Radon in High Water Use Facilities

Webinar

Radiation Safety Institute of Canada
Institut de radioprotection du Canada

Good Science in Plain Language®

June 21, 2017

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Webinar Purpose

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- To introduce people to the potential hazards of radon gas, in facilities which utilize a high volume of water

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In this Webinar...

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- What radon is
- Potential health hazards
- How radon gets into our workplace air
- How to measure radon levels
- Radon radiation protection guidelines and regulations for radon
- Measures to reduce radon exposure

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Radon

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- Radon is an odourless, colourless radioactive gas that is formed naturally by the breakdown of uranium in soil, rock and water
  - Alpha emitter
  - Half life of 3.8 days
  - Inert gas (non-reactive)
  - Water soluble
  - Somewhat more dense than air
  - Accumulates in enclosed spaces

Radon
Rn
Atomic Number: 86
Atomic Mass: 222

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Radon Progeny

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- Radon progeny are the radioactive daughters of radon gas
  - For health-effects, only the short-lived progeny are considered
  - Are solids
  - Attach to dust particles in the environment
  - When inhaled, tend to remain in the lungs
  - Two high-energy alpha emitters

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Radon-222 and Short-Lived Progeny

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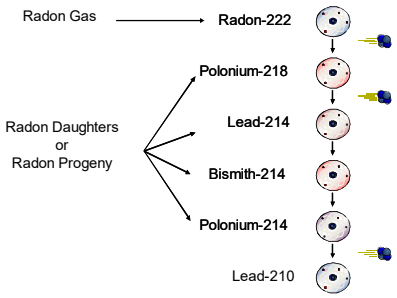

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Radiation Dose

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- The effects of radiation depend on the amount of ***energy*** the radiation transfers to your body.
- This transfer of energy results in a radiation ***dose.***

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Radon – Health Effects

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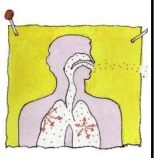
- Radon Progeny attach to dust particles in the air
- When we breath in air, these radioactive aerosols enter into our lungs
- As these decay in the lung, they emit alpha radiation which transfers energy to the cells
- This radiation can damage lung cells
  - No immediate symptoms
  - Mutations are possible
- This cell damage leads to an increased risk of developing lung cancer



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Radon – Health Effects

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- Development of lung cancer due to radon exposure is probabilistic
  - Not everyone exposed to elevated levels of radon will develop lung cancer
  - There is no lower threshold below which the exposure presents no risk
- The more dose received due to radon exposure, the higher the risk of developing lung cancer

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Radon – Health Effects

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- The risk of getting lung cancer from radon depends on:
  - How much radon is in your workplace and home
  - The occupancy time in these areas
  - Whether you are a smoker or have ever smoked

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Radon Measurement Units

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- Radon gas is measured as an activity concentration (Bq/m^3)
  - To calculate dose, must know/assume the relative amounts of radon gas and its progeny
  - Canadian NORM Guidelines: Exposure to 200 Bq/m^3 for 2000 hours results in 1.4 mSv of Effective Dose
- Radon progeny is traditionally measured in Working Levels (WL)
  - Being exposed to 1 WL for 170 hours results in 1 WLM exposure, equivalent to 5 mSv of Effective Dose

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Radon Sources – Building Entry

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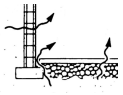
- How does radon enter a building?
  - Entry where building is in contact with soil
    - Cracks in the slab/walls in contact with soil
    - Gaps at floor-wall joints
    - Open sump pits
    - Openings around utility penetrations
    - Floor drains with no traps
    - Etc.
  - Emission from water
    - Particularly ground/well water
  - Through natural gas



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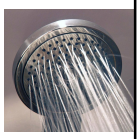
Radon Sources – Water Emission

- Radon in water
  - Radon can dissolve in water which passes through a radon source (rocks and soil with some uranium)
  - Radon escapes from the water into the air
    - More radon escapes from water into air when the water is agitated in air (e.g., splashing, spraying, etc.)
    - How easily radon transfers to air depends on the temperature of the air and water and the amount of agitation



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Radon Sources – Water Emission

- Facilities that use large amounts of ground water may have significantly higher radon concentrations
  - Fish culture, water treatment facilities, etc.

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Indoor Radon Concentration

- Radon concentration indoors is affected by
  - Amount of uranium in soil and building materials
  - Soil characteristics
  - Radon concentration in water
  - Amount of water used
  - Heating, ventilation and air conditioning
  - Occupancy patterns (doors/windows open or closed)

Indoor Radon Concentration

- Radon concentration indoors is also affected by external environmental conditions
  - Temperature
  - Barometric pressure
  - Precipitation
  - Humidity
  - Wind speed

How to Detect Radon

- Radon progeny
  - Causes the most dose
  - Due to the very short half lives, can be complicated to measure
- Radon gas
  - Generally radon gas concentration is measured
  - Radon gas is much easier to detect
  - To convert to dose, an assumption is made about the relative amounts of radon progeny and radon gas (the equilibrium factor)

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How to Detect Radon

- Radon gas can be measured in many ways
  - Short term (not recommended)
    - Grab Sample
    - Charcoal Canister
  - Long term (recommended)
    - Electret Monitor (E-PERM)
    - Alpha Track Monitor
  - Continuous (a good option but can be expensive)
    - Electronic Monitor
      - NOTE: Must be calibrated regularly

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How to Detect Radon

- Long term (electret or alpha track monitors)
  - 3 to 12 months in duration
  - Don't usually require power
  - Sent away for analysis at the laboratory
  - Much better indication of long-term average concentration
  - Relatively inexpensive
  - Recommended by Health Canada

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Regulation of Radon in Workplaces

- Federal
  - Federally regulated workplaces
  - Workplaces regulated under the Nuclear Safety and Control Act
    - Uranium mines, nuclear power, radiation sources, etc.
    - Radiation protection regulations require dose from radon to be monitored and reported
- Provincial
  - Workplaces under provincial regulation
  - Occupational Health and Safety Regulations
  - Mine Safety Regulations

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Ontario Regulations

- Ontario's Occupational Health and Safety Act
  - Employer has a duty to protect the health and safety of the employee
    - "Take every precaution reasonable in the circumstances for the protection of a worker"
  - Regulation is not explicit on how to do so for radon or other naturally occurring radioactive materials
  - Ontario Ministry of Labour staff have indicated that they expect employers to follow the safety measures documented in Health Canada's *Canadian Guidelines for the Management of Naturally Occurring Radioactive Material (NORM)*

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Canadian NORM Guidelines

- Recommends all workplaces be assessed for radon concentration since it can "vary significantly"
- Provides occupational dose limits for exposure to radon in workplaces that are not uranium mines (federally regulated) based on worker type
  - Occupationally Exposed Workers, Incidentally Exposed Workers, Members of the Public
  - Limits are consistent with ICRP recommendations (and Canadian federal regulation limits)

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Canadian NORM Guidelines

- Provides dose conversion factors based on measured radon or radon progeny concentration
- Provides classifications based on radon concentration
  - Indicates actions to be taken to protect the workers

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Canadian NORM Guidelines

Exposure	Annual Dose	NORM Classification
< 200 Bq/m^3 (0.25 WLM)	1.4 mSv	Unrestricted
200 Bq/m^3 – 800 Bq/m^3 (0.25–1 WLM)	1.4 – 5 mSv	Norm Management -Application of an ALARA program which may include changes in work practices, changes to work procedures, and introduction of access controls for members of the public and incidentally exposed workers -Should reduce radon levels to below 200 Bq/m^3.
> 800 Bq/m^3 (1 WLM)	> 5 mSv	Radiation Protection Management -A Radiation Protection Management should be implemented (radiation protection program, dosimetry for workers, provide protective equipment). -The program should include steps to reduce the radon levels to below 200 Bq/m^3.

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Canadian NORM Guidelines

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Dose Limits

Group	Annual Effective Dose Limit (mSv)[a]	Five Year Cumulative Dose Limit (mSv)
Members of the Public and Incidentally Exposed Workers	1	5
Occupationally Exposed Workers	50	100
Pregnant Occupationally Exposed Workers	4 (for the balance of pregnancy)	

These limits exclude natural background and medical exposures.

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Radon in Water Guidelines

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- The health risk from ingesting radon-contaminated drinking water is considered negligible.
  - Majority of the radon escapes when radon is agitated, leaving only minimal amounts in the water itself.
- However, radon in water can significantly increase the airborne radon.
- Canada currently has no guidelines for radon concentrations in drinking water.

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Radon in Homes

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- There are no Canadian regulations governing radon levels in dwellings
- Health Canada has a guideline
  - Take remedial measures in a dwelling whenever the average annual radon concentration exceeds 200 Bq/m^3 in the normal occupancy area.
  - The higher the radon concentration, the sooner remedial measures should be undertaken.
    - If > 600 Bq/m^3, remediate within 1 year
    - If 200 Bq/m^3 – 600 Bq/m^3, remediate within 2 years

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Radon in Homes

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- Health Canada guideline, cont'd
  - Remedial action should aim to reduce radon to a value as low as practical.
  - The construction of new dwellings should employ techniques that will minimize radon entry and facilitate post-construction radon removal

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Control of Radon Hazards

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- Prevent radon entry into the building – radon from soil gas
  - Find and seal entry points (cracks, gaps, sump pits, utility penetrations, etc.)
  - Maintain positive air pressure (vs. soil gas pressure)
  - Sub-slab depressurization
    - Remove air from under floor slab, continuously
    - Radon is removed before it can enter the building

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Control of Radon Hazards

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- Prevent radon entry into the building – radon from water
  - Reduce unnecessary water entry
  - Aeration of water prior to entry

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Control of Radon Hazards

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- Prevent radon entry into the workplace air
  - Limit aeration of radon-bearing water in facility
    - Reduce agitation, splashing, etc.
    - Use radon-reduced water for spraying, etc.
  - If aeration is required (e.g., to add oxygen), separate this from the workplace air
    - Aeration columns in separate room or outside
  - Separate breathing air from air near agitated water
    - Install covers over waste water channels

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Control of Radon Hazards

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- Example water agitation/aeration prevention:

Before

After

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Control of Radon Hazards

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- Ventilation
  - Remove air at water aeration and/or disturbance
  - Separate ventilation for indoor aeration chambers
  - Separate breathing air from air where aeration and disturbance cannot be prevented
    - Cover waste-water channels, etc.
  - Temperature control
    - Cool air takes up less radon than warm air
  - Control air flow path in facility from low to high radon areas

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Control of Radon Hazards

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- Combine Aeration and Ventilation
  - Studies show that
    - Radon removal from source water (aeration) alone is not always enough
    - Ventilation alone is not always enough
  - Often the two must be combined for effective radon control in high water use facilities

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Control of Radon Hazards

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- Protective equipment
  - In areas where radon entry prevention and ventilation are either insufficient or not practical, so that a high radon area exists, Personal Protective Equipment can be considered

  - Properly fitted particulate respirators prevent most dust particles (and thus most radon progeny) from being inhaled, thus reducing the dose
  - This option should be the last choice – the prevention of elevated radon is preferred

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Control of Radon Hazards

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- Employer must inform workers of the radon levels in the workplace
- Procedures can be put in place to limit time in elevated radon areas
- Employees have responsibilities to follow procedures provided

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Control of Radon Hazards

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- The only way to know the level of radon in a workplace or in a home is to test for it!
  - Long term tests of 3 to 12 months are recommended
  - For workplaces, must obtain the average annual concentration to compare to the Canadian NORM Guideline

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