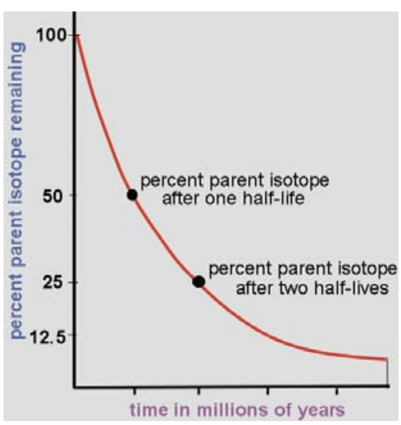
<u>Half-life</u>

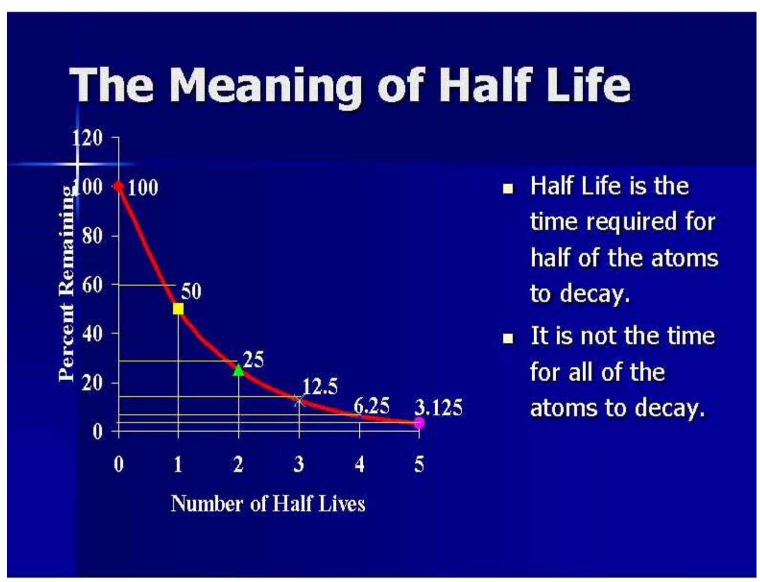
The half-life of uranium is 4.4 billion years – so a 4.4 billion year old rock has only half of the uranium it started with. The half-life of radon is only 3.8 days, meaning that in 3.8 days, there will only be half the amount of radon left, in the next interval, only one quarter remains, and so on. The half-life is important because this is related to the time interval where radon and its decay products are available to be dispersed into the environment and into the body.


Half-life
Uranium-238
4.4 billion years
alpha
Thorium-234
beta
Protactinium-234
beta
Uranium-234
alpha
Thorium-230
alpha
Radium-226
alpha
Radon-222
3.8 days
alpha
Polonium-218
3.05 minutes
alpha
Lead-214
26.8 minutes
beta
Bismuth-214
19.9 minutes
beta
Polonium-214
63.7 Micro-seconds
alpha
Lead-210
beta
Bismuth-210
beta
Polonium-210
alpha
Lead-206
stable

Each radioactive element in the radon decay chain has a different half-life. The half-life is the time required for half the atoms of a radioactive element to decay. It is not the time for all of the atoms to decay. Half life usually occurs in an exponential manner, and continues infinitely, since it is possible to divide the amount left over and never reach zero. Usually at the end of ten half-lives, there is so little material remaining, it practically reaches zero.



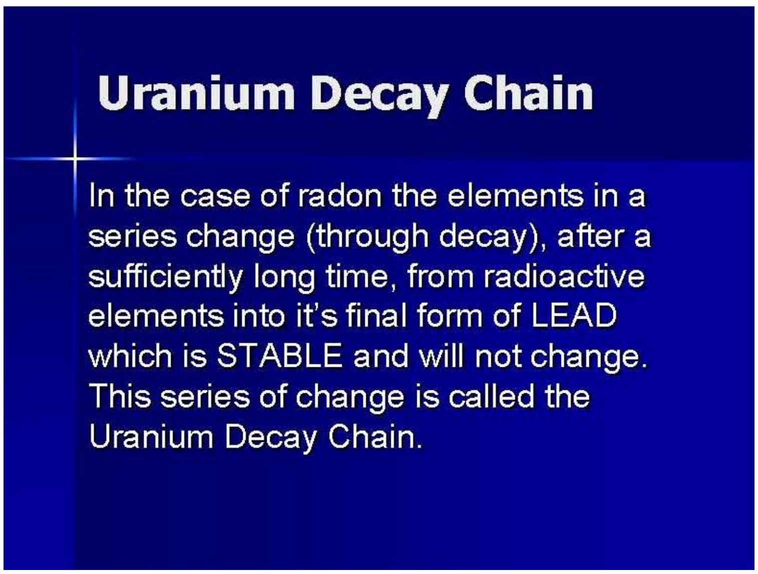


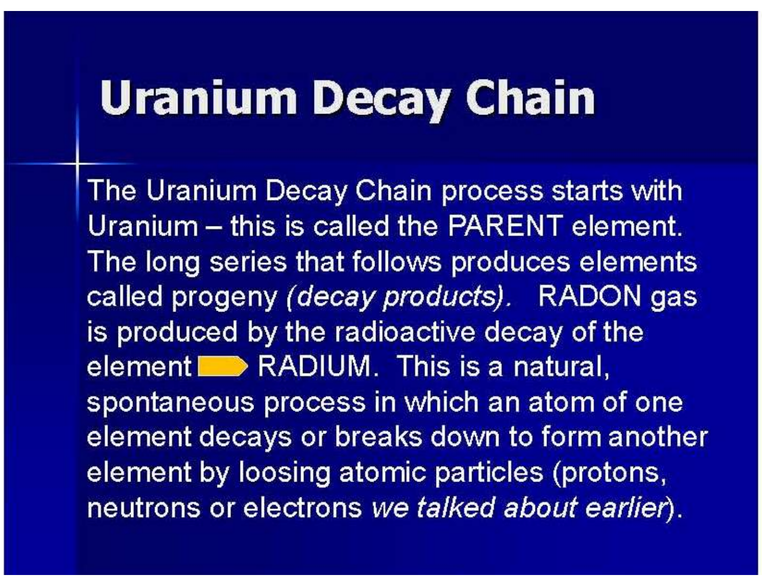


How Does Uranium Turn into Radon?

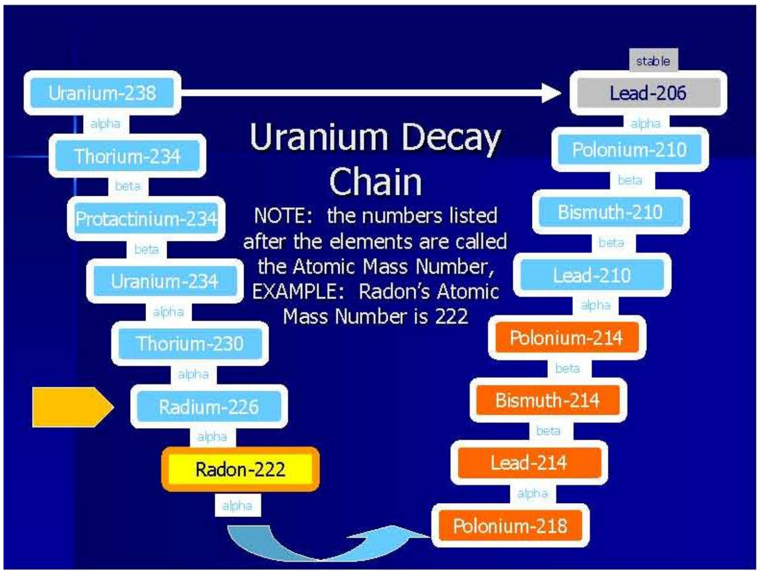
Uranium Decay Series

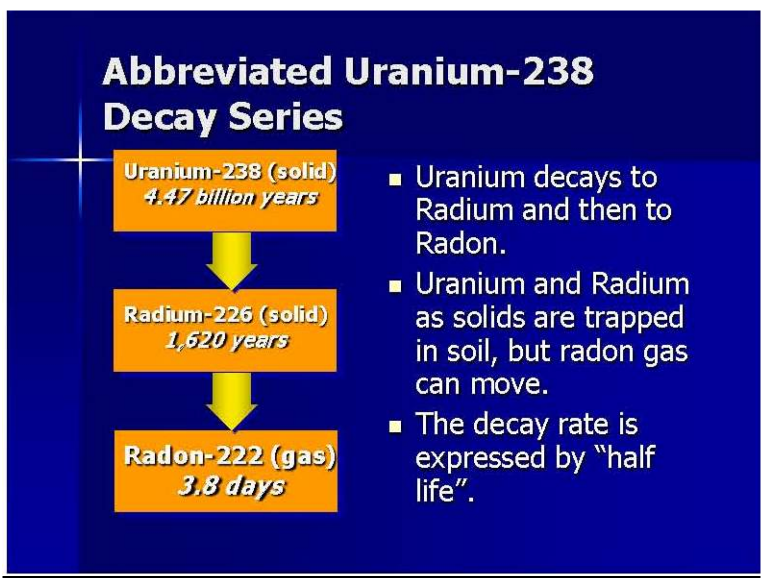
Radon is formed through the radioactive decay series of uranium. Uranium, which is found in nature as a solid material, decays through several intermediate steps to produce radium, (another solid) which produces radon (a gas). Radon then decays into other substances (radon decay products) which are also radioactive. This process continues until non-radioactive lead, which is stable, is formed. Uranium and radium as solids are trapped in soil, but radon gas can and will move throughout the soil and building materials.





The process starts with uranium-238, called the parent element. Since uranium-238 has a half-life of about 4.4 billion years, and the earth is about 5 billion years old, there is about half the original amount of uranium-238 remaining in the earth. The numbers associated with the element, for example uranium-238 is the atomic mass number, which is the total of the number of protons and neutrons in the nucleus. Therefore, uranium-238 has 238 protons and neutrons. Thorium-234 has 234 protons and neutrons and has a short half-life of 24.5 days.





Isotopes

Most elements have many different isotopes, an isotope being defined as having the same number of protons but a different number of neutrons. For example, lead-214, lead-210, and lead-206 are all isotopes of lead. Each has the same number of 82 protons, but differing number of neutrons (132, 128, and 124 respectively). This is why, when you refer to radioactive materials, you must be isotope specific.

Radon is produced by the radioactive decay of radium-226. When radium-226, decays to form radon-222 (radon gas) it loses 2 protons and 2 neutrons – these 2 protons and 2 neutrons are called the alpha particle.

There are also several isotopes of radon. Of most concern to public health is radon-222, made up of 86 protons and 136 neutrons. In general, all references to radon, concern radon-222.

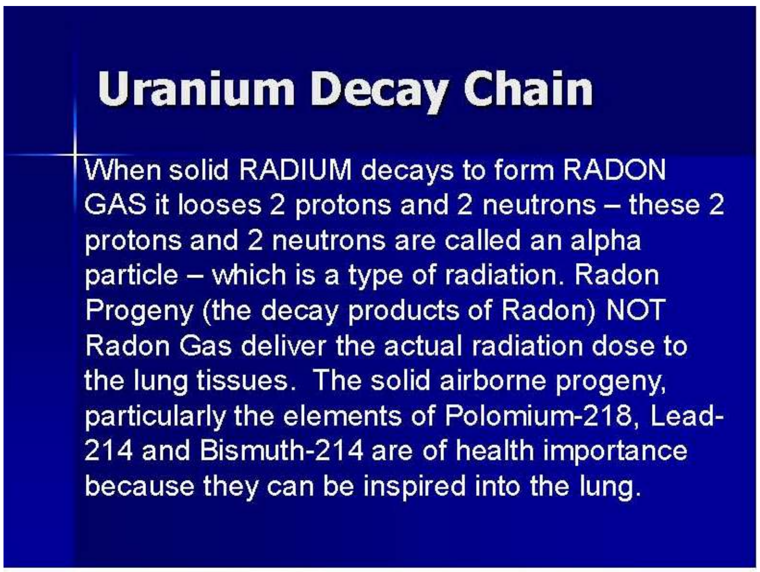
Radon Decay Products

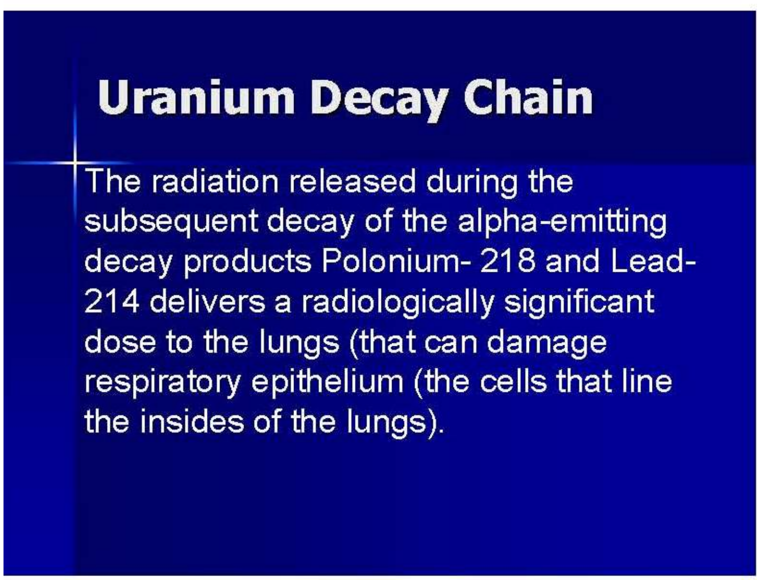
Radon-222 in turn produces other elements which are called radon decay products (RDPs). RDPs, which are in solid form, include polonium-218, lead-214, bismuth-214, and polonium-214. These radon progeny have short half-lives, but account for the major portion of the harmful health effects to the body.

- Polonium-218 and polonium-214 are the alpha emitters that do the most damage.
- Bismuth-214 and lead-214 are beta emitters that also produce gamma radiation.

It is the RDPs, not the radon gas, that deliver the actual radiation dose to the lung tissues. The RDPs are of concern to human health because they can be inspired into the lung. The radiation released during the subsequent decay of the alpha-emitting decay products polonium-218 and polonium-214 delivers a radiologically significant dose to the respiratory epithelium (cells that line the insides of the lungs).

The radiation from RDPs can impact adjacent atoms, and if this happens, the impacted atom can be altered by changing its electrostatic charge. This atom is then referred to as an ion and can chemically react with other atoms. This is the reason that RDPs are said to cause ionizing radiation. This ionizing radiation causes detrimental health effects, and can be scientifically measured and recorded.

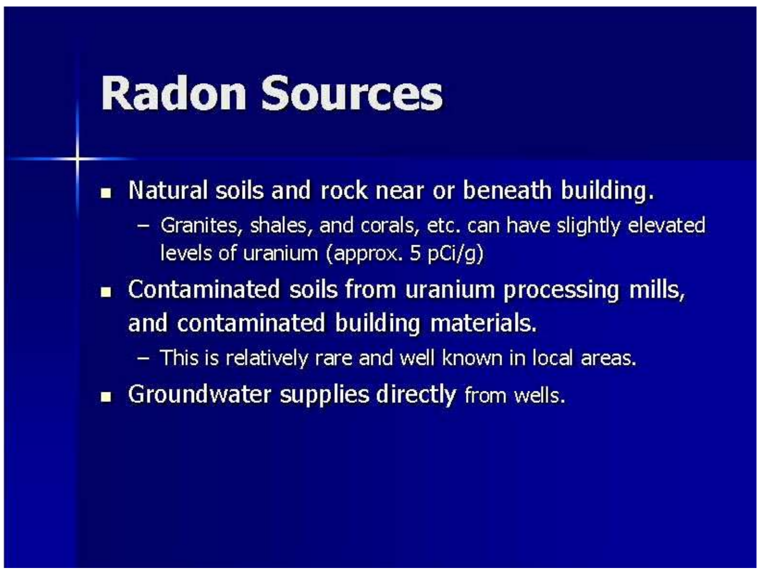




RDPs have several characteristics:

- Nearly all decay products are radioactive, often more reactive than the original parent.
- The decay series is scientifically predictable.
- They are relatively short-lived.
- They have a static electric charge.
- They are chemically reactive.
- They are solid particles, rather than gases, which act like an aerosol.
- They cause cell damage if they enter the lungs.
- Airborne solid particles attach themselves to solid objects such as dust, walls, clothing, etc.

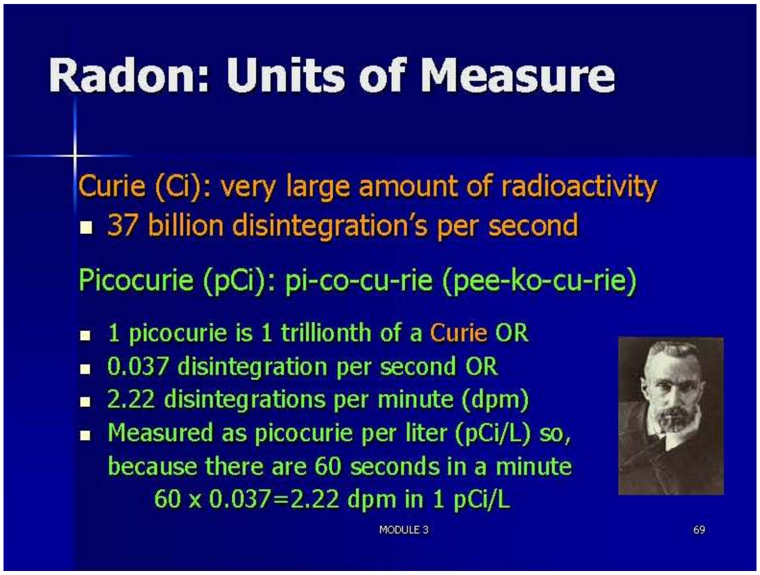
Where is Uranium found?



How is Radon Reported (Units of Measure)?

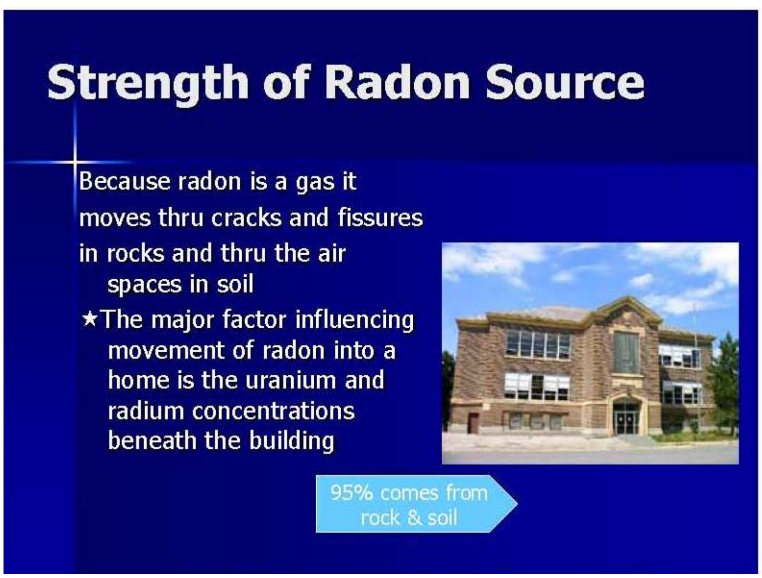
In the U.S, radioactive materials are measured in Curies. A curie is the amount of radioactivity released from one gram of radium. A picoCurie is a millionth of a millionth or a trillionth of a Curie. A picoCurie is measured as 2.22 atomic disintegrations per minute (0.037 disintegrations per second).

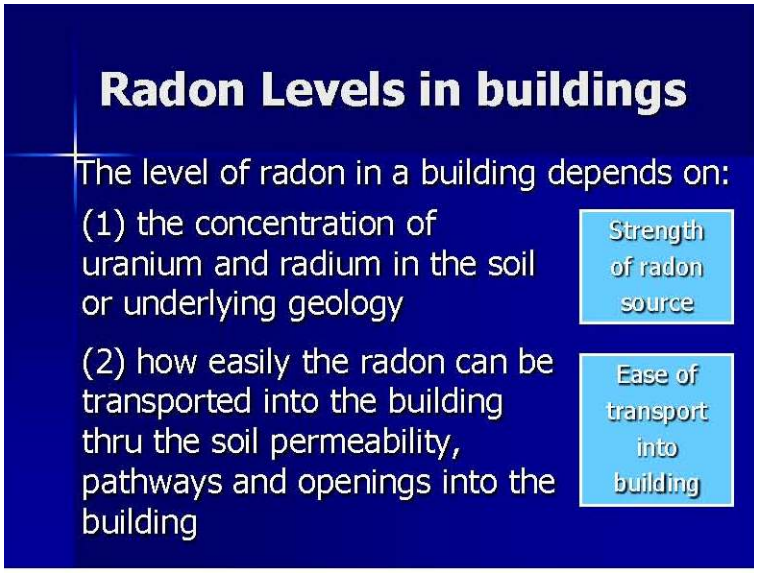
Radon gas (Radon-222) is measured in picoCuries per liter (pCi/L), which is a measure of the number of radioactive disintegrations per minute for each liter of air.

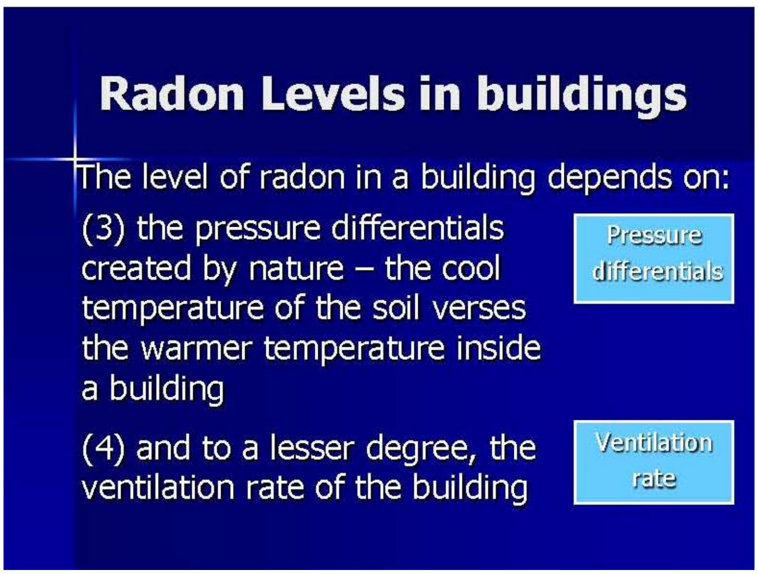


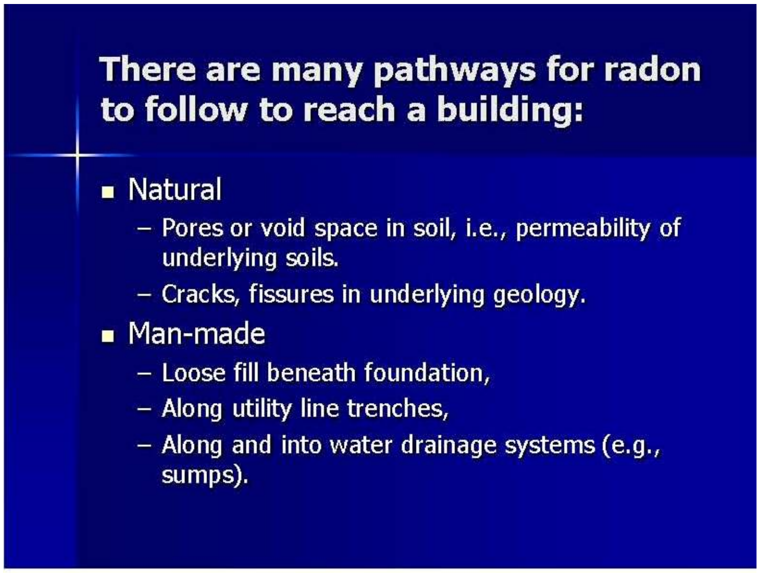
What are the Routes of Radon Entry

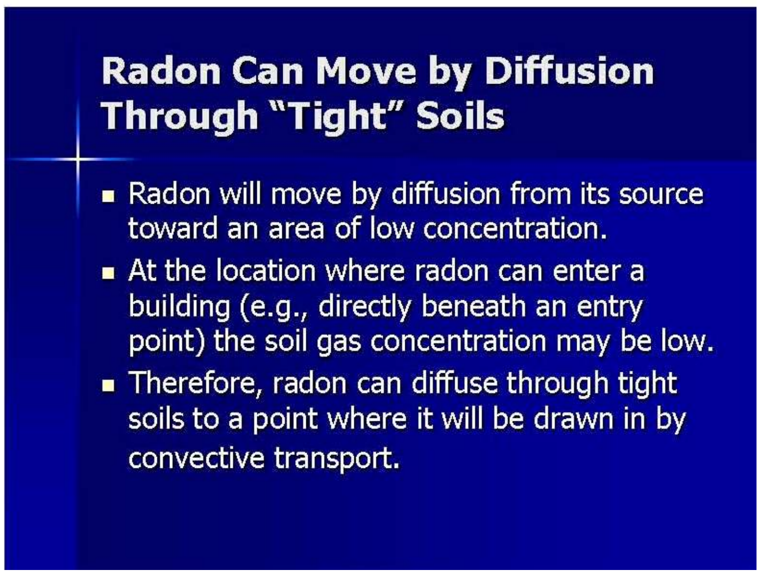
Many factors contribute to the entry of radon gas into a school building. Schools that are in the same community can have significantly different radon levels from one another. As a result, school officials cannot know if elevated levels of radon are present without testing.



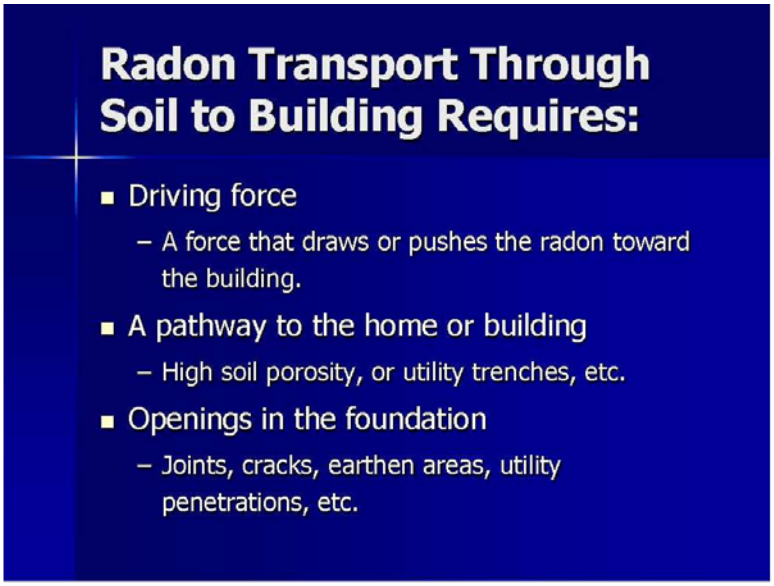

Radon Levels in buildings
The level of radon in a building depends on:
(1) the concentration of uranium and radium in the soil or underlying geology
Strength of radon source
(2) how easily the radon can be transported into the building thru the soil permeability, pathways and openings into the building
Ease of transport into building


Radon Levels in buildings
The level of radon in a building depends on:
(3) the pressure differentials created by nature – the cool temperature of the soil verses the warmer temperature inside a building
Pressure differentials
(4) and to a lesser degree, the ventilation rate of the building
Ventilation rate

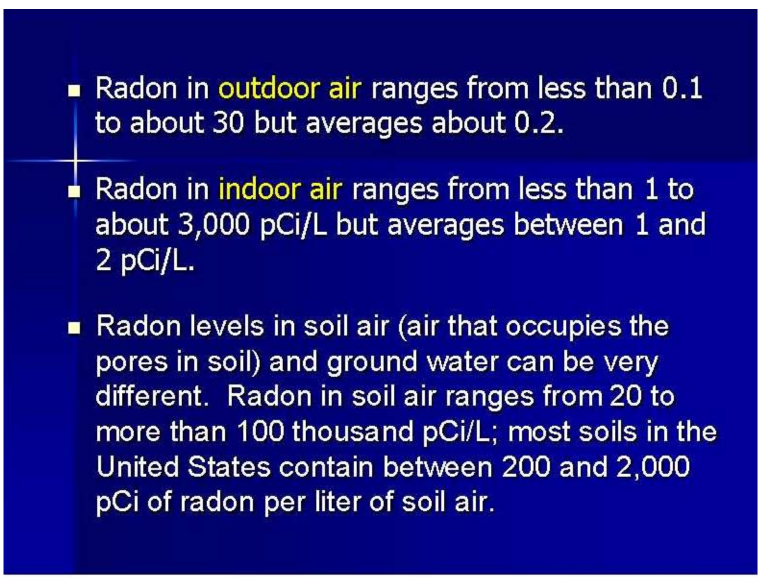

There are many pathways for radon to follow to reach a building:
Natural
– Pores or void space in soil, i.e., permeability of underlying soils.
– Cracks, fissures in underlying geology.
Man-made
– Loose fill beneath foundation,
– Along utility line trenches,
– Along and into water drainage systems (e.g., sumps).


Radon Can Move by Diffusion Through "Tight" Soils
Radon will move by diffusion from its source toward an area of low concentration.
At the location where radon can enter a building (e.g., directly beneath an entry point) the soil gas concentration may be low.
Therefore, radon can diffuse through tight soils to a point where it will be drawn in by convective transport.

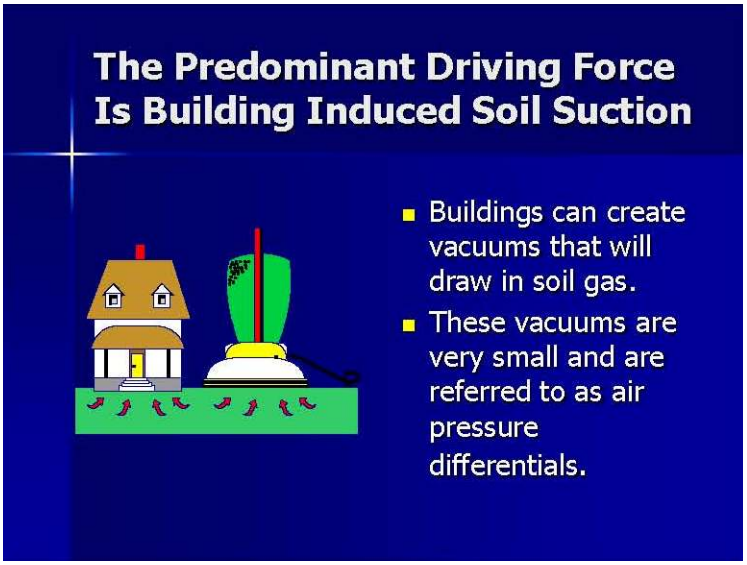
The most common way for radon to enter a building is from the soil gas through pressure-driven transport if all the following exist:



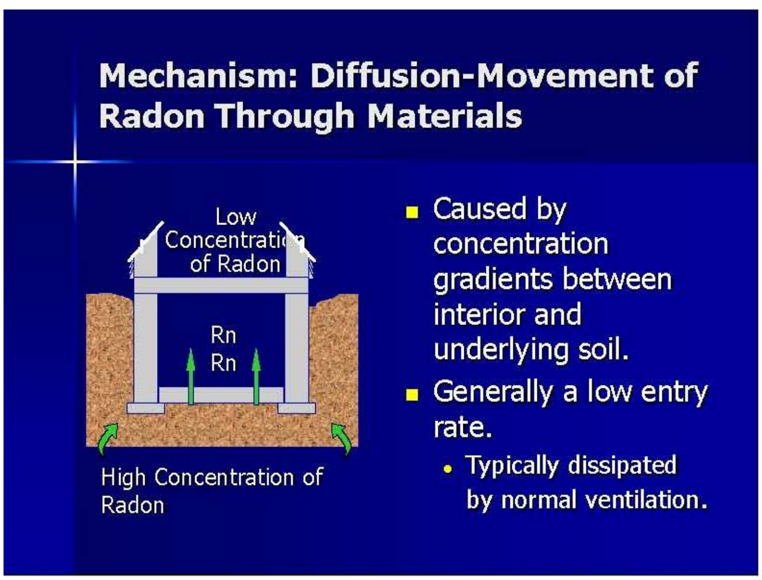
Although radon comes from the soil, there is no direct correlation between radon or radium concentrations in the soil and indoor radon concentrations.



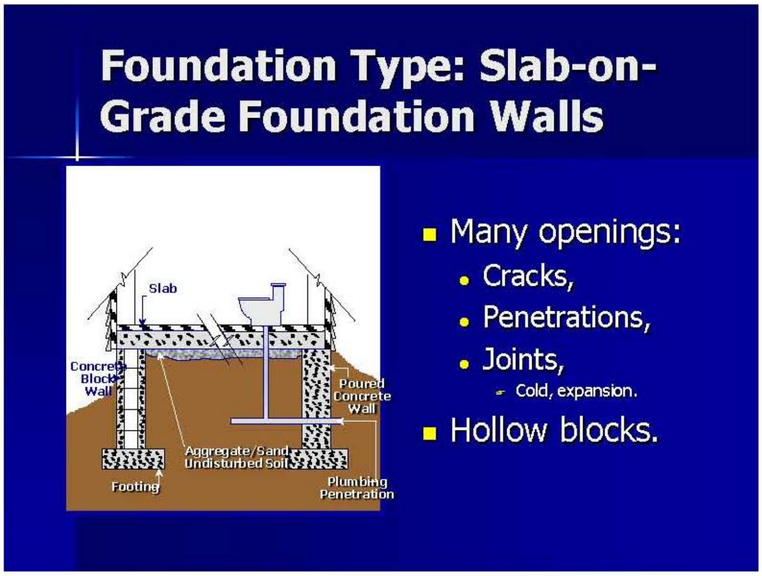
Pressure driven transport occurs when a lower indoor air pressure draws air from the soil or bedrock into the building. Schools and large buildings usually operate at an inside air pressure lower than of the surrounding soil. The design and operation of mechanical ventilation systems also depressurize the building and enhance radon entry.

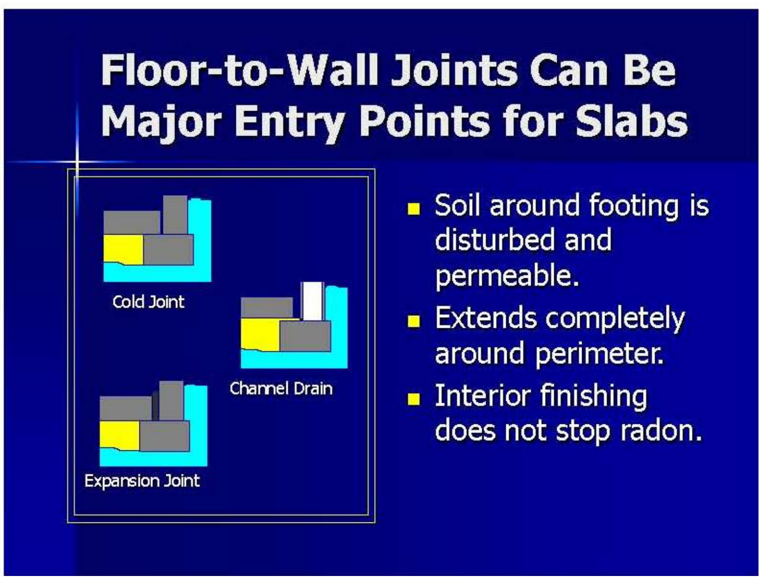


Radon also can enter buildings when there are no pressure differences. This type of radon movement is called diffusion-driven transport. Diffusion is the same mechanism that causes a drop of food coloring placed in a glass of water to spread through the entire glass. Diffusion-driven transport is rarely the cause of elevated radon levels in existing buildings. It is also highly unlikely that diffusion contributes significantly to elevated radon levels in schools and other large buildings.

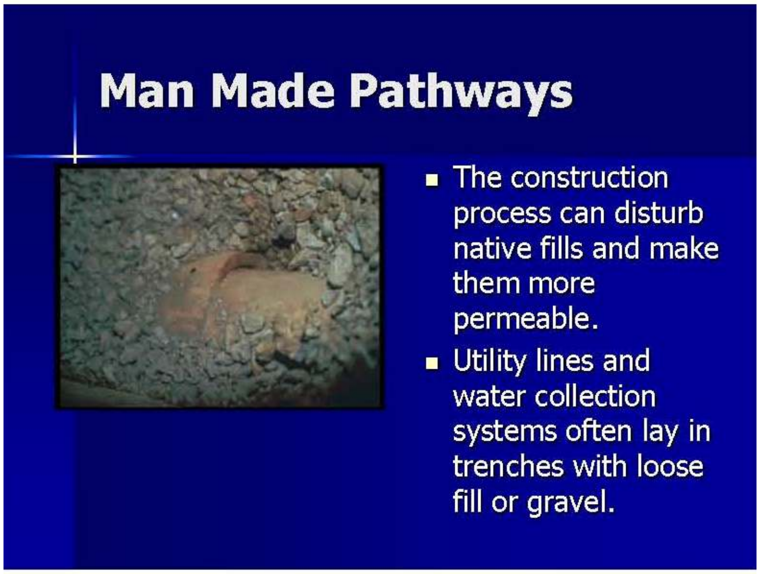


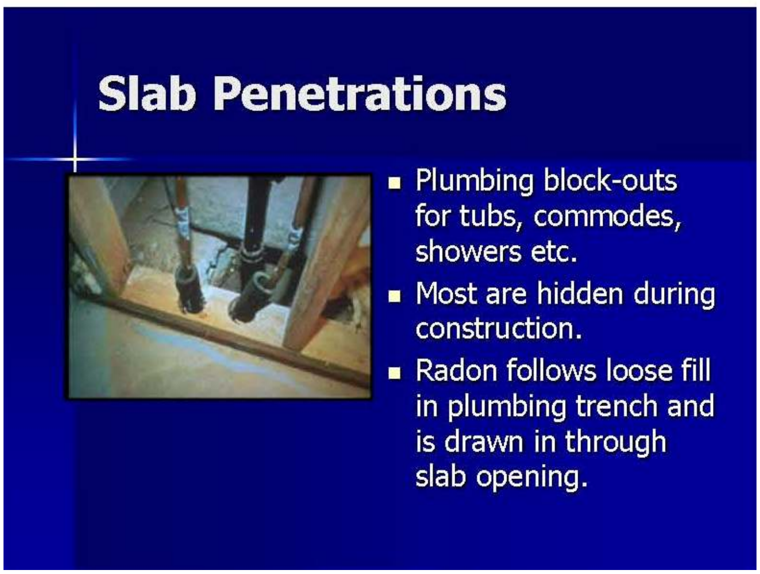
Many schools and large buildings are constructed on adjoining slab on grade construction, which allows radon gas to enter through the foundation and expansion joints between the slabs.

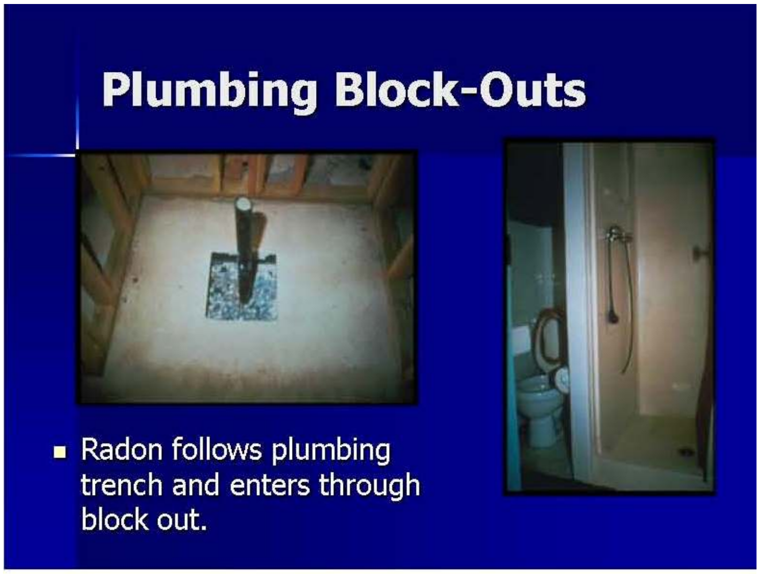




Other features, such as the presence of a basement area, crawl spaces, utility tunnels, subslab HVAC ducts, cracks, or other penetrations in the slab (e.g., around pipes) also provide areas for radon to enter indoor spaces.

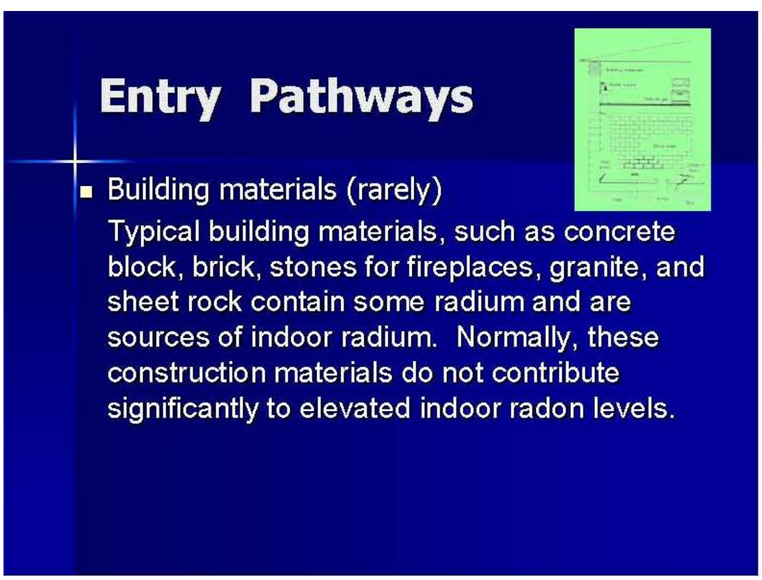

Man Made Pathways
The construction process can disturb native fills and make them more permeable.
Utility lines and water collection systems often lay in trenches with loose fill or gravel.


Slab Penetrations
Plumbing block-outs for tubs, commodes, showers etc.
Most are hidden during construction.
Radon follows loose fill in plumbing trench and is drawn in through slab opening.



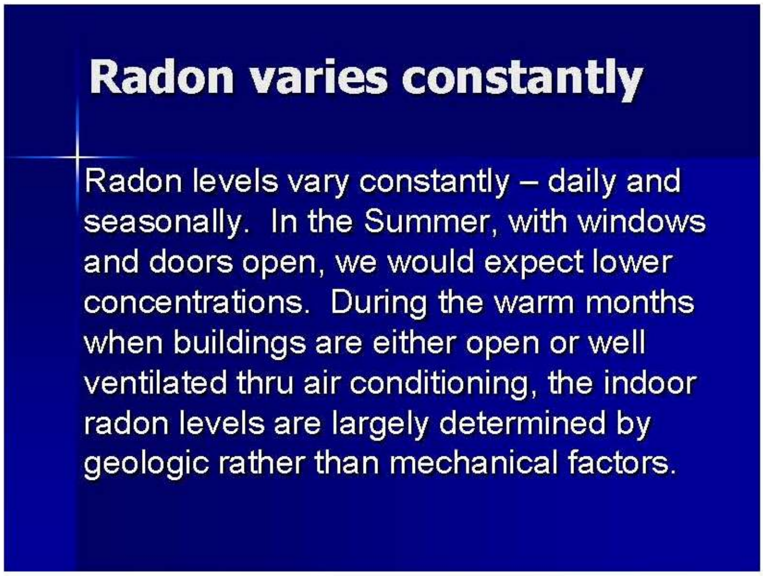
Another way radon can enter a building is through well water. In certain areas of the country, well water that is supplied directly to a building and that is in contact with radium-bearing formations can be a source of radon in a building. At this writing, the only known health risk associated with exposure to radon in water is the airborne radon that is released from the water when it is used.

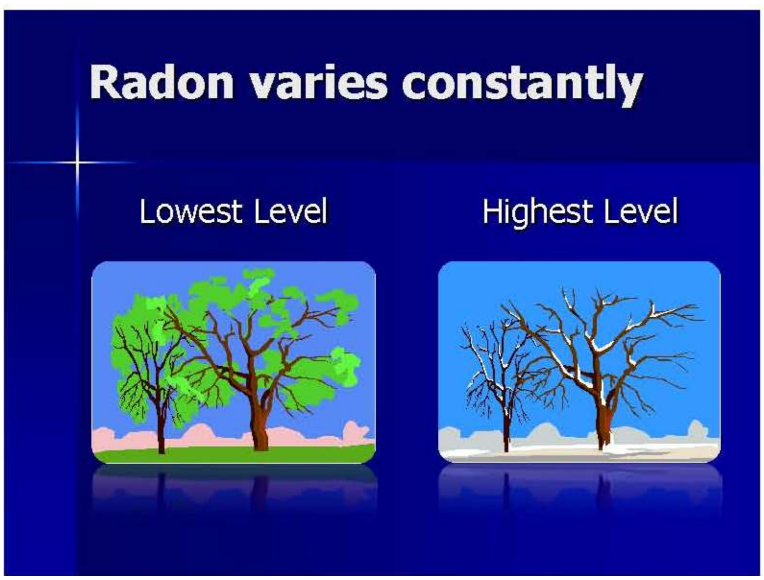
Radon can also emanate from building materials. However, this has rarely been found to be the cause of elevated levels in existing schools and other large buildings. The extent of the use of radium-contaminated building materials is unknown but is generally believed to be very minor.

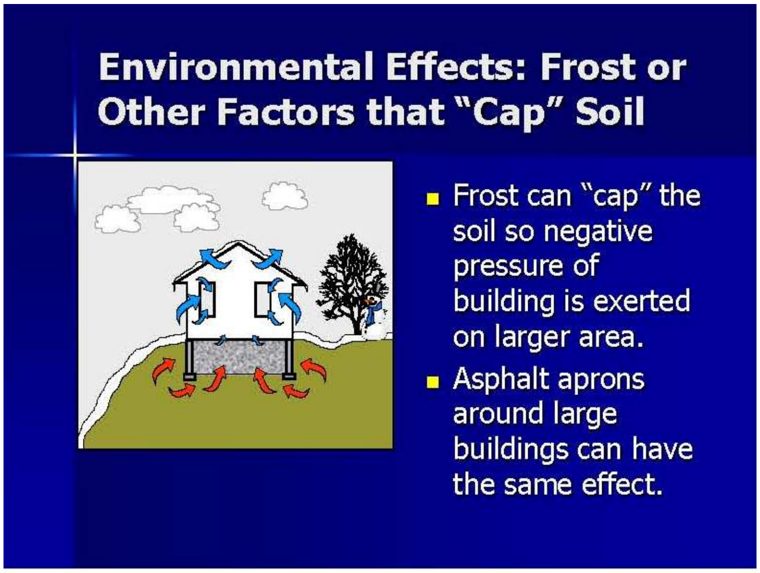


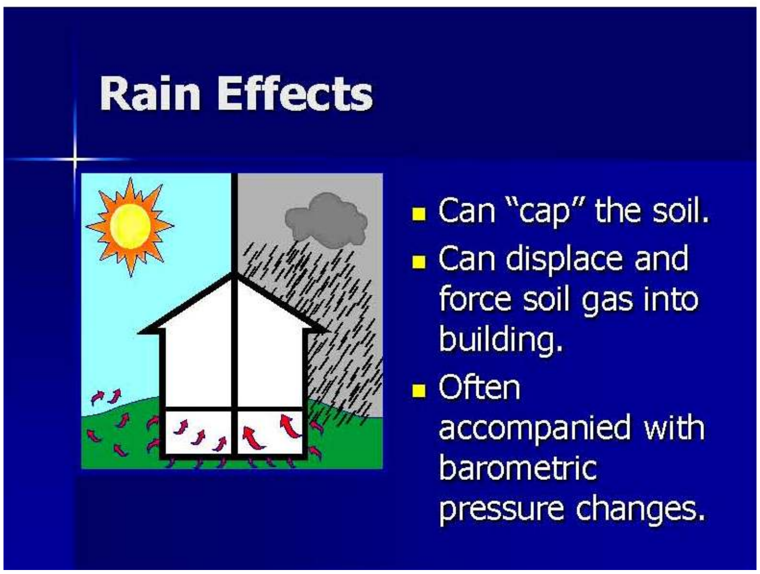
What Are the Environmental Factors Influencing Radon Concentrations?

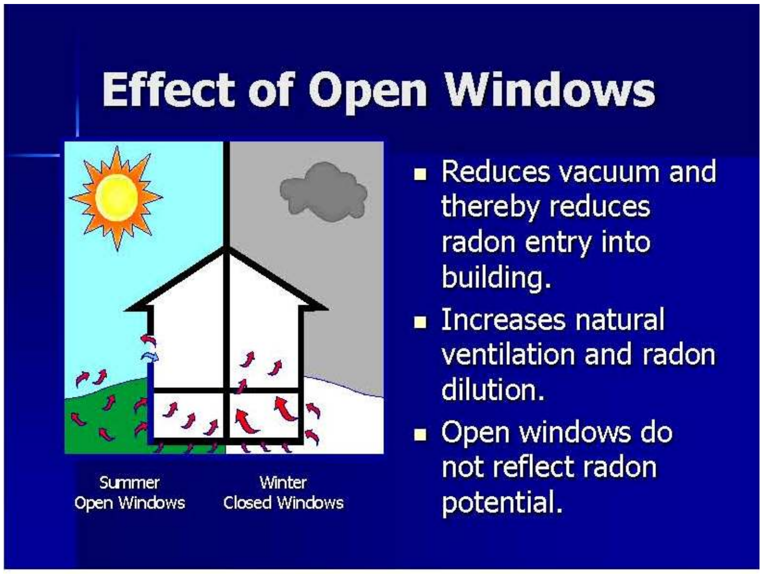
Seasonal variations affect radon concentrations.

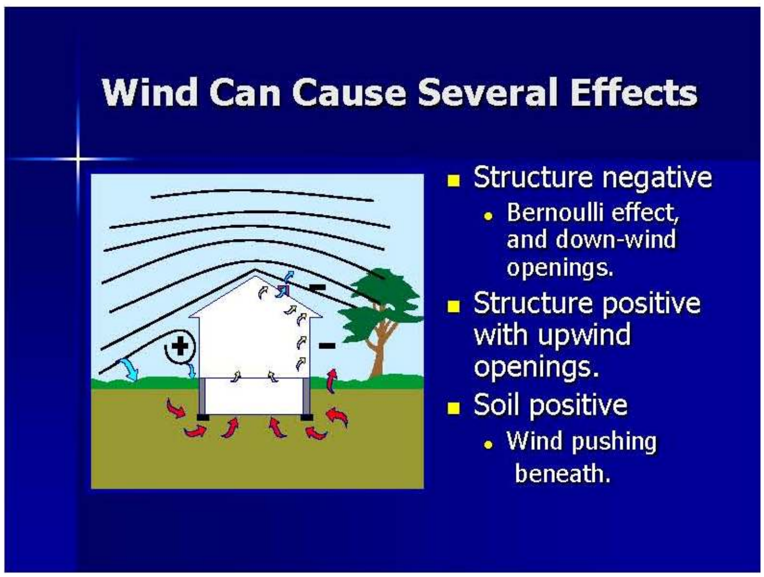


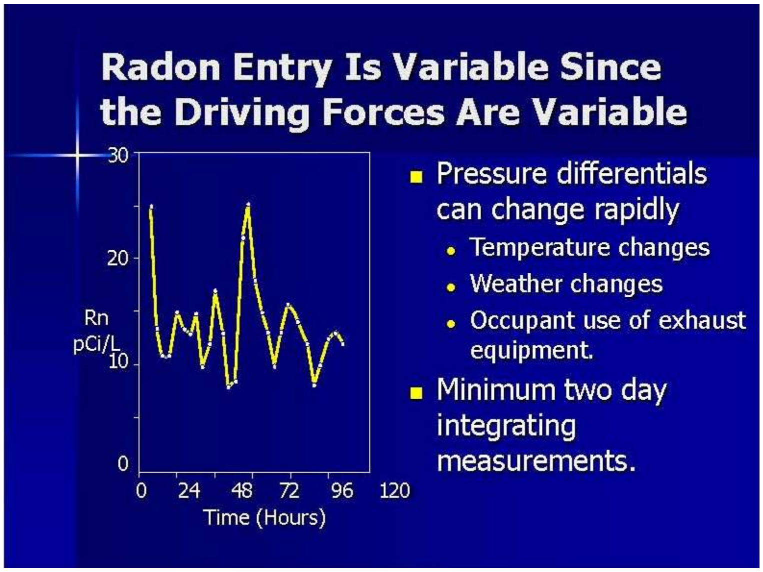



Environmental Effects: Frost or Other Factors that "Cap" Soil
Frost can "cap" the soil so negative pressure of building is exerted on larger area.
Asphalt aprons around large buildings can have the same effect.


Rain Effects
Can "cap" the soil.
Can displace and force soil gas into building.
Often accompanied with barometric pressure changes.


Effect of Open Windows
Summer
Open Windows
Winter
Closed Windows
Reduces vacuum and thereby reduces radon entry into building.
Increases natural ventilation and radon dilution.
Open windows do not reflect radon potential.


Wind Can Cause Several Effects
Structure negative
Bernoulli effect, and down-wind openings.
Structure positive with upwind openings.
Soil positive
Wind pushing beneath.



<u>HVAC Systems</u>

Depending on their design and operation, HVAC systems can influence radon levels in schools by:

- increasing ventilation (diluting indoor radon concentrations with outdoor air);
- decreasing ventilation (allowing radon gas to build up); pressurizing a building (keeping radon out); and,
- depressurizing a building (drawing radon inside).

Overall indoor air quality concerns may interest schools in general. Many schools have poor indoor air quality resulting in part from low rates of ventilation (low outdoor air intake). The frequency and thoroughness of HVAC maintenance can also play an important role. For example, if air intake filters are not periodically cleaned and changed, this can significantly reduce the amount of outdoor air ventilating the indoor environment. Less ventilation allows radon to build-up indoors.

An understanding of the design, operation, and maintenance of a school's HVAC system and how it influences indoor air conditions is essential for understanding and managing a radon problem as well as many other indoor air quality concerns in schools.

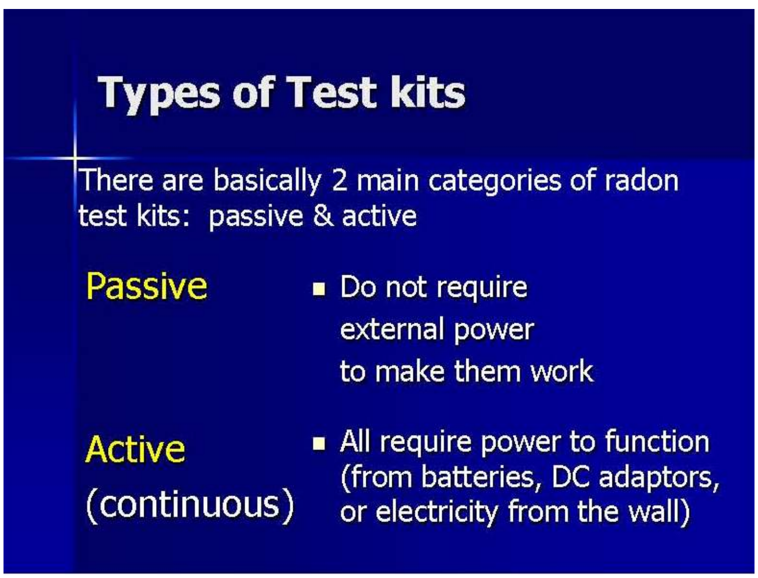
Who May Conduct Radon Testing in Schools?

A school district may select a Radon Professional licensed to test schools and commercial buildings from the list of IEMA approved professionals. This list is available on the IEMA website at www.radon.illinois.gov. The on-site presence of the licensed radon measurement professional providing supervision is required for all radon measurement activities in schools and commercial buildings. The licensed professionals must meet more stringent and separate requirements, which include submittal of standard operating procedures for the performance of school and commercial building measurements to IEMA.

Alternatively,

Under PA96-0417, a school district may elect to have one or more employees from the district attend an IEMA approved Internet-based training course on school testing in order to receive an exemption (from IEMA licensing requirements) to conduct their own testing in that school district. These school districts that use employees to conduct radon measurements must perform the measurements in accordance with procedures approved by IEMA. If this exemption is not received, the school district must use a licensed radon professional to conduct measurements.

What Are the Available Types of Radon Test Kits?



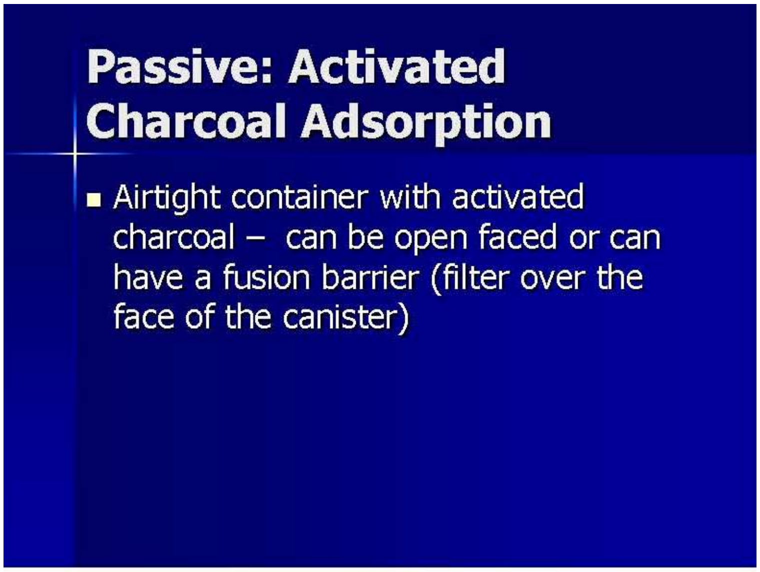
For school district testing, it is recommended that a passive device be used. Passive devices require no electrical power to perform its function. Passive devices are exposed to indoor air by being "uncapped" or similarly activated, then left in place for a length of time known as the measurement period.

Active devices, on the other hand, require an electrical power source and are capable of charting radon gas concentration fluctuations throughout the course of a given measurement period (usually by producing integrated periodic measurements over a period of two or more days).

A. Activated Charcoal Adsorption Devices (AC) are passive devices, and the charcoal within these devices has been treated to increase its ability to adsorb gases. The passive nature of the activated charcoal allows continual adsorption and desorption of radon. During the entire measurement period (typically two to seven days), the adsorbed radon undergoes radioactive decay.

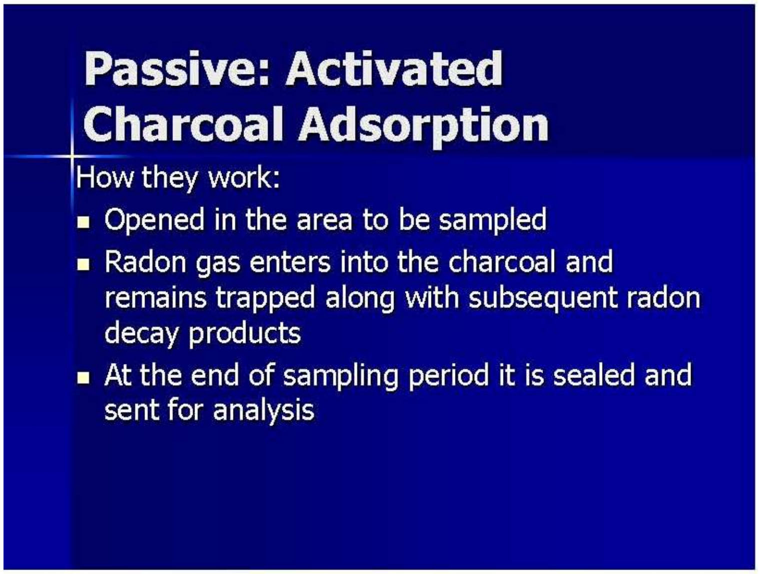
   As with all passive devices, the average concentration calculated is subject to error if the radon concentration in a room varies substantially during the measurement period. This device does not uniformly adsorb radon during the exposure period, as a result, these test kits are not true integrating devices. ACs must be promptly returned to the laboratory period using the mail service that guarantees delivery to the laboratory within two to three days at maximum.

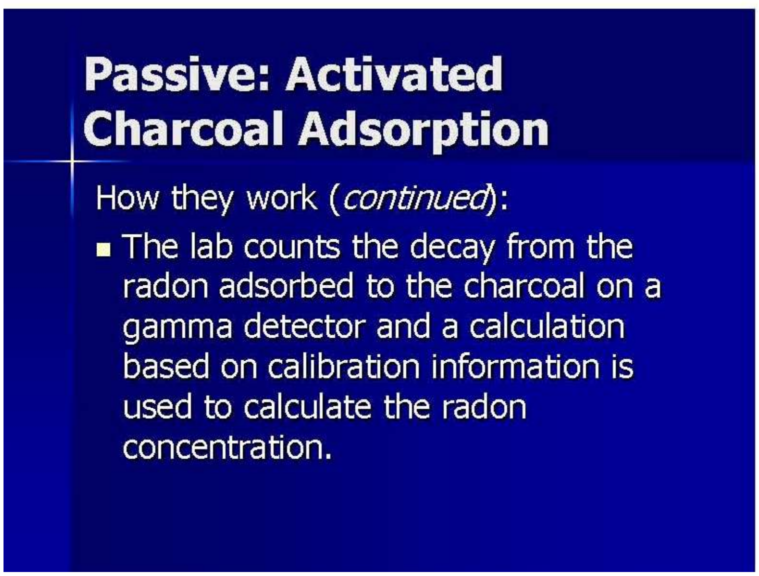
   Different types of ACs are commercially available. A device commonly used contains charcoal packaged inside an air-permeable bag. Radon is able to diffuse into this bag where it can be adsorbed onto the charcoal. Another device is a circular container that is filled with activated charcoal. One side of the container is fitted with a screen that keeps the charcoal in but allows air to diffuse in the charcoal. For some of these devices, the charcoal container has a diffusion barrier over the opening to improve the uniformity of response to variations of radon concentration over time.

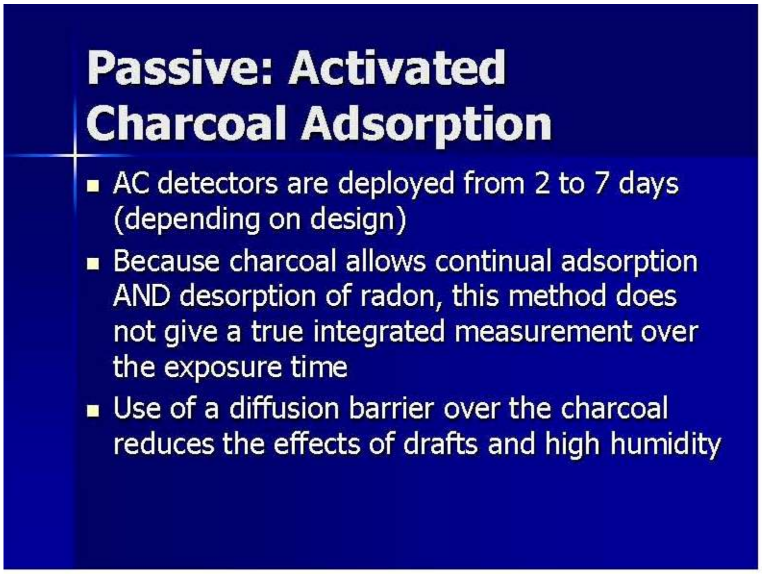

Passive: Activated Charcoal Adsorption
Airtight container with activated charcoal – can be open faced or can have a fusion barrier (filter over the face of the canister)

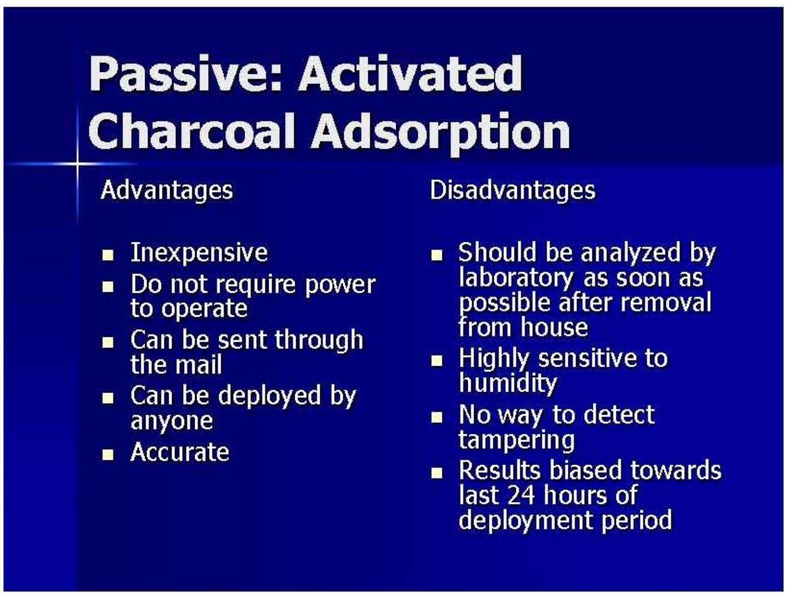

Passive: Activated Charcoal Adsorption
Examples:
Bag
Canisters
RADON TEST KIT

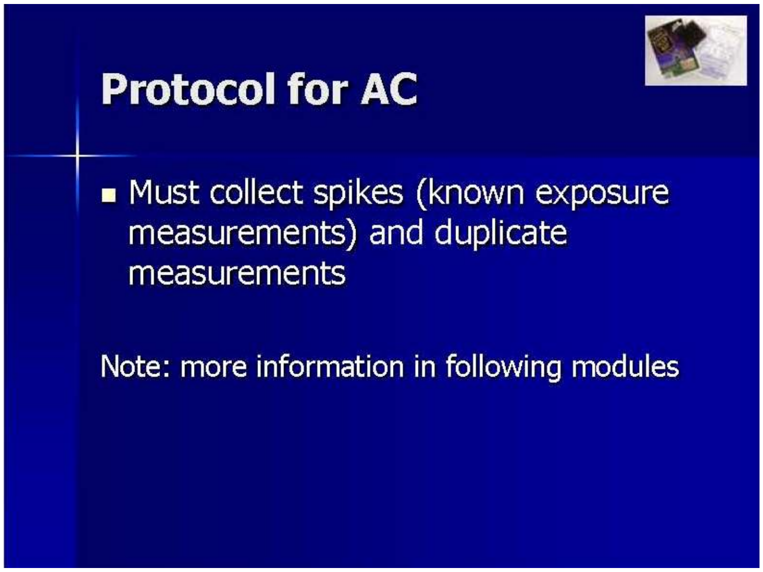
How Does the AC Device Work?






Passive: Activated Charcoal Adsorption
AC detectors are deployed from 2 to 7 days (depending on design)
Because charcoal allows continual adsorption AND desorption of radon, this method does not give a true integrated measurement over the exposure time
Use of a diffusion barrier over the charcoal reduces the effects of drafts and high humidity


Passive: Activated Charcoal Adsorption
Advantages
Inexpensive
Do not require power to operate
Can be sent through the mail
Can be deployed by anyone
Accurate
Disadvantages
Should be analyzed by laboratory as soon as possible after removal from house
Highly sensitive to humidity
No way to detect tampering
Results biased towards last 24 hours of deployment period



B. Electrect-Ion Chambers (EIC) are passive devices which function as true integrating detectors measuring the average radon gas concentration. EICs take advantage of the fact that radiation is emitted from the decay of radon and radon decay products imparts an electrical charge on the airborne particles that are released. These charged particles or ions are attracted to an electrostatically charged disc in the EIC chamber which reacts to their presence by losing some of its charge. The amount of the reduction in charge is directly related to the average radon concentration in the chamber.

EIC's may be designed to measure for short periods (typically two to seven days) or for longer periods, up to one year. The type of elcetret and chamber volume determine the usable measurement period. The electret is removed from the chamber and its voltage is measured with a specialized reader both before and after the measurement period. The difference between the two voltage readings is used to calculate the average radon concentration. IEMA has a limited supply of electrets that may be used by districts.

Electret Ion Chambers (EL & ES)

Passive Electret Ion Camber - EL stands for long-term device and ES stands for a short-term device

These devices contain an electrostatically charged Teflon disk (called an electret) located inside the main chamber.

EL – deployed for 1 -12 months
ES – deployed for 2 -7 days

Electret Ion Chambers (EL & ES)

How they Work:

- The plunger at the top is used to open and close the device. With the plunger open the radon gas enters the main chamber through a filter which prevents the entry of radon decay products (solids).
- The radon gas inside the chamber decays and creates electrostatically charged particles that are attracted to the charged Teflon disc. The charged particles (radon decay products) reduce the voltage on the disc by small amounts.

Electret Ion Chambers (EL & ES)

How they Work:

- The electret is removed from the chamber and its voltage is measured with a specialized reader both before and after the measurement period.
- The difference between the two voltage readings is used to calculate the average radon concentration.

Electret Ion Chambers (EL & ES)

Advantages

- Results can be given immediately
- Does not require power
- Can be reused after reading the voltages

Disadvantages

- Sensitive to background radiation
- Sensitive to altitude
- Voltage measurements should be done at the same temperature
- Difficult to detect tampering

What is the Difference Between a Short Term and Long Term Test?

There are two ways to use the radon test kits for radon testing:

- A short-term test is the quickest way to test for radon. In this test, the testing device remains in an area (e.g., schoolroom) for a period of 2 to 90 days depending on the device. Because radon levels tend to vary from day to day and from season to season, a short-term test is less likely to give an average radon level for a school year.

- A long-term test remains in place for more than 90 days. A long-term test (e.g., a test conducted over the school year) will give a result that is more likely to represent the school year average radon level in a schoolroom.

What is the Measurement Protocol /Strategy for Screening Measurements?

Activated Charcoal or Electret Ion Chamber kits are recommended.

1. Activated Charcoal devices, which are simple to operate, place and can be used without any assistance may used to conduct school screening measurements. Test kits may be purchased in a hardware store, department store, home improvement store, or ordered through the mail or internet. However, the test kits must be provided by a laboratory licensed with IEMA in accordance with the Radon licensing Act.
2. Electret Ion Chamber devices, which are simple to operate and place, but may be more costly to purchase can be used with the assistance from IEMA. IEMA has a limited supply of electrets that may be used by districts. These devices will require coordination between IEMA and the district. IEMA will need to read the voltages for the district, which will require the district to coordinate their screening measurements with the availability of the EIC's from IEMA.

For School District Measurements, the short-term testing is recommended.

The short-term test is the suggested method. In order to assure adequate test results, only devices that are used for a measurement period of at least 48 continuous hours should be used when testing for radon in school buildings.

For school districts a short-term test, using a two-step approach is recommended, as described below.

➢ Step 1 Initial Measurements

Initial measurements shall be short-term measurements of at least 48 hours to 90 days, depending on the device used, and shall be made in all frequently occupied rooms in contact with the soil, whether the contact is slab-on-grade, a basement, berm, a room above a crawlspace or any combination to provide a quick test of whether or not high radon concentrations are present.

- A surveillance of the building should be done prior to placement of devices.
- Frequently occupied rooms include classrooms, offices, conference rooms, gymnasiums, auditoriums, cafeterias and break rooms All rooms should be tested simultaneously.
- A minimum of one test kit must be placed every 2000 square feet of open floor area.
- All teachers or frequent adult users should be aware that the room is being tested.
- Schools shall only be tested for radon during periods when the HVAC system is operating as it does normally.
- A decision not to mitigate should not rely solely on these initial screening measurements.

Perform a follow-up measurement in every room where the initial test result is 4 pCi/L or greater

➢ Step 2 Follow-up Measurements

If the results of a radon screening test in any frequently occupied room are found to be 4.0 pCi/L or above, it is recommended that the school district hire a licensed radon professional to perform follow-up measurements before any mitigation decisions are made.

All follow-up measurements in a school should be conducted simultaneously. Follow-up measurements should be made in the same locations and under the same conditions as the initial measurements (to the extent possible, including similar seasonal conditions and especially HVAC system operation). This will ensure that the two results are as comparable as possible.

The higher the initial short-term test result, the more certain you can be that a short-term test should be used rather than a long-term follow-up test. In general, the higher the initial measurement, the greater the urgency to do a follow-up test as soon as possible. For example, if the initial short-term measurement for a room is several times the radon action level (e.g., about 10 pCi/L or higher), a short-term follow-up measurement should be taken immediately.

Interpreting Test Results

- **Short-term test: If follow-up measurement tests were deployed, take action to reduce the radon level if the average of the initial and follow-up measurement results is 4 pCi/L or more.**

Schools can reduce radon levels by working with a licensed radon mitigation professional. The professional will proceed by performing *diagnostic testing* and ultimately making decisions for m*itigation*. Diagnostics involve the evaluation of radon entry points and the identification of the appropriate radon reduction technique. Mitigation is the design and implementation of a radon reduction system.

It is not recommended that schools use a single short-term test as the basis for determining whether or not action needs to be taken to reduce radon levels, before consulting with IEMA or a licensed radon professional. A follow-up measurement to confirm an initial short-term measurement of 4 pCi/L or higher should be conducted before making such a decision. Indoor radon levels depend upon a number of variables and can fluctuate significantly from day to day. Short-term tests (particularly tests of 2 to 5-days) may in some cases reflect an unusual peak in the radon concentration thus indicating a need for remedial action which may not be necessary. In addition, USEPA studies have shown that the averaging of two such short-term measurements reduces the possibility of misrepresenting the average radon concentration.

Although it is beyond the scope of this course, a long-term measurement provides a better understanding of the average radon level for a school year.

When a room's initial result is only slightly elevated above 4 pCi/L (e.g., between 4 and 10 pCi/L), a long-term follow-up measurement, preferably taken over the entire nine month school year, is appropriate. The result from such a test may best represent the average radon concentration for the school year in that room. A long-term test should be conducted over the school year immediately following the completion of initial measurements.

What Rooms Should be Tested?

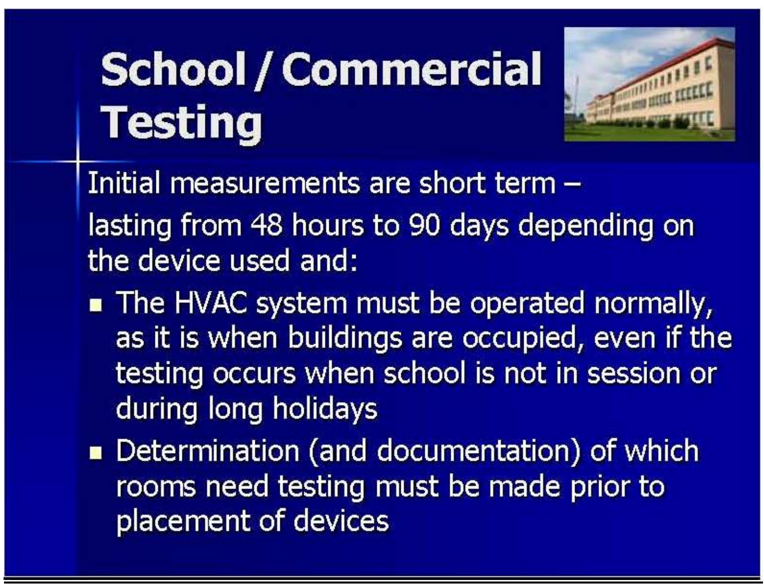
Radon levels in schools often vary greatly from room to room in the same building. A known radon measurement result for a given classroom cannot be used as an indicator of the radon level in adjacent rooms.

Therefore, schools must conduct initial measurements in *all frequently occupied rooms in contact with the soil.* Frequently occupied rooms are usually classrooms, offices, laboratories, cafeterias, libraries, and gymnasiums.

USEPA studies indicate that radon levels on upper floors are not likely to exceed the levels found in ground-contact rooms. Testing rooms on the ground-contact floor is sufficient to determine if radon is a problem in a school.

Areas such as rest rooms, hallways, stairwells, elevator shafts, utility closets, and storage closets need not be tested. (Note: these areas may be important areas for diagnostic testing if elevated radon is found).

Schools should only be tested for radon during periods when the HVAC system is operating as it does normally when the buildings are occupied, even if the testing occurs when school is not in session or during long holidays.

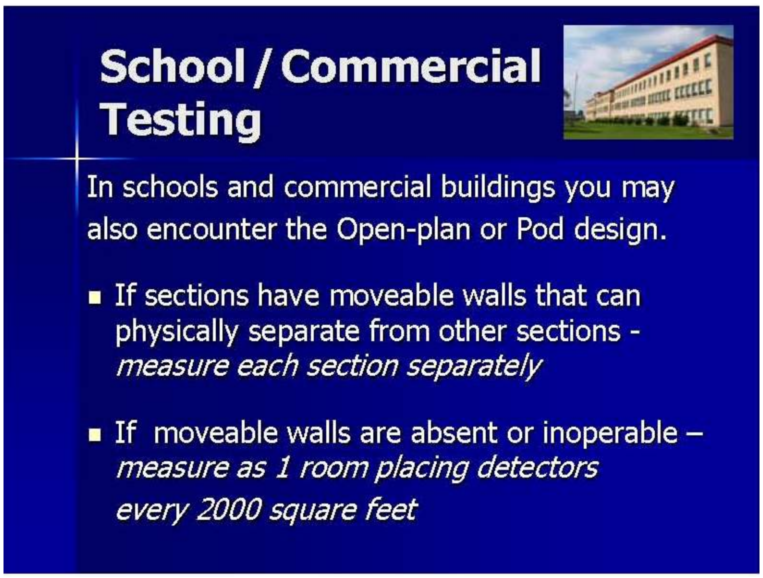


Recommendations for Specific School and Commercial Building Designs

- *Slab-on-Grade Design:* Measure only frequently occupied rooms in contact with the ground.

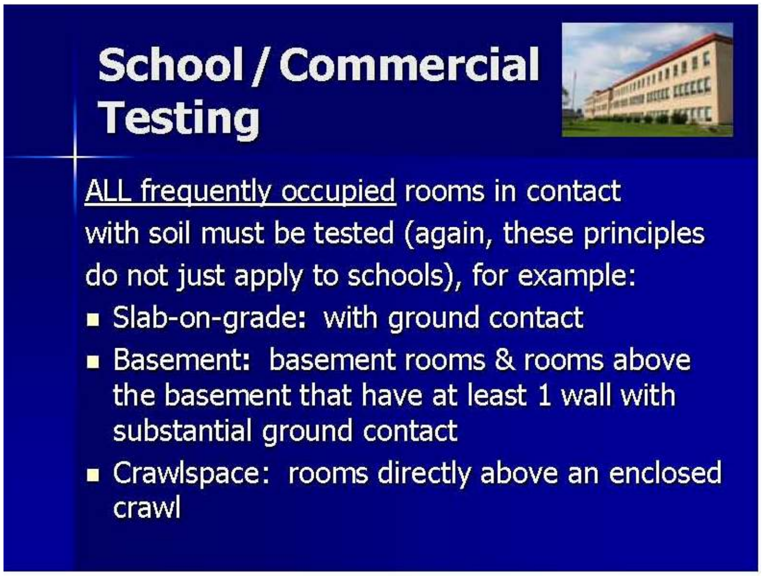
- *Open-Plan or Pod Design:* If sections of a pod have moveable walls that can physically separate them from other sections, measure each section separately.

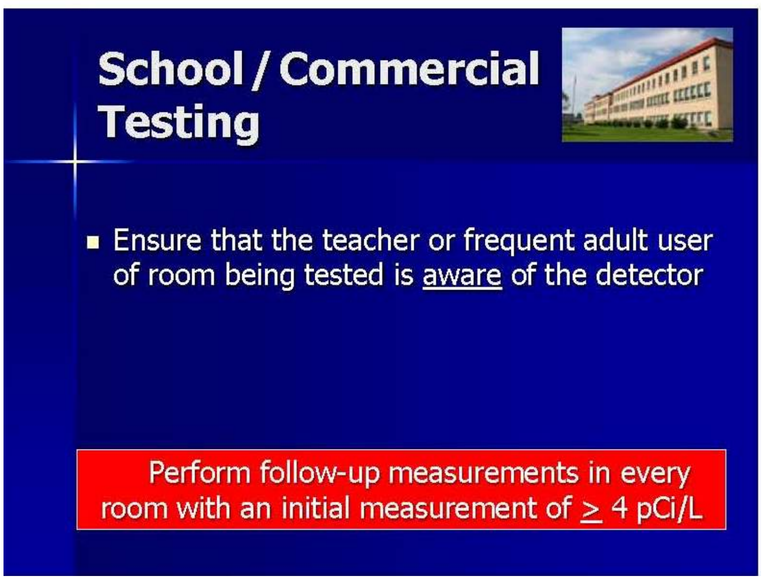
- If moveable walls are absent or inoperable, measure the pod as one room placing test kits every 2000 square feet.



- *Crawl Space Design:* If classrooms are above an enclosed crawl space, measure rooms directly above the crawl space.

- *Basement Design:* In addition to measuring all frequently occupied basement rooms, measure all frequently occupied rooms above the basement that have at least one wall with substantial contact with the ground.


School / Commercial Testing
ALL frequently occupied rooms in contact with soil must be tested (again, these principles do not just apply to schools), for example:
Slab-on-grade: with ground contact
Basement: basement rooms & rooms above the basement that have at least 1 wall with substantial ground contact
Crawlspace: rooms directly above an enclosed crawl


School / Commercial Testing
Ensure that the teacher or frequent adult user of room being tested is aware of the detector
Perform follow-up measurements in every room with an initial measurement of ≥ 4 pCi/L

What are the Procedures for Radon Testing?

The purpose of initial screening measurements is to identify rooms that have a potential for elevated radon levels (e.g., levels of 4 pCi/L or greater) during the occupied school year.

1. A **Test Kit Placement Log** and **Test Kit Location Floor Plan** must be prepared for each school in which radon measurements are made. The school's emergency escape map can be used as the floor plan, since it usually provides the most accurate and up-to-date information.

    a. Test kit location must be accurately recorded on both the device log and floor plan. Test kit location must be recorded within three reference distances (x,y,z) consisting of 2 walls and floor of the room. **See the Radon Test Kit Placement Strategy and Protocol Checklist, Sample Test Kit Placement Log, and Floor Plan included in the Reference section for additional assistance.**

2. The appropriate number of test kits must be determined in advance. The test-kits must be purchased from a source that is approved by IEMA. Testing must be done following the directions on the test kit.

3. Test kits must be placed in the lowest structural areas occupied by students and teachers.

4. Testing must occur during the time that students and teachers are normally present (during weekdays).

5. In addition to placing test kits to determine radon concentrations, additional test kits should be provided to serve as quality control measures (duplicate and blank measurements).

    a. *Blank measurements:* Must represent 5 percent of the number of test kits deployed, or a maximum of 25 test kits, whichever is less within the building.

    b. *Duplicate measurements:* Must represent 10 percent of the number of test kits deployed, or a maximum of 50 test kits, whichever is less within the building.

6. All test kits used, (including duplicates and blanks below) must be noted on the Devise Placement Log and Floor Plan by serial number.

7. Test kit placement must be:

    a. Where they are least likely to be disturbed or covered up.

b. At least 3 feet from doors, windows to outside or ventilation ducts.

c. At least 1 foot from exterior walls.

d. At least 20 inches to 6 feet from floor

e. Approximately every 2,000 square feet for large spaces.

8. Test kits must **not** be placed

a. Near drafts resulting from heating, ventilating vents, air conditioning vents, fans, doors, and windows.

b. In direct sunlight

c. In areas of high humidity such as bathrooms, kitchens, laundry rooms, etc.

d. Where they may be disturbed at any time during the test.

9. Test kits may be suspended in the breathing zone, and if suspended, shall be 20 inches to 6 feet above the floor, at least 1 foot below the ceiling. In a Pod floor plan, test kits are often suspended.

10. Test kits must be used under closed conditions (closed windows/doors except for normal exit/entry)

a. *Closed conditions:* Short-term tests should be made under closed conditions in order to obtain more representative and reproducible results. Open windows and doors permit the movement of outdoor air into a room. When closed conditions in a room are not maintained during testing, the subsequent dilution of radon gas by outdoor air may produce a measurement result that falls below the action level in a room that actually has a potential for an elevated radon level. Closed building conditions should be maintained for at least 12-hours prior to the start of 2 to 5-day measurements (e.g., initiate testing after a weekend).

b. All external doors should be closed except for normal use – structural defects need to be repaired prior to testing.

c. Closed conditions must be verified when placing and retrieving test kits. Closed conditions should be documented in the measurement files.

11. Test kits are generally placed during colder months (October through March, depending on geographical location)

a. *Colder months:* Because testing under closed conditions is important to obtain meaningful results from short-term tests, schools should schedule their testing during the coldest months of the year. During these months, windows and exterior doors are more likely to be closed. In addition, the heating system is more likely to be operating. This usually results in the reduced intake of outside air. Moreover, studies of seasonal variations of radon measurements in schools found that short-term measurements may more likely reflect the average radon level in a room for the school year when taken during the winter heating season.

b. Check and document local weather forecasts prior to placing test kits. Do not conduct measurements of less than 96 hours during severe storms or period of high winds.

   The definition of severe storm by the National Weather Service is one that generates winds of 58 mph and/or ¾ inch diameter hail and may produce tornadoes.

12. Test Kits should be placed during weekdays with HVAC systems operating normally

    a. *Weekday testing:* When using 2 to 5-day short-term tests, it is recommended that testing be conducted on weekdays with HVAC systems operating normally. This approach has the important advantage of measuring radon levels under the typical weekday conditions for that school. This also eliminates the burden of weekend testing and non-routine adjustments to the HVAC systems. Based upon USEPA studies, this recommendation to conduct 2 to 5-day tests on weekdays does not invalidate radon measurements that were conducted on weekends with HVAC system operating continuously.

    b. Any air conditioning systems that recycle interior air may be operated.

    c. Window air conditioning units may be operated in a re-circulating mode and must be greater than 20 feet from the test kit.

    d. Ceiling fans, portable humidifiers, dehumidifiers and air filters must be greater than 20 feet from the test kit.

    e. Portable window fans must be removed or sealed in place.

    f. Fireplaces or combustion appliances (except for water heaters/cooking appliances) may not be used unless they are the primary source of heat for the building.

13. If radon mitigation systems are in place in the school, they should be functioning.

14. Schools should *avoid* conducting initial measurements under the following conditions:

    a. During abnormal weather or barometric conditions (e.g., storms and high winds)

       Weather conditions: If major weather or barometric changes are expected, it is recommended that the 2 to 5-day testing be postponed. USEPA studies show that barometric changes affect indoor radon concentrations. For example, radon concentrations can increase with a sudden drop in barometric pressure associated with storms.

    b. During structural changes to a school building and/or the renovation or replacement of the HVAC system

What are Quality Assurance Measurements?

Quality Assurance (QA) measurements must be taken to ensure that the testing results are reliable. The term quality assurance refers to maintaining the minimum acceptable standards of precision and accuracy during the entire data collection process. When radon measurement test kits are being placed at the school, additional test kits which serve as quality assurance measurements should be deployed.

A component of the test kit includes a detector that is capable of measuring the radon concentration. Quality assurance measurements include side-by-side test kits (duplicates) and unexposed control test kits (blanks).

1. *Duplicates*: Duplicates provide an indication of the precision of the measurement.

    a. Pairs of test kits placed in the same location side-by-side for the same measurement period. The number of duplicates should be 10 percent of all measurements taken in a school building (they need not exceed 50 extra test kits). Duplicates are stored, deployed, place, and removed and shipped to the laboratory for analysis in the same manner as the other measurement test kits so that the processing laboratory cannot distinguish between them.

    b. Since duplicates are placed side-by-side (approximately 4 inches apart), the measured value for these duplicates should be the same. For duplicate pairs, where the average of the two duplicates is greater than or equal to 4 pCi/L, they should not differ by more than 25%. If they do, each measurement is questionable. Problems in handling the test kits during the measurement process, in the laboratory analysis, or in the test kit itself, may introduce error into the test results.

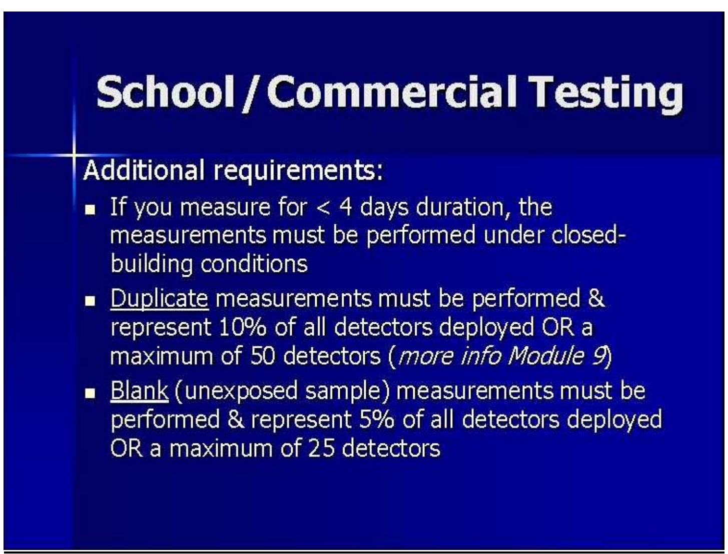
c. Duplicate data provide an indication of precision of measurement (see section below). If the data is not within the expected level of precision (RPD – see below), the cause of the problem should be investigated.

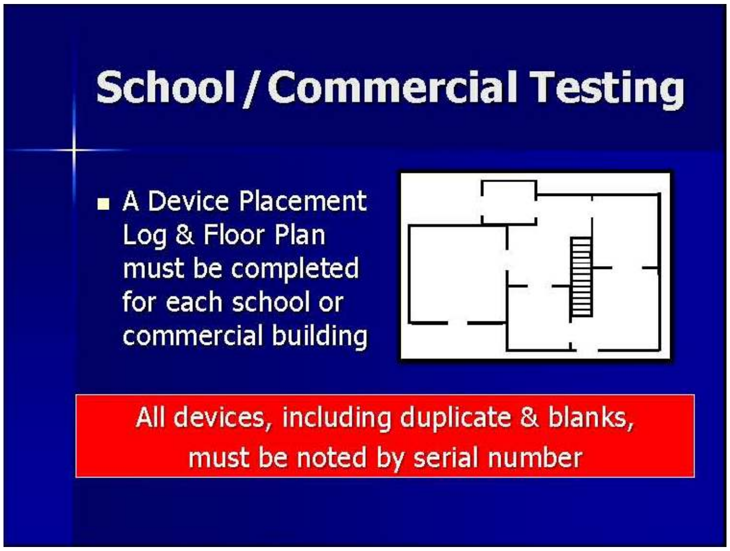
d. The test kit placement log, mentioned previously, should be used to document the devices used. Duplicate devices should be included in the test kit log.

2. *Blanks:* Blanks can be used to determine whether the manufacturing, shipping, storage, or processing of the test kit has affected the accuracy of the measurements. They are called blanks because they are not used in the room where a measurement is being taken. As a result, blanks should have results at or near 0.0 pCi/L. Any value other than 0.0 is a measure of accuracy and indicates a problem with the test kit or laboratory analysis.

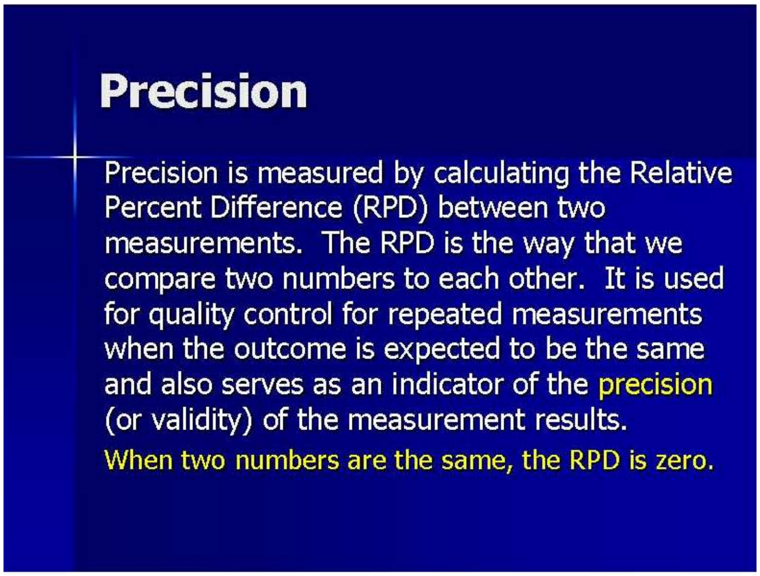
   a. Blanks are unwrapped (but not opened) and immediately rewrapped at the end of the exposure period. They are shipped with the other test kits so that the laboratory cannot distinguish between them. The number of blanks should be 5% of all the test kits used (or 25, whichever is less).

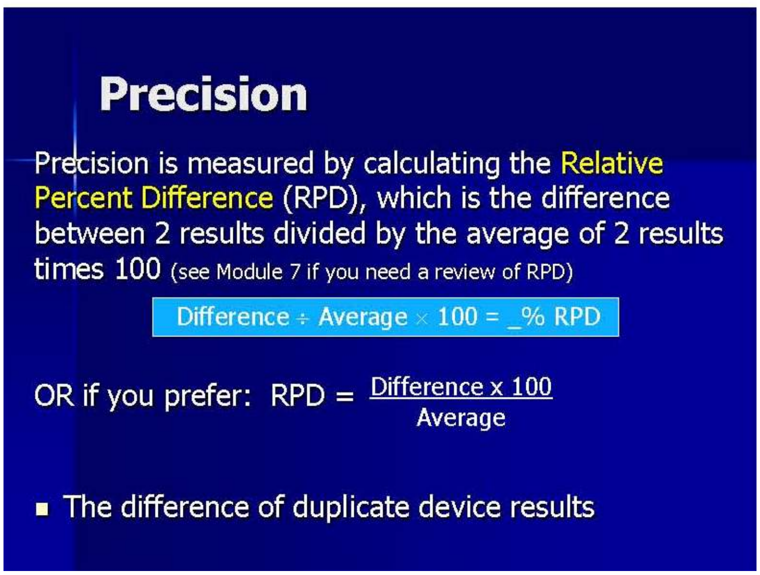
   b. The device placement log, mentioned above, should be used to document the devices used. Blanks should be included in the device log.

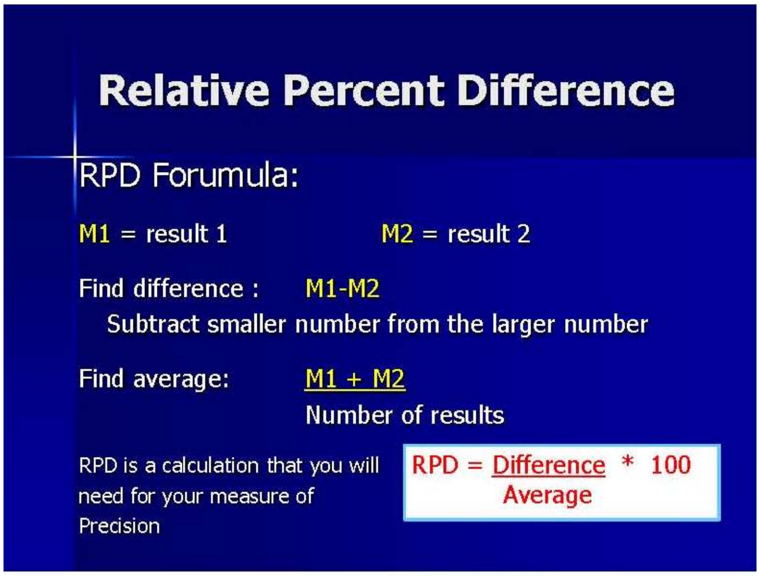


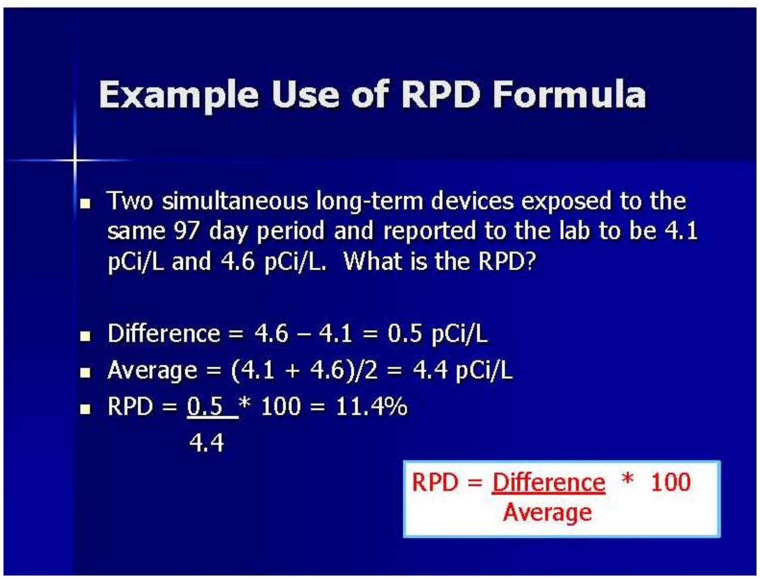

School / Commercial Testing
A Device Placement Log & Floor Plan must be completed for each school or commercial building
All devices, including duplicate & blanks, must be noted by serial number

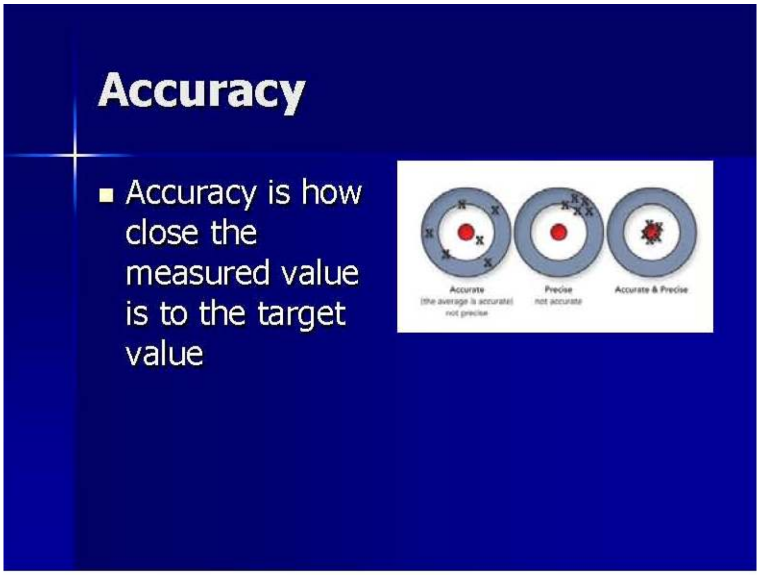
What is Precision, Relative Percent Difference and Accuracy?

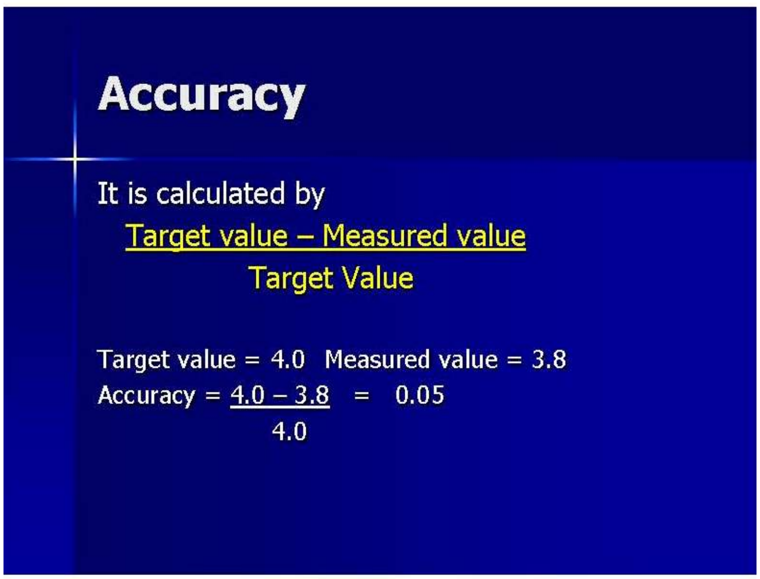





Relative Percent Difference
RPD Forumula:
M1 = result 1
M2 = result 2
Find difference : M1-M2
Subtract smaller number from the larger number
Find average: M1 + M2
Number of results
RPD is a calculation that you will need for your measure of Precision
RPD = Difference * 100
Average


Example Use of RPD Formula
Two simultaneous long-term devices exposed to the same 97 day period and reported to the lab to be 4.1 pCi/L and 4.6 pCi/L. What is the RPD?
Difference = 4.6 – 4.1 = 0.5 pCi/L
Average = (4.1 + 4.6)/2 = 4.4 pCi/L
RPD = 0.5 * 100 = 11.4%
4.4
RPD = Difference * 100
Average





What Information is Necessary to Determine if Mitigation is Needed?

The decision to mitigate will depend upon the levels of the measured radon levels and the type of test(s) taken. Very elevated radon concentrations, and site-specific considerations suggest a quicker response rate.

What are the Types of Mitigation Systems?

Schools and large commercial buildings are more complex than residential homes. Like most other indoor air contaminants, radon can best be controlled by keeping it out of the building in the first place, rather than removing it once it has entered. Radon can be controlled through:

- ❖ Soil Depressurization. A suction fan is used to produce a low-pressure field under the building slab. This low-pressure field prevents radon entry by causing air to flow from the building into the soil (rather than from the soil into the building).

- ❖ Building Pressurization. Indoor/subslab pressure relationships are controlled to prevent radon entry. More outdoor air is supplied than exhausted so the building is slightly pressurized compared to both the exterior of the building and the subslab area.

- ❖ Sealing Entry Routes. Seal major entry routes to prevent or minimize radon entry.

A. For new school buildings, the above radon prevention techniques are relatively inexpensive and easy to install during construction.

B. For existing buildings,

- The most effective and frequently used radon reduction technique for soil depressurization is active soil depressurization (ASD). ASD has been effective, especially with higher levels of radon. ASD creates a lower pressure beneath the slab to reverse the flow of air through a building foundation, thereby reducing radon entry. A series of pipes penetrate the slab or foundation walls. A high suction fan is attached to these pipes to vent the soil gas from beneath the building foundation. ASD is accompanied by sealing radon entry routes, which effect efficiency of radon removal and reduces energy costs. ASD, however, has no effect on general air quality within the building.

- Pressurization and ventilation with a HVAC system. Because of local building code requirements, occupancy patterns, school building construction or operation and levels of radon, the use of the HVAC system may be more appropriate. This method directly influences radon entry by altering air pressure differences between the radon in the soil and building interior. Depending upon the type and operation, a HVAC system can create positive or negative air pressure. Positive pressure can prevent radon entry, while negative pressure enhances radon entry. The positive pressure can be achieved through additional heating, cooling and/or dehumidification, along with enhanced routine operation and maintenance.

- Radon enters the building from the soil through cracks and openings in the slab and sub-structure, however, it is difficult, if not impossible to seal every crack and penetration. Therefore, sealing radon entry routes is often used in conjunction with the other mitigation techniques.

What are the Reporting Requirements?

Reporting to parents and faculty: Each school district may maintain, make available for review, or notify parents and faculty of the results of the radon testing.

Reporting to the State Board of Education: Each school district shall report radon test results to the State Board of Education. The State Board of Education shall prepare a written report every two years. This report will include results from all schools that have performed testing and shall be submitted to the General Assembly and the Governor.

When Should Periodic Retesting be Done?

In addition to initial and follow-up measurements, it is recommended that schools retest periodically, or after significant changes to the building structure or the HVAC system have been made, whichever is less. Suggested times for retesting are as follows:

1. If no mitigation is required after initial testing (e.g., all rooms were found to have levels below 4 pCi/L), retest all frequently occupied rooms in contact with the ground every 5 years. As a building ages and settles, radon entry may increase due to cracks in the foundation or other structural changes.
2. If radon mitigation measures have been implemented in a school, retest these systems as a periodic check on any implemented radon reduction measures.
3. If major renovations to the structure of a school building or major alterations to a school's HVAC system are planned, retest the school before initiating the renovation. If elevated radon is present, radon-resistant techniques can be included as part of the renovation.
4. Retest after major renovations to the structure of a school building or after major alterations to a school's HVAC system. These renovations and alterations may increase radon levels within a school building.

Where should Additional Questions be Directed?

- *Patrick Daniels – (217) 782-1325*
- *patrick.daniels@illinois.gov*
- *Cindy Ladage – (217) 785-9889*
- *cindy.ladage@illinois.gov*

Fax Number – (217) 524-1254

Frequently Asked Questions about Radon and Schools

1. Does radon cause headaches, eye irritation, or sick-building syndrome? *No.*
2. Do children have a greater risk of cancer from radon exposure?

   Children usually are more sensitive to environmental pollutants; however, there is no conclusive data right now that shows that children are more at risk than adults from radon exposure.
3. Is there a hazard from touching/being near the radon test kit? *No*
4. Do building materials emit radon?

   The primary route of radon entry to a building or home is through the soil. However, there may be a few building materials that will emit small amounts of radon gas, such as granite, concrete, gypsum board (sheet rock), bricks, and field stone. However, this is RARELY the case because most of these materials are very dense. This means that if there is radon-producing radium in these materials, only a small amount of the radon gas near the surface ever makes it out into the environment.
5. Should testing be delayed if the school is planning major renovations to the building or the HVAC system?

   Initial and follow up tests should be conducted prior to major HVAC or building renovations. Testing can show if a radon mitigation system needs to be installed as a part of renovation. Testing must also be done after renovation.
6. Should upper floors of a school or building be tested? Does this mean that upper floors never have elevated levels?

   Upper floors may indeed have elevated levels of radon. However, measurements in ground floor rooms are likely to be a good indicator of radon levels for all floors.
7. In schools with a basement level (below ground level), the first floor is often built at ground level, and therefore is in contact with the soil, only along it's outside edge. Should this floor be tested?

   Although this floor appears to have limited contact with the soil, the outside rooms may have openings permitting radon entry and should be tested if they are frequently occupied. If the basement rooms are occupied, or expect to be occupied in the future, the basement rooms should also be tested. In addition, schools with crawl spaces between the ground and first floor should test all frequently occupied first floor rooms.
8. Nearby homes and schools have reported no elevated levels of radon, should we still test?

   Yes, radon levels vary with geology, man-made and building structure, HVAC systems, etc. The only way to know if radon is present is to test; and re-test every five years (or whenever there is significant renovation).

9. What are the costs of testing in schools for radon?

   The cost may be dependent upon the number of rooms to be tested, and the type of test kit used.

10. If a room's short term initial test result is very high (for example above 100 pCi/L) should a follow-up measurement be taken?

    Follow up measurements are usually recommended before making any further decisions. However, generally, the higher results are more accurate.

11. Should a room be retested if there evidence of tampering? *Yes*

12. How do you place radon test kits in large, open spaces such as cafeterias, gymnasiums, or auditoriums?

    Since flat elevated surfaces are rare, test kits may be hung from the ceiling and or wall, however you should refer to the device instructions.

13. How do we test partitioned classrooms?

    Classrooms with movable partitions should be individually tested.

14. Can you test during unusual weather conditions (heavy rain, snow or wind)?

    Avoid testing during these conditions.

15. Should we take quality assurance duplicates and blanks during the follow up tests?

    Yes, however there are generally less samples taken for a follow up test.

16. When two devices (duplicates) are placed in a room during initial testing, which measurement result is taken as the test result?

    Both tests are recorded, but the average is taken as the test result.

17. What should be done if a device is picked up late or handled incorrectly?

    All test kits should be handled in accordance with manufacturer's instructions. If there is any discrepancy or problems, the serial number of the device should be recorded and noted to the laboratory doing the analysis.

References

1. "Radon Prevention in the Design and Construction of Schools and other Large Buildings" USEPA Air and Radiation (EPA 625-R-92-016) June 1994
2. "Radon Measurement in Schools Revised Edition" USEPA Air and Radiation (EPA 402-R-92-014) July 1993
3. "Radon Measurement in Schools: Self Paced Training Workbook" USEPA Air and Radiation (EPA 402-B-94-001)
4. "Reducing Radon in Schools: A Team Approach" USEPA Air and Radiation (EPA 402-R-94-00b)
5. "Radon Prevention in the Design and Construction of Schools and Other Large Buildings", USEPA Air and Radiation (EPA 625-R-92-016)

MULTI-GOVERNMENTAL ROLES

There are many governmental agencies involved in the Radon Program. Subsequently there may be laws, rules and regulations, and standards which may be on a federal, state, or local level. All federal and state laws, rules, regulations, standards and local codes must be followed.

The term "guidance" must be distinguished from "standard". Many guidance documents and recommendations have been published and are available. This course only includes guidance specifically provided by USEPA or IEMA. Guidance represents a practical recommendation of what is a reasonable course for a given set of conditions, based on experience to date. Often, alternative reasonable course of action are possible. A radon professional will also face special circumstances where a site-specific careful, informed judgment of the necessary approach must be made. Following guidance will not, in all cases, guarantee a fully successful mitigation system. However, by effectively drawing upon prior experience, use of the guidance should reduce the risk of installing an unsuccessful system, and should facilitate making subsequent modifications to achieve success.

U.S. Surgeon General

U.S. Department of Health & Human Services

Office of the Surgeon General

FOR IMMEDIATE RELEASE
Thursday, January 13, 2005

Contact: HHS Press Office
(202) 690-6343

Surgeon General Releases National Health Advisory on Radon

U.S. Surgeon General Richard H. Carmona warned the American public about the risks of breathing indoor radon by issuing a national health advisory today. The advisory is meant to urge Americans to prevent this silent radioactive gas from seeping into their homes and building up to dangerous levels. Dr. Carmona issued the advisory during a two-day Surgeon General's Workshop on Healthy Indoor Environment.

"Indoor radon is the second-leading cause of lung cancer in the United States and breathing it over prolonged periods can present a significant health risk to families all over the county," Dr. Carmona said. "It's important to know that this threat is completely preventable. Radon can be detected with a simple test and fixed through well-established venting techniques."

Radon is an invisible, odorless and tasteless gas, with no immediate health symptoms, that comes from the breakdown of uranium inside the earth. Simple test kits can reveal the amount of radon in any building. Those with high levels can be fixed with simple and affordable venting techniques. According to U.S. Environmental Protection Agency (EPA) estimates, one in every 15 homes nationwide has a high radon level at or above the recommended radon action level of 4 picoCuries (pCi/L) per liter of air.

National Health Advisory on Radon

Radon gas in the indoor air of America's homes poses a serious health risk. More than 20,000 Americans die of radon-related lung cancer every year. Millions of homes have an elevated radon level. If you also smoke, your risk of lung cancer is much higher. Test your home for radon every two years, and retest any time you move, make structural changes to your home, or occupy a previously unused level of a house. If you have a radon level of 4 pCi/L or more, take steps to remedy the problem as soon as possible.

"Americans need to know about the risks of indoor radon and have the information and tools they need to take action. That's why EPA is actively promoting the Surgeon General's advice urging all Americans to get their homes tested for radon. If families do find elevated levels in their homes, they can take inexpensive steps that will reduce exposure to this risk," said Jeffrey R. Holmstead, Assistant Administrator, Office of Air and Radiation, U.S. Environmental Protection Agency (EPA).

"Based on national averages, we can expect that many of the homes owned or financed by federal government programs would have potentially elevated radon levels. The federal government has an opportunity to lead by example on this public health risk. We can accomplish this by using the outreach and awareness avenues we have, such as EPA's Web site, to share information and encourage action on radon to reduce risks," said Edwin Piñero, Federal Environmental Executive, Office of the Federal Environmental Executive (OFEE).

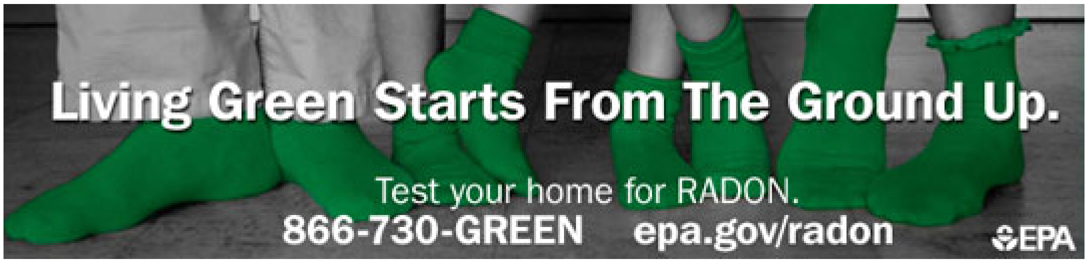
A national Public Service Announcement (PSA) that was released to television stations across America in January, National Radon Action Month, is reinforcing this recently updated health advisory. In the television spot, the camera scans a neighborhood with rooftop banners that remind the occupants of the importance to test their homes for radon.

The Surgeon General's Workshop on Healthy Indoor Environment is bringing together the best scientific minds in the nation to discuss the continuing problem of unhealthful buildings. Indoor environments are structures including workplaces, schools, offices, houses and apartment buildings, and vehicles. According to a recent study, Americans spend between 85 and 95 percent of their time indoors.

In just the past 25 years, the percentage of health evaluations that the National Institute for Occupational Safety and Health at the Centers for Disease Control and Prevention (CDC) has conducted related to indoor-air quality has increased from 0.5 percent of all evaluations in 1978, to 52 percent of all evaluations since 1990. This means that in those years, the evaluations related to air quality concerns have increased from one of every 200 evaluations to one of every two.

The problem is also adversely affecting our children's health as millions of homes and apartments and one in five schools in America have indoor air quality problems. This can trigger various allergies and asthma. Asthma alone accounts for 14 million missed school days each year. The rate of asthma in young children has risen by 160 percent in the past 15 years, and today one out of every 13 school-age children has asthma. Dr. Carmona is especially focusing on how unhealthy indoor environment affects children, as he promotes 2005 as The Year of the Healthy Child.

United States Environmental Protection Agency (USEPA)



The risk posed by indoor radon has impacted the need for construction techniques that prevent exposure to radon in residential and non-residential buildings. The Indoor Radon Abatement Act of 1988 (IRAA) states that "the national long term goal of the United States with respect to radon in buildings is that the air within buildings should be as free of radon as the ambient air outside the building". The IRAA authorizes USEPA to:

- Issue such regulations as may be necessary to carry out IRAA provisions
- Administer grants to help States establish radon programs, conduct radon surveys, develop public information on radon, and conduct demonstration and mitigation projects
- Report on studies of radon in federally owned buildings
- Conduct a study of the extent of radon contamination in school buildings
- Create a citizen's guide to radon
- Develop model construction standards and techniques
- Establish regional radon training centers
- Provide technical assistance to States, and
- Establish proficiency programs for companies offering radon services

USEPA's program is within the Office of Air and Radiation – Indoor Environments. Since 1988, USEPA has administered a voluntary program to reduce exposure to indoor air by promoting awareness, testing, installation of radon mitigation systems in existing homes, and use of radon resistant new construction techniques. But, USEPA's ability to achieve results with a voluntary program is limited.

Illinois Emergency Management Agency (IEMA)

Radon Industry Licensing Act (420 ILCS 44) - effective July 30, 1997

Licensing of radon professionals. Primary responsibility with Illinois Emergency Management Agency. The Illinois Emergency Management Agency shall have primary responsibility for coordination, oversight, and implementation of all State functions in matters concerning the presence, effects, measurement, and mitigation of risks of radon and radon progeny in dwellings and other buildings. The Department of Natural Resources, the Environmental Protection Agency, the Department of Public Health, and other State agencies shall consult and cooperate with the Agency as requested and as necessary to fulfill the purposes of this Act.

Radon Industry Licensing Act

Title 32: Energy: Chapter II: Illinois Emergency Management Agency: Subchapter b: Radiation Protection, Part 422 Licensing of Radon Detection and Mitigation Services

32 Illinois Administrative Code 422

Established rules for implementation of State Radon Requirements

Licensing of Radon Detection and Mitigation Services

Illinois State Board of Education

PUBLIC Act 096-0417

Provides that it is recommended that every occupied school building of a school district be tested every 5 years for radon. Provides that it is recommended that new schools of a school district be built using radon resistant new construction techniques. Allows a school district to maintain, make available for review, and notify parents and faculty of test results. Requires the district to report radon test results to the State Board of Education. Requires the State Board to prepare a report every 2 years of the results from all schools that have performed tests, to be submitted to the General Assembly and the Governor. Provides that if IEMA exempts an individual from being required to be a licensed radon professional, the individual does not need to be a licensed radon professional in order to perform screening tests. Provides that if the results of a radon screening test are found to be 4.0 pCi/L or above, the school district may hire a licensed radon professional to perform measurements before any mitigation decisions are made. Provides that if radon levels of 4.0 pCi/L or above are found, it is recommended that affected areas be mitigated by a licensed radon mitigation professional with respect to both design and installation. Provides that a screening test may be done with a test kit found in a hardware store, department store, or home improvement store or with a kit ordered through the mail or over the Internet. Requires the kit to be provided by a laboratory licensed in accordance with the Radon Industry Licensing Act.

PUBLIC Act 096-0417

Sample Detector Log for measuring radon in schools

- This type of document should be used ALONG WITH floor plan (see other page of attachment) for proper documentation of radon detector location
- Example placements for regular classroom (CR7), duplicate measurement (CR32), blank measurement (CR35), and room over 2,000 sq. ft. (Gym A) are provided

---

Name of Building being Tested: _____South Elementary – ### Street, City, Zip Code ______________________________

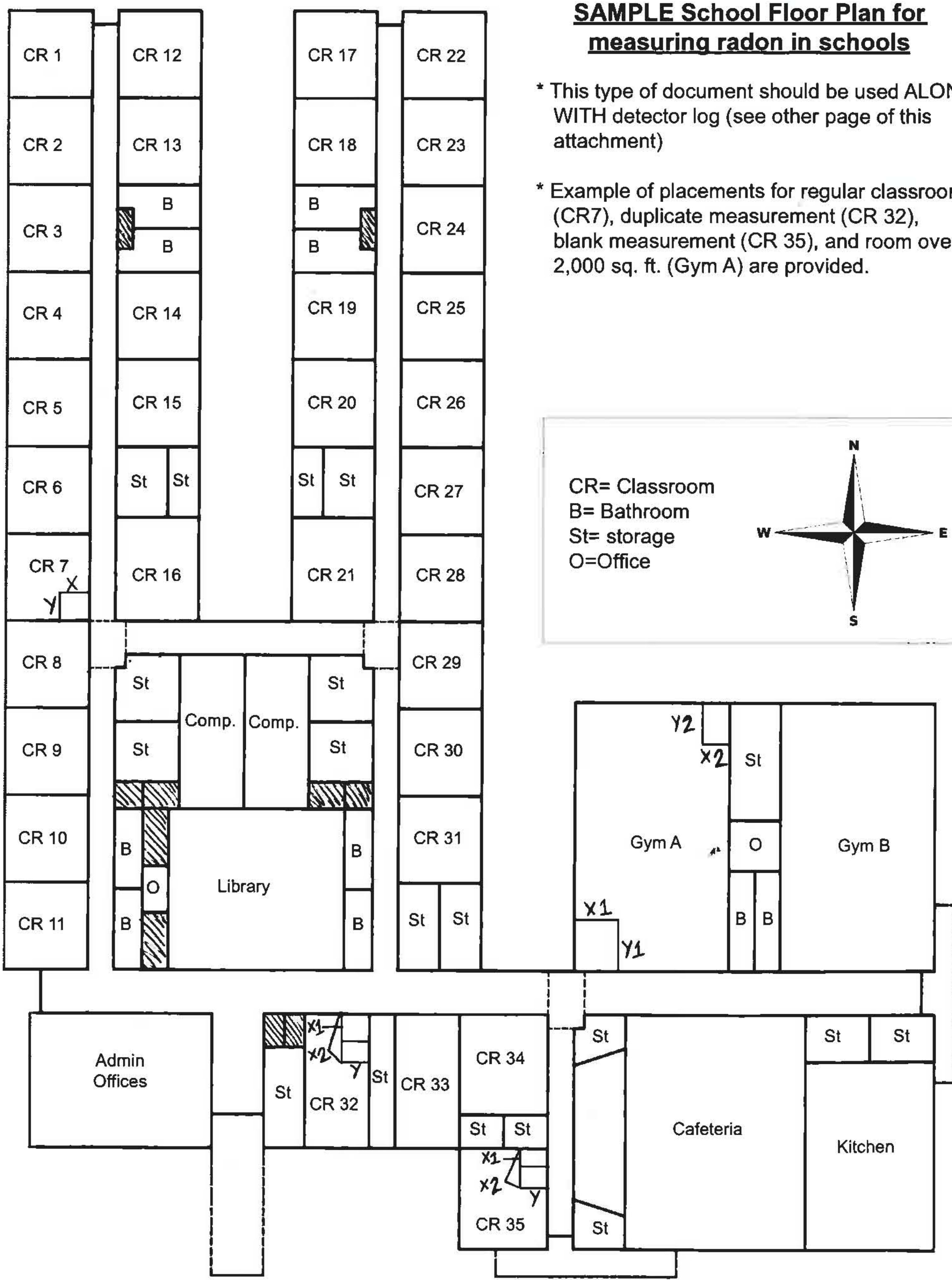
Name of Individuals performing testing: _______John Doe ____

Detector Number	Location	Duplicate/ Blank	Distance of X	Distance of Y	Distance of Z (floor)	Date Started	Time Started	Date Ended	Time Ended
001	CR 7		3' 1"	4' 3"	3' 6"	1/1/2010	6:00am		
002	CR 32 (1)		3' 4"	5' 1"	3' 5"	1/1/2010	6:05am		
003	CR 32 (2)	D	3' 8"	5' 1"	3' 5"	1/1/2010	6:07am		
004	CR 35 (1)		4' 2"	8' 3"	4' 1"	1/1/2010	6:12am		
005	CR 35 (2)	B	4' 6"	8' 3"	4' 1"	1/1/2010	6:14am		
006	Gym A (1)		5' 3"	6' 2"	5' 6"	1/1/2010	6:19am		
007	Gym A (2)		7' 8"	4' 6"	5' 6"	1/1/2010	6:22am		

SAMPLE School Floor Plan for measuring radon in schools

* This type of document should be used ALONG WITH detector log (see other page of this attachment)

* Example of placements for regular classroom (CR7), duplicate measurement (CR 32), blank measurement (CR 35), and room over 2,000 sq. ft. (Gym A) are provided.



Radon Measurement for School Districts:

Radon Test Placement Strategy and Protocol Checklist

NOTE: This document has been prepared to aid school districts performing radon testing in schools. The step-wise approach is aimed to help school districts determine where to test, how many test kits are required, where to place test kits, and proper documentation of the process. This document is meant to be used as a general guideline, not a mandate, as each school will present different situations. If specific questions or issues arise regarding testing in your school contact the Illinois Emergency Management Agency at (217) 782-1325 for assistance.

1. Determine placement strategy and number of test kits needed.

- ☐ 1.1 Get a current copy of the schools floor plan - ALL levels (emergency exit maps work well for this purpose)
  - ☐ 1.1.a Make sure all rooms in the building floor plan are individually labeled, if they are not then create labels for them
  - ☐ 1.1.b Determine different foundation types found through out the building and indicate which sections of the building are over each foundation on the floor plan
- ☐ 1.2 Determine the structurally lowest rooms in the building for all foundation types that students and faculty could spend time in (even if the room is not currently being utilized). DO NOT include areas such as storage, stairways, hallways, and elevator shafts.

** At the end of section 1.2 you should have a rough list of rooms that need to be tested - now specific testing criteria needs to be addressed.

1.3 Determine if any of the rooms selected are larger than 2,000 square feet.

- ☐ no
- ☐ yes - how many? _____ how big is the room(s)? ____________________________ (1 radon test kit must be placed for every 2,000 sq. ft.)

1.4 Determine if any of the rooms selected are subject to high humidity (kitchen or bathroom).

- ☐ no
- ☐ yes - how many? _____ (activated charcoal and charcoal scintillation test kits can not be used in rooms with high humidity)

☐ 1.5 To determine the number of test kits needed to test the building take:

_______ (total number of rooms after section 1.2)
+ _______ (number of rooms over 2,000 square feet- determined in section 1.3)
+ _______ (number of rooms over 4,000 square feet- determined in section 1.3)
+ _______ (number of rooms over 6,000 square feet- determined in section 1.3)
- _______ (rooms with high humidity- determined in section 1.4)

____

_______ = test kits needed to test the school

☐ 1.6 Determine the number of duplicate measurements that need to be deployed during measurement. To do this take:

_______ (test kits needed to test the school - determined in section 1.5)
x .1 (10% of all test kits deployed)

_______ = number of duplicate measurements that must be deployed (if greater than 50, only 50 have to be done)

☐ 1.7 Determine the number of blank measurements that need to be deployed during measurement. To do this take:

_______ (test kits needed to test the school - determined in section 1.5)
\+ _______ (number of duplicate measurements - determined in section 1.6)
x .05 (5% of all test kits deployed)

_______ = number of blank measurements that must be deployed (if greater than 25, only 25 have to be done)

☐ 1.8 Determine total number of test kits needed to perform all required tasks. To do this take:

_______ (test kits needed to test the school - determined in section 1.5)
\+ _______ (number of duplicate measurements - determined in section 1.6)
\+ _______ (number of blank measurements - determined in section 1.7)

_______ = **Total Number of Test Kits Needed**

*** Note: Double check that number of duplicates and blanks are correct for the TOTAL number of test kits needed (10% and 5% respectively). Amounts may need to be adjusted slightly once all figures added together.*

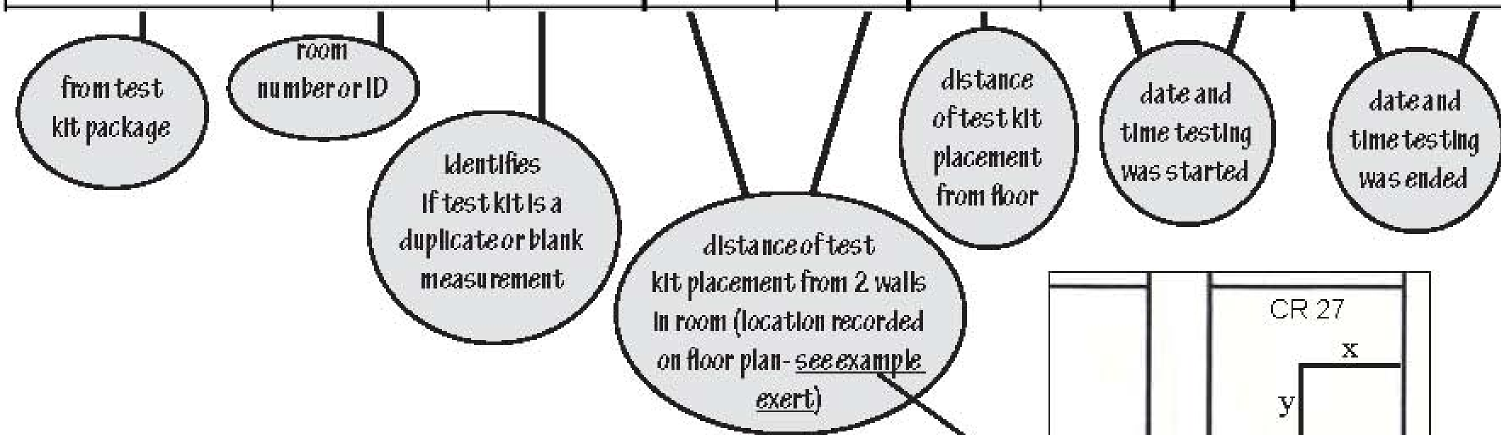
2. Test Kit Placement. Once the number of test kits is determined, they need to be placed in the rooms.

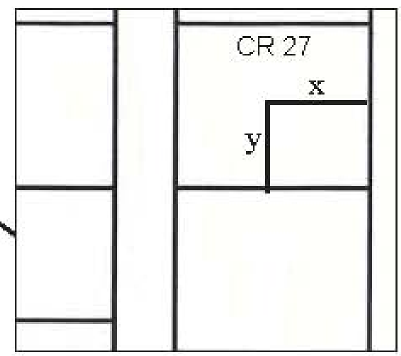
2.1 Be sure to check these items before placing the radon test kits:

- ☐ Closed conditions have been maintained in the building for 12 hours.
- ☐ HVAC system is operating as it normally would when students and faculty are present.
- ☐ Testing is being done during a time that students and faculty are present.

2.2 As detectors are placed in the rooms determined during section 1, thorough and accurate data needs to be recorded on the device log and floor plan (see sample on next page)

Detector Number	Location	Duplicate/ Blank	Distance of X	Distance of Y	Distance of Z (floor)	Date Started	Time Started	Date Ended	Time Ended
001	CR 7		3' 1"	4' 3"	3' 6"	1/1/2010	6:00am		
002	CR 32		3' 4"	5' 1"	3' 5"	1/1/2010	6:05am		
003	CR 32	D	3' 8"	5' 1"	3' 5"	1/1/2010	6:07am		
004	CR 35		4' 2"	5' 3"	4' 1"	1/1/2010	6:12am		
005	CR 35	B	4' 6"	5' 3"	4' 1"	1/1/2010	6:14am		





2.3 Protocol for all test kits. Be sure that each detector placed is:

- ☐ in a location where it will be undisturbed
- ☐ 3 feet from all doors and windows
- ☐ 3 feet from ventilation ducts
- ☐ at least 1 foot from all exterior walls
- ☐ 4 inches from all other objects
- ☐ 20 inches - 6 feet from the floor
- ☐ if test kit is hung from ceiling, it must be at least 1 foot from the ceiling
- ☐ 4 feet from heat source, fireplace, or furnace
- ☐ out of direct sunlight
- ☐ out of direct air flow from vents

2.4 Specific protocol for duplicate measurements. If the test kit you are placing is a duplicate measurement also be sure to place the test kit:

- ☐ Placed side-by-side next to the measurement test kit for that room (4-5 inches away from measurement test kit.)

2.5 Specific protocol for blank measurements. If the test kit you are placing is a blank measurement, also be sure to:

- ☐ Keep the test kit in the original packaging
- ☐ Place the test kit side-by-side next to the measurement test kit for that room (4-5 inches away from measurement test kit.)

2.6 Testing Period. The length of time test kits should be left out is dependent upon type of test kit chosen. See manufacture's instructions for more specific recommendations. In general:

- Short term tests last 3-90 days
- Long term tests last 90-365 days

3. Retrieving Test Kits. Once the testing period has elapsed, test kits need to be retrieved.

3.1 Protocol for measurement and duplicate test kits.

- ☐ Record ending date and time information on the device log
- ☐ Record ending information on the test kit package (if required)
- ☐ Seal and prepare test kits to be mailed to the lab by the manufacture's instructions

3.2 Protocol for blank test kits.

- ☐ Remove test kit from original packaging
- ☐ Record starting and ending information on test kit package similar to other measurement test kits (if required) - they should not be distinguishable to the lab
- ☐ Record ending information on the device log
- ☐ Seal and prepare test kits to be mailed to the lab by the manufacture's instructions

3.3 Mail all test kits (measurement, duplicate, and blank) to the lab for analysis immediately after retrieving from testing location.