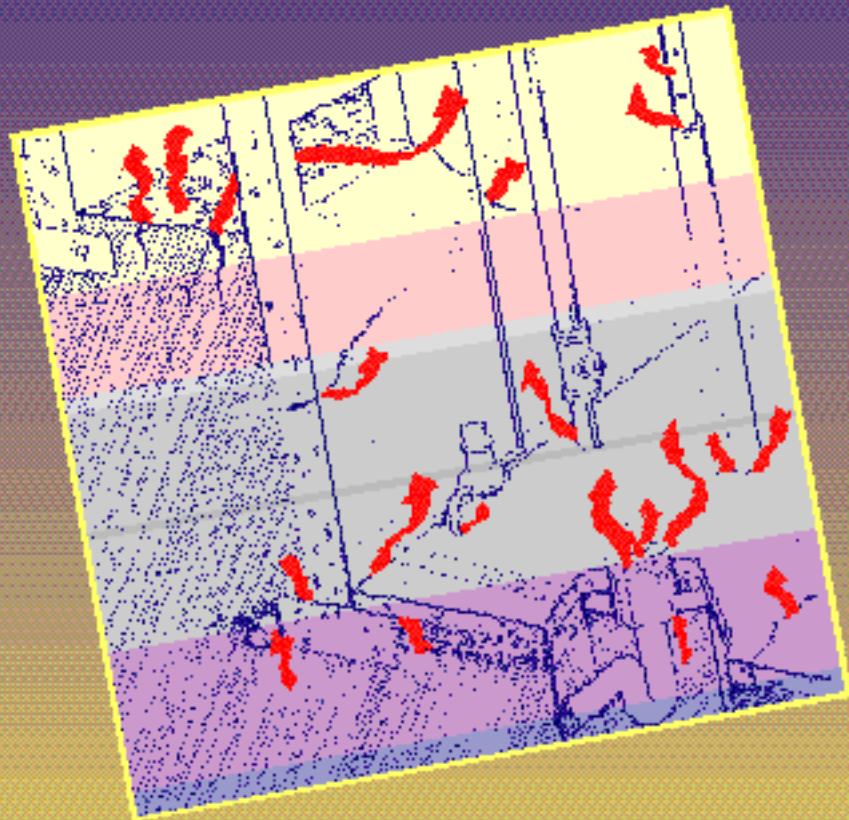


A GUIDE FOR CANADIAN HOMEOWNERS

RADON



Radon

A GUIDE FOR CANADIAN HOMEOWNERS

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Canada

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INTRODUCTION

What is Radon?

Radon is a radioactive gas that is colourless, odourless and tasteless. It is formed by the natural breakdown of uranium in soil, rock and water. Radon also breaks down to form additional radioactive particles called “progeny”.

Radon escapes from the ground into the outdoor air. It is diluted to low concentrations and is not a concern. However, radon that enters an enclosed space, such as a home, can sometimes accumulate to high levels.

Concern in Canada about indoor radon levels began in the mid-1970’s. Some homes in communities where uranium ore was either mined or processed were found to have elevated radon concentrations. After this discovery, Health Canada surveyed the radon levels in 14,000 homes in 18 cities across Canada.

The majority of homes surveyed showed low concentrations of radon. However, a small but significant minority of homes in some cities were found to have high levels.

What is the Risk?

The only known health risk associated with exposure to radon is an increased risk of developing lung cancer.

Radon gas and radon progeny in the air can be breathed into the lungs where they breakdown further and emit “alpha particles” (see **figure 1**). Alpha particles release small bursts of energy which are absorbed by nearby lung tissue. This results in lung cell death or damage.

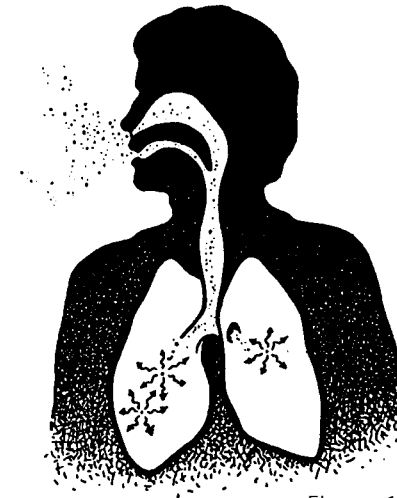


Figure 1

When lung cells are damaged, they have the potential to result in cancer when they reproduce. Cancers caused by radioactivity are started by chance and not everyone exposed to radon will develop lung cancer. The time between exposure and the onset of the disease is usually many years.

Your risk of developing lung cancer from radon depends on the concentration of radon in the air you breathe and the length of time you are exposed. This knowledge is based on animal experiments and studies of underground uranium miners.

However, there is uncertainty about using this information to estimate the risk from radon in homes. Studies of lung cancer rates and radon levels in homes have had differing results. For example, a study done in Winnipeg from 1983 to 1990 failed to show an increase in lung cancer risk due to elevated levels of radon in homes. Two recent studies from Finland and the United States have confirmed these findings but a study from Sweden has shown a small increase in risk.

Until the results of this and other similar studies can be compared, it is difficult to accurately estimate how many lung cancers in Canada are due to radon exposure in homes.

What is the Effect of Smoking?

Smoking is the major cause of lung cancer – it is responsible for about 90% of all lung cancer deaths in males and 80% of lung cancer deaths in females.

The National Cancer Institute of Canada estimated that in 1996, 12,400 men and 7,600 women will develop lung cancer and that 11,000 men and 6,000 women will die from lung cancer.

Exposure to radon and tobacco use may combine to increase the risk of lung cancer. Research has compared the cancer rates in smoking and non-smoking uranium miners. Results indicate that smoking promotes earlier development of lung cancers that may have been caused by radon.

Not smoking is the most effective way you or your family can reduce the risk of lung cancer.

A Personal Evaluation of Exposure

Besides smoking habits, there are other living patterns that could influence your assessment of risk and the need to take action. Consider these questions to help evaluate your personal exposure:

- How much time do your family members spend at home? The guidelines in this booklet assume that 75% of a person's time is spent at home.
- Do you have bedrooms or a home office in your basement? Radon concentrations tend to be greater on the lower levels of

a home. A person who sleeps or spends much of their waking hours in the basement is exposed to more risk than others in the same house that do not.

- How long will you live in your home? The guidelines in this booklet are based on an exposure period of about 70 years. Consider the amount of time you expect to live in your home.

Also consider that taking action to reduce radon in your home may have other benefits:

- Mould and odour problems that can result from moisture and soil gas contaminants entering your home are often reduced by radon reduction work.
- Sealing major cracks, holes and gaps in foundations can reduce cold drafts, lower energy bills and keep insects out.
- Sealing a sump will reduce both radon entry and the risk of injury to small children.

The Canadian Guideline for Radon in Homes

There is no regulation in Canada that governs what is deemed to be an acceptable radon level in a home. It is the choice of each homeowner to determine what level of radon exposure they are willing to accept.

Health Canada, in conjunction with the provinces, has developed a guideline to indicate when remedial action is necessary. This guideline was approved by the federal and provincial Ministers of Health in 1988 and reviewed again by a federal-provincial-territorial subcommittee in 1993:

It is recommended that remedial measures be taken where the level of radon in a home is found to exceed 800 Bq/m³ as the annual average concentration in the normal living area. Because there is some risk at any level of radon exposure, homeowners may wish to reduce levels of radon as low as practicable.

The average level of radon in outdoor air is about 10 Bq/m³ (0.3 pCi/L). However, levels can occasionally reach several times this amount for short periods of time.

Indoor radon levels typically range from about 30 to 100 Bq/m³ (0.8 to 2.7 pCi/L) with an average concentration of 45 Bq/m³ (1.2 pCi/L). A small number of homes in some regions have radon levels that exceed an annual average of 800 Bq/m³ (22 pCi/L).

Reducing indoor radon levels to be no more than outdoor levels is not yet technologically achievable. However, most homes today can be reduced to 75 Bq/m³ (2 pCi/L) or less.

How Radon Can Enter Your Home

During much of the year, the air pressure inside your home is lower than in the soil surrounding the foundation. This difference in pressures draws air and other gases in the soil, including radon, into the home.

Soil gas containing radon can enter a house any place it finds an opening where the house contacts the soil. These openings can be present even in well-built and new houses.

Potential entry routes for radon in homes with poured concrete foundations include (see figure 2):

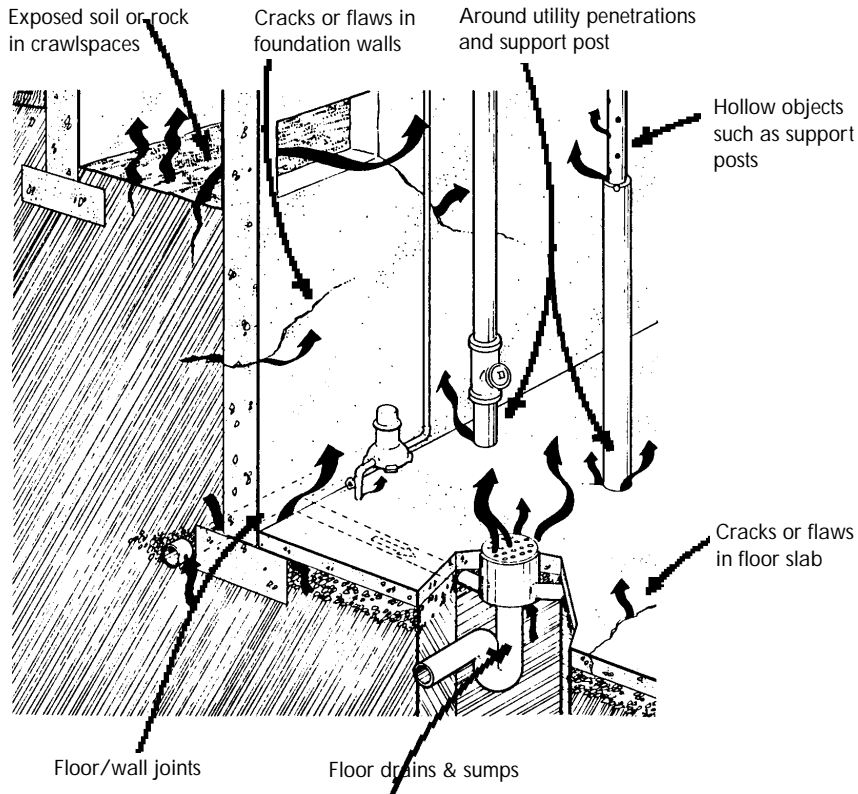


Figure 2: Typical radon entry routes in poured concrete foundation walls and floors

Homes with concrete block foundation walls can have other entry routes (see figure 3) such as:

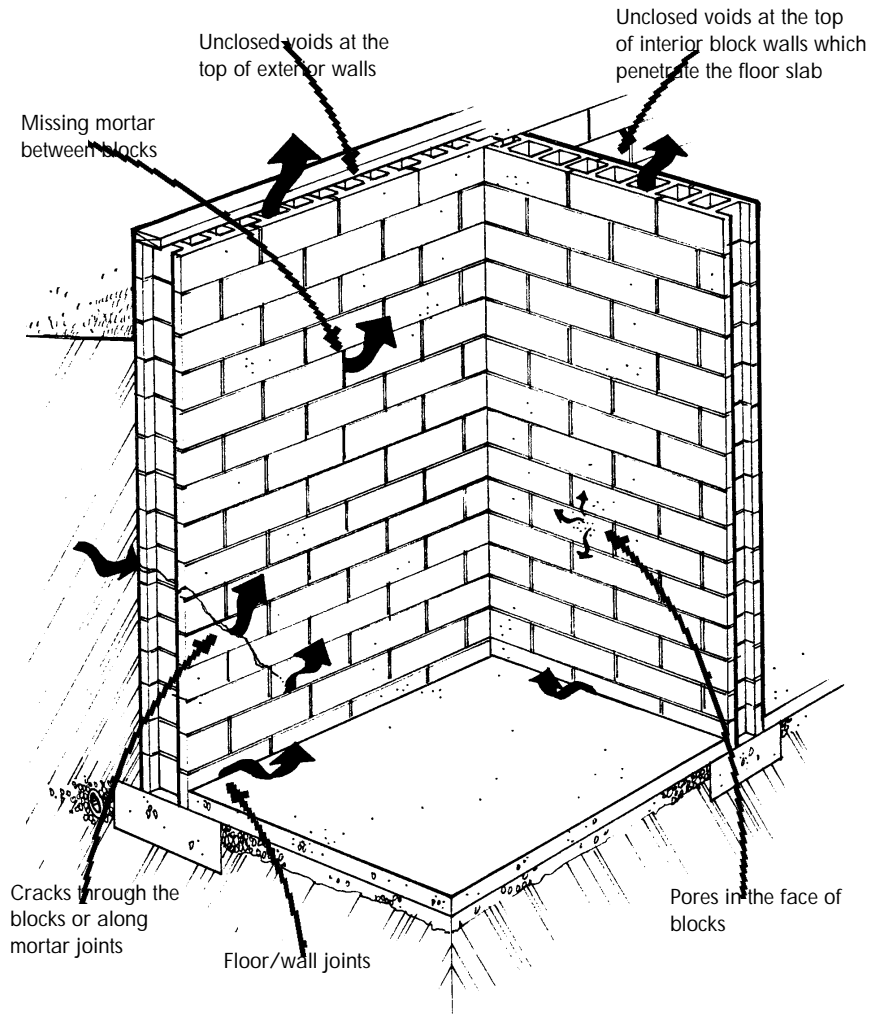


Figure 3: Typical radon entry routes in concrete block foundation walls

Homes with less common types of foundations (e.g. concrete slab-on-grade, stone, pressure-treated wood) may have other entry routes where openings or paths exist between the house and the soil. In many homes, regardless of the foundation type, some entry routes will be hidden. For example, they may be concealed by paneling, carpeting, appliances, wood framing or other objects.

In a few areas, large amounts of radon can dissolve in groundwater from private or small community wells. It can then be released into the air in a home when the water is agitated by activities such as showering, clothes washing or cooking.

Instead of wells, the water supply for larger communities are often drawn from open bodies of water. These sources tend to be low in radon.

Except in a few unusual cases, building materials used to construct a house are not a significant source of radon.

Which Homes Have a Problem?

Almost all homes have some radon. The levels can vary dramatically even between similar homes located next to each other.

The amount of radon in a home will depend on many factors such as:

- **Soil Characteristics** - Radon concentrations can vary enormously depending on the uranium content of the soil. Also, radon flows more easily through some soils than others.
- **Construction Type** - The type of home and its design affect the amount of contact with the soil and the number and size of entry points for radon. It also affects the rate of exchange of outdoor and indoor air.
- **Foundation Condition** - Foundations with numerous cracks and openings have more potential entry points for radon.
- **Occupant Lifestyle** - The use of exhaust fans, windows, fireplaces, etc. influence the pressure difference between the house and the soil which draws radon indoors. These factors also influence the rate of exchange of outdoor and indoor air.
- **Weather** - Variations in weather (e.g. temperature, wind, barometric pressure, precipitation, etc.) can affect the amount of radon which enters a home.

Because there are so many factors, it is very difficult to predict the radon level in a home.

The only way to determine whether your home has high radon levels is to test for it.

MEASURING RADON LEVELS

Methods For Measuring Radon

Several methods can be used to measure radon in a home:

- **Charcoal Detectors** – These devices consist of a container filled with charcoal and covered with a screen and filter (see **figure 4**). They are exposed to the air in your home for a specified time period (usually 2 to 7 days), sealed and then sent to a laboratory for analysis.

This method is relatively inexpensive – about \$15 to \$30 including the analysis.

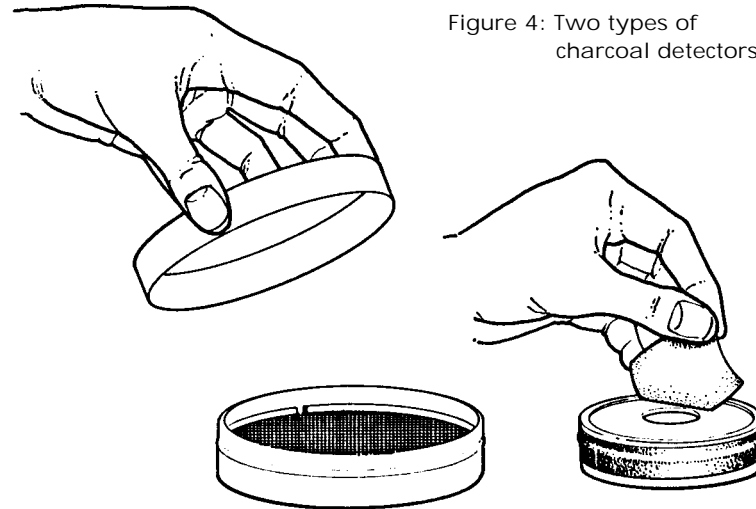


Figure 4: Two types of charcoal detectors

- **Passive Alpha-Track Detectors** – These detectors use a small sheet of special film enclosed in a container with a filter-covered opening (see **figure 5**). Passive alpha-track detectors are exposed to the air in a home for a period that can range from several months to one year.



Figure 5: Passive alpha-track detector

Passive alpha-track detectors must be returned to a laboratory for analysis. They cost about \$30 to \$50 including the analysis.

- **Active Alpha-Track Detectors** – This type of detector is similar to a passive alpha-track detector. However, it offers more accurate measurement by using a small electric air pump (see **figure 6**). Active alpha-track detectors are usually used to measure radon for periods of one week to about two months.

Active alpha-track detectors must be returned to a laboratory for analysis. They cost about \$70 including the analysis.

- **Electret Ion Chamber** – This method uses a special plastic canister that contains a disk called an “electret” with an electrostatic charge (see **figure 7**). It is exposed and the change in the electret’s charge read to determine the radon level. There are two versions, one for short-term tests of a few days or weeks, and one for long-term tests of several weeks or months.

Electret ion chambers may be read in the home or mailed to a lab for analysis. Their cost is in the same range as passive and active alpha-track detectors.

- **Continuous Monitors** – These devices typically measure radon over a series of minutes and report the results in hourly increments. Results are normally available in the home. The cost of continuous monitor measurements is generally more expensive than other devices.

Specialized measurement methods not listed above are also available. They require an experienced technician with analytical equipment to visit the house. Because these measurements are expensive, they are not commonly used for initial radon testing in a home. However, they find greater application in follow-up measurements, research work, and to evaluate the success of radon reduction work.

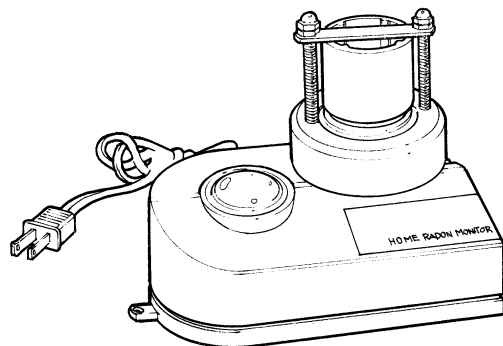


Figure 6: Active alpha-track detector

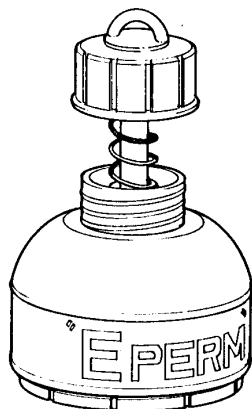


Figure 7: E-PERM detector

Units of Measure

Your home’s measurements will be reported to you in one of three ways. Results from devices that measure concentrations of radon gas are reported as either “Becquerels per cubic metre” (Bq/m³) or “picoCuries per Liter” (pCi/L). Canada and other countries which have adopted the metric system use Bq/m³. One pCi/L equals 37 Bq/m³.

Results from devices that measure the radiation emitted from radon progeny are reported as “Working Levels” (WL) or milliWorking Levels (mWL). The ratio between radon gas and its radon progeny vary with conditions. In most houses, 0.1 WL is approximately equivalent to 800 Bq/m³ (22 pCi/L) of radon.

Purchasing Radon Detectors and Measurement Services

Radon detectors and radon measurement services can be difficult to find in many parts of Canada, even in large urban centres.

Charcoal and passive alpha-track devices are available in some retail stores that sell building, hardware or health care products. These detectors are sometimes offered by mail through ads placed in magazines about home improvement or health issues.

Active alpha-track detectors, electret ion chamber and continuous monitor radon measurements may be available from companies listed in your local or regional Yellow Pages – look under the headings “Gas Detectors”, “Environmental Consultants”, or “Radon Detection”. These companies may also offer charcoal and passive alpha-track detectors.

Professional home inspectors can be contacted to identify whether local sources exist for radon detection devices and services in your community.

When choosing radon detectors, the lowest price may not be your best choice. The level of service, accuracy of detectors, expertise and advice can vary considerably between different suppliers of radon detectors and measurement services.

For advice about the availability of radon measurement devices and services in your region, contact your provincial or territorial government (see **page 37**).

Determining Your Home's Radon Level

Because radon levels in a home can vary significantly over time, use an extended measurement period, preferably a full year.

While the variation differs from home-to-home, it is not uncommon to see radon levels in a house change by a factor of 2 to 3 or more over a one-day period. Seasonal variations can be even more dramatic with the highest levels usually experienced during winter.

A year-long measurement period will give a much better indication of your exposure than a measurement of shorter duration. Passive alpha-track and long-term electret ion chamber detectors are the most practical methods for this type of extended measurement.

Observe the manufacturer's instructions and the guidelines below when placing a radon detector in your home:

- Make the measurement in the lowest lived-in area of your home such as the basement, if it is finished.
- Avoid taking measurements in the kitchen. The exhaust fan as well as humidity and airborne particles from cooking may effect the accuracy of some types of radon detectors. Also avoid bathrooms since relatively little time is spent in this room.
- Place the detector where it will not be disturbed during the measurement period but avoid small enclosed areas such as a cupboard or closet.
- Do not place the detector close to an outside wall or near a sump or floor drain.
- Avoid locating the detector in drafts from heating or air conditioning vents, near windows or doors, or sources of heat such as stoves, fireplaces or strong sunlight.
- Place the detector at least 200 mm (8 in.) below the ceiling and 500 mm (20 in.) above the floor.

Compare the results of the year-long measurement of the radon level in your home to *The Canadian Guideline For Radon In Homes* on **page 3**.

Some people may not want or be able to wait a year for the results.

For example, news of high radon levels in your community, renovating a basement as living space, or making an offer-to-purchase on a home may hasten your desire to know whether there is a radon problem.

In these cases, follow the steps below to determine the radon level in your home:

Make an Initial Short-Term Measurement

1 2 3
STEP Make an initial short-term measurement in the lowest lived-in level of the home. Use a charcoal, active alpha-track or short-term electret ion chamber detector or a continuous monitor.

Short-term detectors are typically exposed for 7 days or less – follow the manufacturer's recommendation. Attempt to keep all windows and doors closed except for normal entry and exit for at least 12 hours prior to the start of the test. They should also be kept closed as much as possible throughout the testing period.

When possible, short-term measurements should be made during cold weather (e.g. October to April). The heating season usually corresponds to the highest radon levels.

If low radon levels are found under these “worst case” conditions, your home is likely to have low levels under less challenging conditions.

Remember that a single short-term measurement is not a reliable indicator of the long-term radon level in your home. This type of measurement only serves to indicate a potential radon problem. Depending upon the result, you may need to have follow-up measurements made to give you a better idea of the long-term radon level in your home.

Perform Follow-up Measurements if Necessary

1 2 3
STEP Compare the results of your initial short-term measurement to these guidelines to determine whether follow-up measurements are advisable:

- If your initial short-term measurement is above 150 Bq/m³ (4 pCi/L), expose a passive or active alpha-track or long-term electret ion chamber detector for a minimum of three months. Place the detector in the same location used for the initial measurement. Usually, measurements taken during the heating season will reflect worst case conditions.
- For initial measurements greater than 800 Bq/m³ (22 pCi/L), perform a follow-up measurement as soon as possible.
- If your initial short-term measurement is less than 150 Bq/m³ (4 pCi/L), follow-up measurements are probably not required.

Decide Whether Further Action is Required

1 | 2 | 3
STEP Compare the results of the final follow-up radon measurement in your home to *The Canadian Guideline for Radon in Homes* on **page 3**.

REDUCING RADON LEVELS

Reducing Radon in Existing Homes

This section gives an overview of what can be done to reduce radon levels in existing homes. For a more comprehensive and technical discussion about the selection, design and operation of measures to reduce radon levels in homes, refer to these U.S. Environmental Protection Agency publications (see **page 40** for address):

- *Radon Reduction Techniques for Detached Houses – Technical Guidance (Second Edition)*
- *Radon Reduction Techniques for Existing Houses – Technical Guidance (Third Edition) for Active Soil Depressurization Systems*

Methods to reduce the level of radon in your home vary considerably in their complexity, long-term effectiveness and cost.

The effectiveness of any one radon reduction method will depend upon the unique characteristics of your home, the level of radon, the routes of the radon entry, and how thoroughly the job is done. A single method may be sufficient, but sometimes several methods must be combined to achieve acceptable results (especially when levels are high).

Many radon reduction measures require installation by a professional contractor or skilled homeowner. However, there are some steps many homeowners can make immediately, often at little cost. These steps might not always be sufficient by themselves, but they may give some reduction until more comprehensive measures can be implemented. These steps include:

Close Major Entry Routes for Radon

1 | 2
STEP Many openings in a foundation that may allow radon to enter a home may be small or hidden. However, some openings are large and obvious.

The reduction in radon levels that can be achieved by closing a particular entry route is impossible to predict. However, if a major opening is accessible, it is advisable to close it since some reduction in radon levels may be obtained.

There are also other benefits to closing major entry routes. Moulds, odours, insects and cold drafts will find it more difficult to enter the basement. It is also necessary to close major entry routes if an active soil depressurization system is to be installed (refer to **page 16**).

Major openings that can be important to seal include:

- **Open sumps** – Sumps can be fitted with an airtight cover (see **figure 8**). If the sump also acts as a floor drain, add a special trap to the airtight cover and slightly recess the cover into the sump.

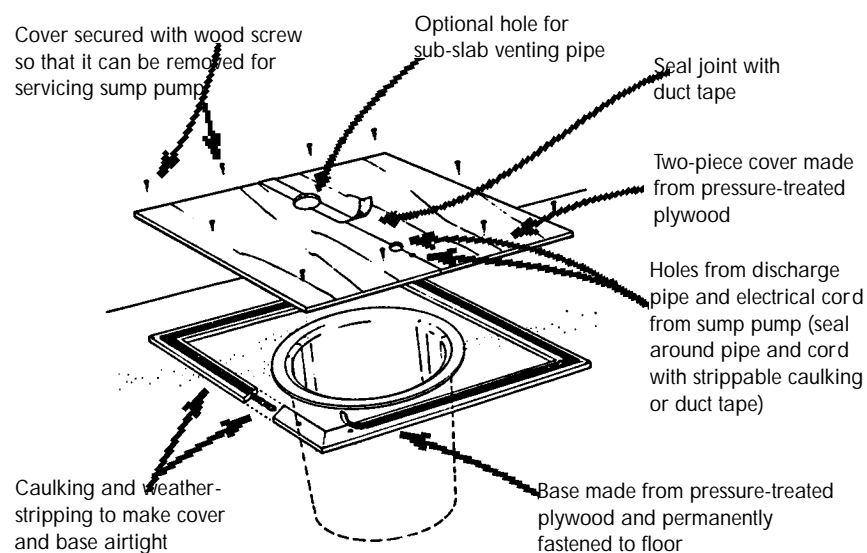


Figure 8: Sealing open sumps

- **Floor drains** – Basement floor drains can have special traps installed that allow water to drain, but prevent radon from entering the basement (see **figure 9**). These special traps are not a substitute for a sewer back-up valve.

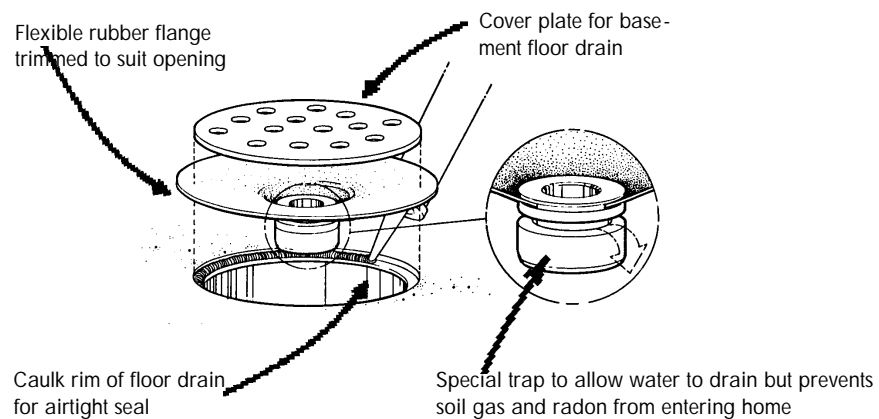


Figure 9: Trap for existing floor drains

- **Exposed soil** – Exposed soil in crawlspaces can be covered by a barrier with sealed edges and joints (see **figure 17, page 25**). If there are major gaps in the basement floor slab (e.g. cold storage room), concrete should be poured to cover any exposed soil.
- **Voids in concrete block walls** – If there isn't a solid row of block, seal voids in the top of foundation and interior load bearing walls (see **figure 10**).

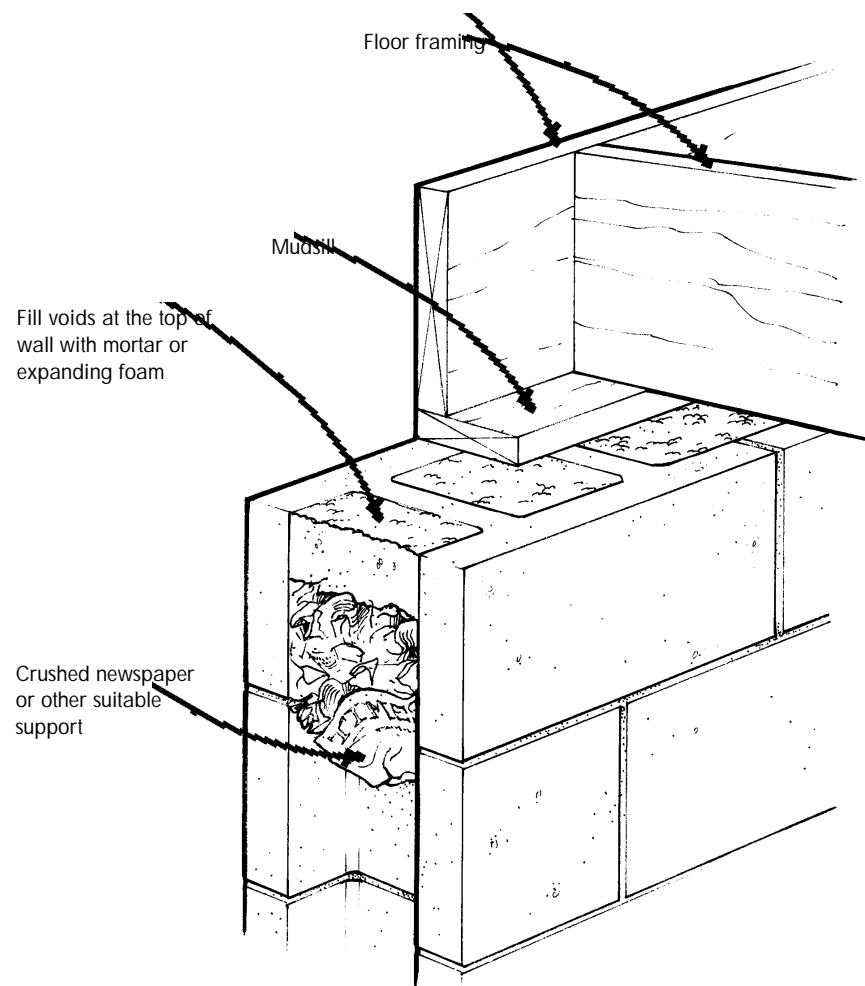


Figure 10: Sealing voids in the top of concrete block walls

Reduce Forces that Draw Radon into the Home

1 2
STEP Research has indicated that reducing the negative indoor pressure that draws radon into a home can be an effective measure for some homes. However, there is a need for further research to reduce uncertainties about this technique.

To reduce negative pressure in your home, open a nearby window to provide outdoor air when using a fireplace or wood stove. When not in use, make sure the chimney damper is shut. Where possible, also open a nearby window when you operate an exhaust fan vented to the outdoors such as the kitchen fan, bathroom fan, clothes dryer or central vacuum system.

An alternative is to install a combustion-air duct and fresh-air duct (see **figure 20, page 27**). This would avoid the inconvenience, discomfort and security problem of opening windows.

Besides reducing radon entry, providing combustion and make-up air can improve energy efficiency and combustion safety.

After taking steps to close major entry routes and reduce forces that draw radon into a home, more comprehensive and long-term measures to consider include:

Depressurize the Soil Around the Foundation

OPTION 1 Active soil depressurization has been found to be the most effective and reliable radon reduction technique in existing homes. It is also the most common method used by contractors that specialize in radon reduction.

This method involves installing a vent pipe through the basement floor slab (see **figure 11, page 17**) or connecting it to the foundation drain tiles through the sump. A fan which runs continuously is connected to the vent pipe. This reverses the air pressure difference between the house and soil reducing concentrations of soil gas, including radon, next to the foundation.

The soil in a crawlspace can be vented in a similar manner by installing a sealed polyethylene or comparable membrane over the soil and venting the area beneath the membrane.

For homes with concrete block foundations, it is sometimes necessary to add suction to the block cores. If the block cores are open at the top of the wall, it is important to seal them. This will minimize the amount of heated or cooled air that is removed from the basement.

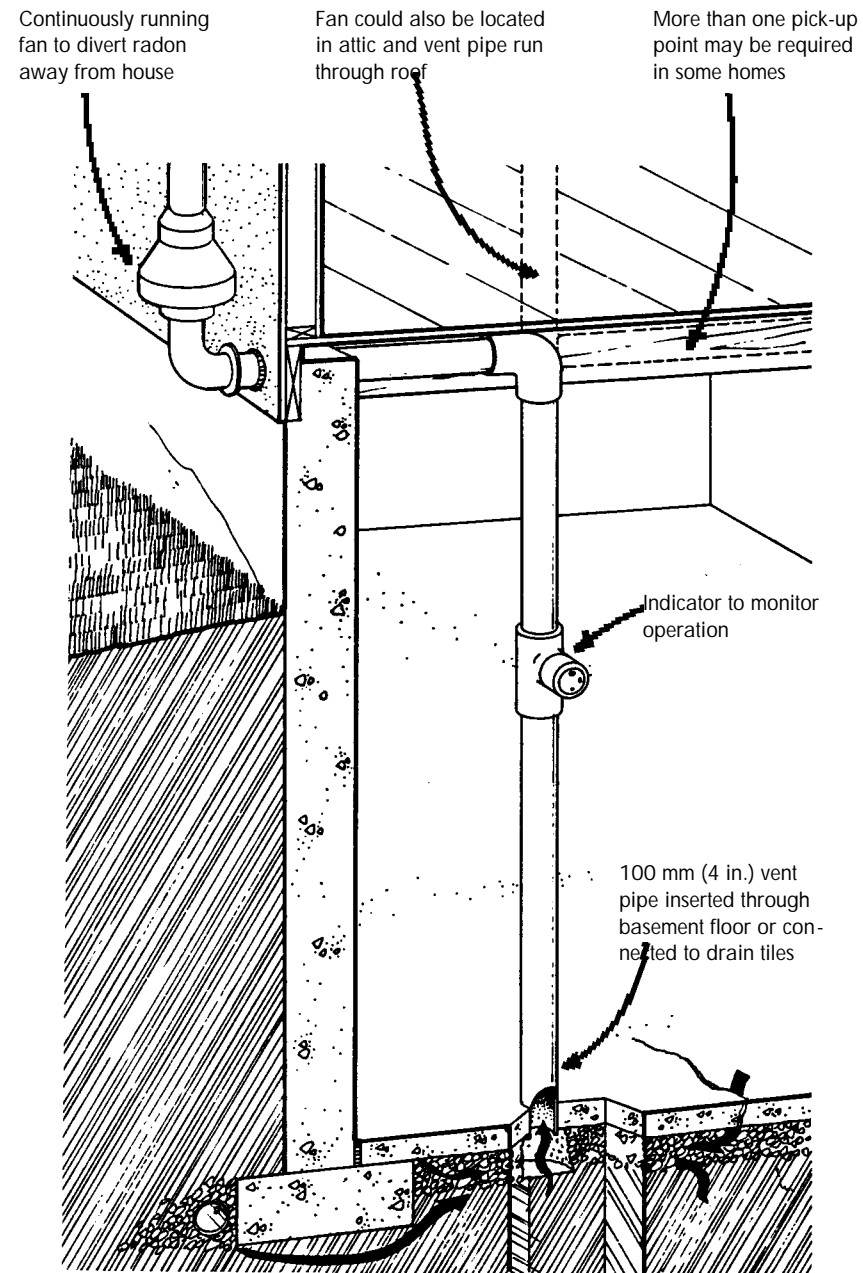


Figure 11: Soil depressurization system

With any active soil depressurization system, it is wise to make sure that operation of the system does not cause backdrafting of combustion appliance (e.g. furnace, boiler, water heater, fireplace, wood stove). Backdrafting occurs when the room in which a combustion appliance is located is depressurized to the extent that combustion products spill into the home instead of venting to the outdoors. Backdraft testing may be done by a trained radon reduction or heating contractor.

The cost of an active (with fan) soil depressurization system range from about \$800 to \$3,000 including material and labour. There is also an operating cost for electricity for the fan and a modest increase in heating and cooling bills due to increased house ventilation.

When large radon reductions (80% or more) are desired, active soil depressurization is almost always the recommended approach. If smaller reductions are sufficient, the remaining options described in this section may be a reasonable alternative.

Seal any Remaining Entry Routes for Radon

OPTION 1 After closing major openings, a further reduction in radon levels
OPTION 2 can sometimes be achieved by sealing remaining entry routes.
OPTION 3
OPTION 4 Minor cracks in foundation walls and floors can be sealed (see **figure 12**). Larger cracks require special techniques – consult your building material supplier or a contractor.

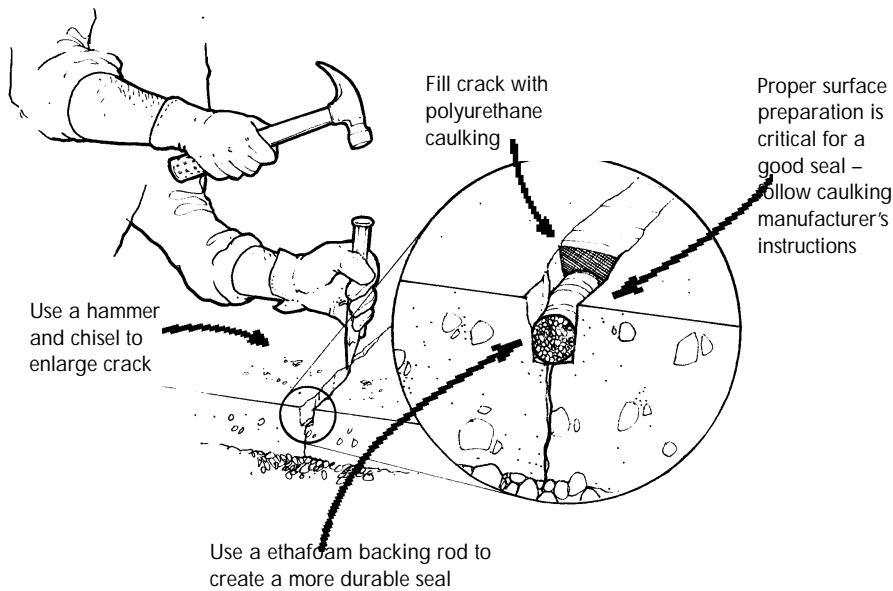


Figure 12: Sealing foundation wall and floor cracks

If accessible, the joint between the foundation wall and basement floor can be sealed (see **figure 13**). The gap around utility penetrations (e.g. water, sewer, electrical, natural gas, fuel oil) in wall and floors can be sealed in a similar manner.

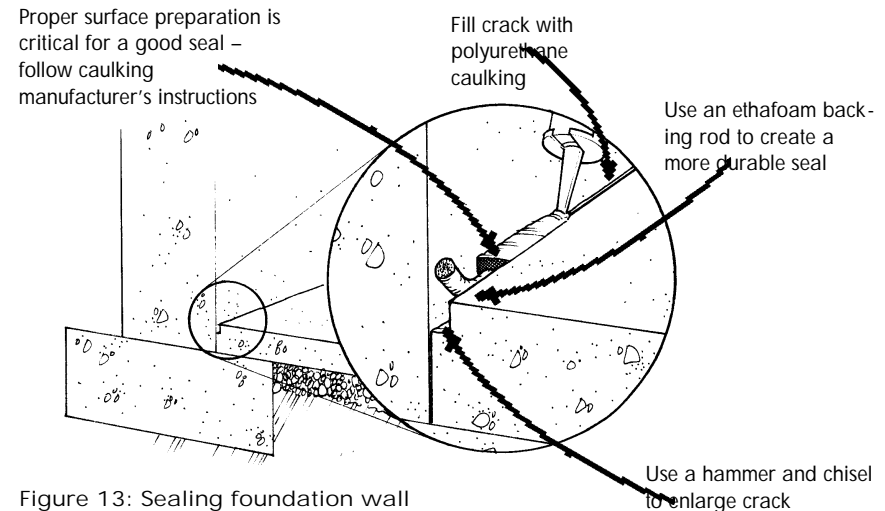


Figure 13: Sealing foundation wall and basement floor joint

Sealing of all entry routes for soil gases such as radon is difficult and challenging. Proper preparation of surfaces to be caulked is extremely important to obtain an effective, long-lasting seal. Entry routes are often numerous – some may be concealed or inaccessible.

Because of these difficulties, when sealing of entry routes is used alone, you should expect only a low to moderate reduction in radon levels. A thorough job of sealing can result in 0% to 50% reduction in radon levels. Sealing will also improve the effectiveness of an active soil depressurization system.

The cost of sealing entry routes is highly variable. It can range from a few hundred dollars to \$2,000 or more. Although the material cost is relatively low, it is very labour-intensive to do a comprehensive job. As the house ages and settles, the seals can deteriorate, and new cracks or entry routes can appear. As a result, there will be an ongoing cost to maintain the seals.

Increase Mechanical Ventilation of the Home

OPTION 1 Rather than relying upon natural air movement to remove radon
OPTION 2 from a home, mechanical ventilation can be used. A system with
OPTION 3 balanced intake and exhaust air flows is essential so that the house
OPTION 4 is not depressurized which may draw in more radon. This can be accomplished by installing a heat recovery ventilator (HRV)(see figure 14).

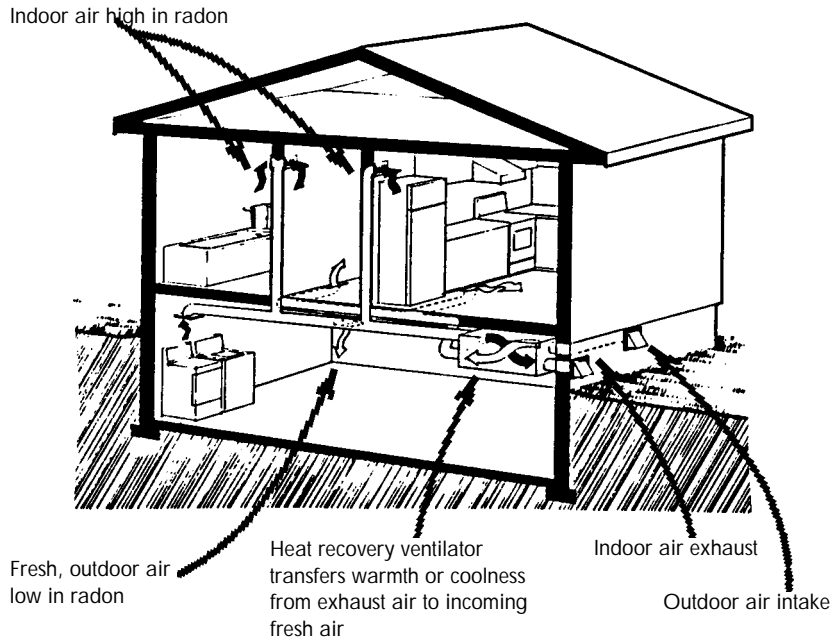


Figure 14: Increasing ventilation with a HRV

Besides supplying balanced ventilation, a HRV will reduce the energy penalty associated with providing more ventilation to a home.

The suitability of an HRV for radon reduction is limited to situations where only modest reductions are needed. In most homes, an HRV might reduce radon levels by 25% to 75%. HRV's are best suited to homes that are relatively airtight and have other indoor air quality problems such as excessive condensation during winter.

An HRV will cost about \$1,500 to \$2,500 (material and labour). There is also an operating cost for electricity for the HRV's fans as well as an increase in heating and cooling costs due to greater ventilation of the home.

Remove Radon from Well Water

OPTION 1 If testing confirms that the radon levels in your well water are
OPTION 2 excessive, there are two techniques available.

OPTION 3 The first method involves either spraying water in a contained air
OPTION 4 space, or introducing air bubbles into the water.

The second method uses granular-activated carbon (GAC) to remove radon from the water. The GAC method has been more widely tested, and is more commonly used in individual homes. Radiation build-up in the GAC unit itself may cause exposure and disposal problems.

For details about radon removal from water, refer to these U.S. Environmental Protection Agency publications (see page 40 for address):

- *Radon Reduction Techniques for Detached Houses – Technical Guidance (Second Edition)*
- *Removal of Radon From Household Water*

Preventative Measures for New Homes

It is very difficult to predict before construction whether a new home will have high radon levels. Fortunately, preventative measures can be taken by your builder during the design and construction process.

Most of these measures are low-cost, desirable for other benefits they provide, and difficult to install after the home is constructed. They include:

- minimizing potential entry routes for radon;
- reducing forces that draw radon into a home; and
- making provision for an active soil depressurization system.

Many elements of these measures are a requirement of the *1995 National Building Code of Canada (NBC)* issued by the National Research Council of Canada. Check with your builder whether your local authority with jurisdiction for building codes has adopted and enforces the NBC's soil gas control requirements. If not, make sure these measures are included in the plans and specifications for your new home.

Minimize Potential Entry Routes for Radon

1 2 3
STEP The entry routes for radon in new construction are similar to those discussed for existing homes (see **page 4**). Methods your builder can use to reduce entry routes in a new home include:

- Minimize cracking of the basement floor slab by:
 - Properly preparing the sub-slab area (i.e. replace unstable soil, large stones, etc.)
 - Using higher strength concrete. For basement floors, concrete with a 28-day minimum compressive strength of 20 Mpa (2900 psi) is recommended.
 - Using additive in the concrete called “plasticizers” to improve the workability of the concrete. If a plasticizer is not used, there is a likelihood that water will be added on-site to produce more workable concrete. Adding water to the concrete will lower its strength and increase its tendency to crack.
 - Providing proper curing conditions. Moistening the slab or coating it with a special compound during curing will result in stronger, more durable concrete. Also if the weather is hot and dry or below freezing, your contractor must take appropriate precautions.

For more information on how to minimize problems with foundations, contact your local CMHC office for the booklet *Concrete Foundations*.

- Use control joints in the concrete floor slab. Since some cracks in the basement slab may be unavoidable, your contractor can direct cracks into controlled locations where they can be sealed with polyurethane caulking (see **figure 15**). Control joints can be created by:
 - casting plastic special “T’s” into the slab; or
 - using a trowel before the concrete has set; or
 - saw cutting the slab within one day of its being poured.

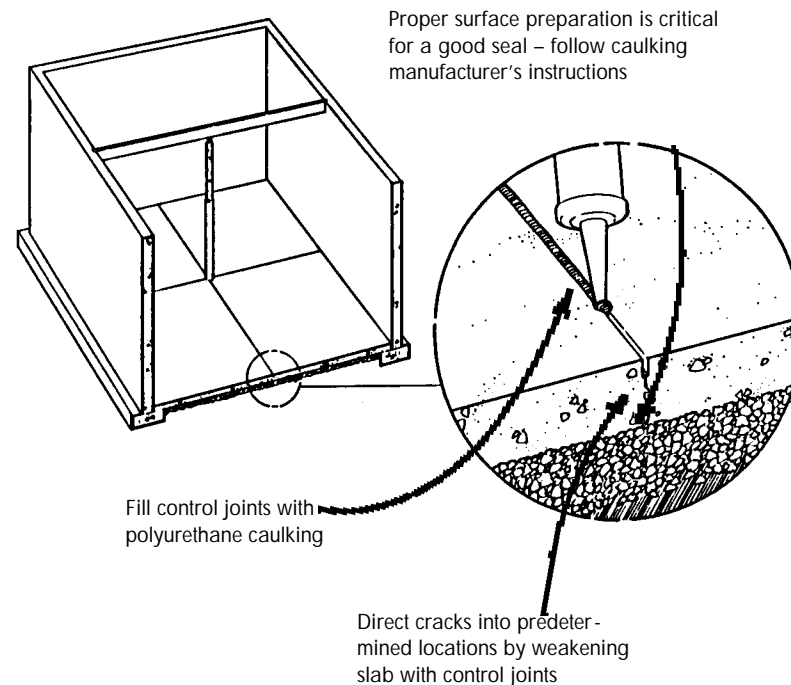


Figure 15: Control joints for new concrete floor slabs

- Seal the basement floor/foundation wall crack. There are several options for sealing this potential radon entry point (see **figure 13, page 19** and **figure 16, page 24**). Note that proper preparation of surfaces to be caulked is critical to obtain an effective, long-lasting seal.

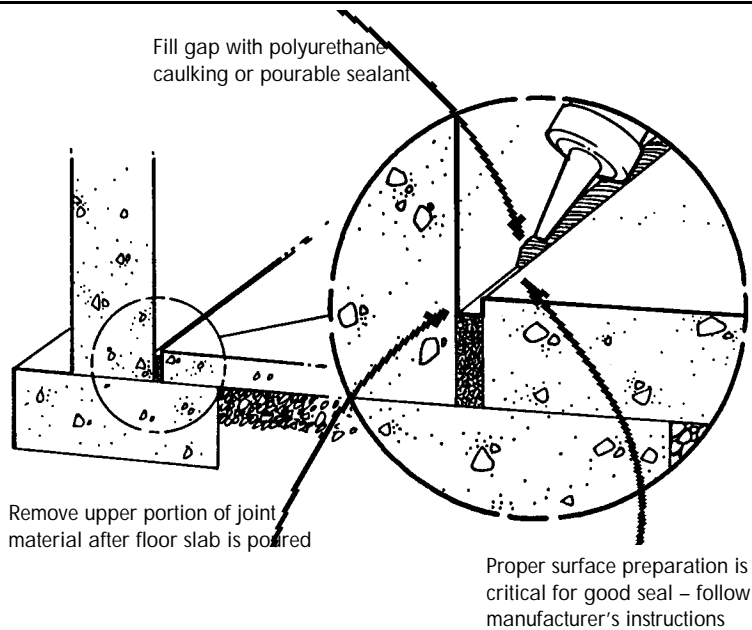


Figure 16: Seal foundation wall and basement floor joint in new construction

- Seal around all penetrations of the foundation walls and basement floors by objects such as utility lines (e.g. water, sewer, electrical, natural gas, fuel oil). The center of hollow objects which penetrate the walls or floors (e.g. metal support posts or masonry for fireplaces) should also be sealed or blocked.
- Install a barrier of at least 0.15 mm (6 mil) polyethylene under the basement floor slab or on top of exposed soil in crawlspaces (see **figure 17, page 25**). Joints in the polyethylene should be overlapped no less than 300 mm (12 in.). In crawlspaces, seal the joints and edges with acoustical sealant. Look for products which are more a more durable alternative to regular polyethylene such as cross-laminated polyethylene.

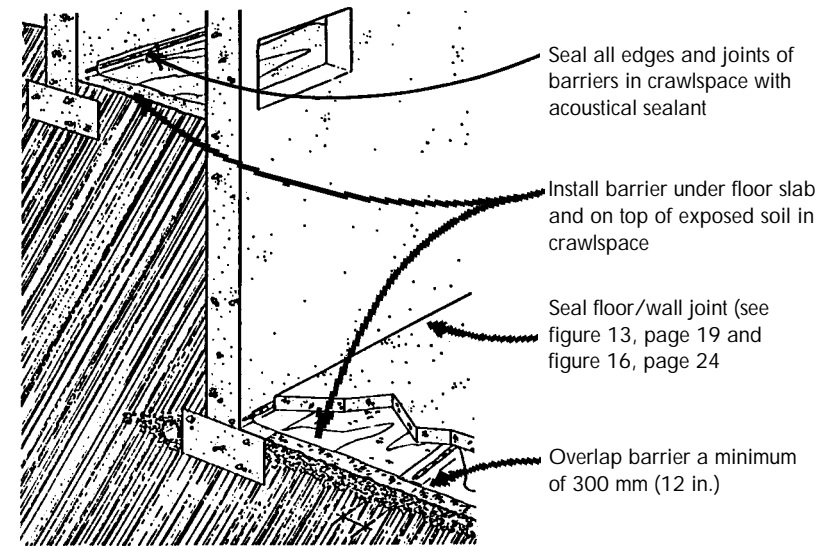


Figure 17: Polyethylene barrier for crawlspaces and basement floor slabs

- **Install special traps in floor drains that allow water to drain but prevent radon from entering the basement (see **figure 18**).** These traps have the added benefit of keeping out moulds, odours, insects and cold drafts. However, they are not a substitute for a sewer back-up valve.

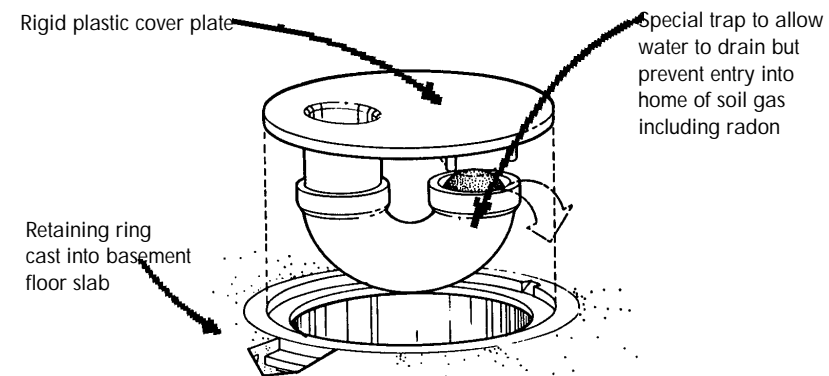


Figure 18: Trap for new floor drains

- Use a sealed lid on the sump. Your builder may either purchase a sealed unit or field fabricate a sealed lid (refer to **figure 8, page 14**). A sealed lid keeps out radon as well as moulds, odours, insects and cold drafts. It also reduces the risk of injury to small children.

- Use a solid course of masonry units at the top and bottom of concrete block foundation walls (see **figure 19**). If regular concrete blocks with voids are used instead, a major entry route for radon may be created.

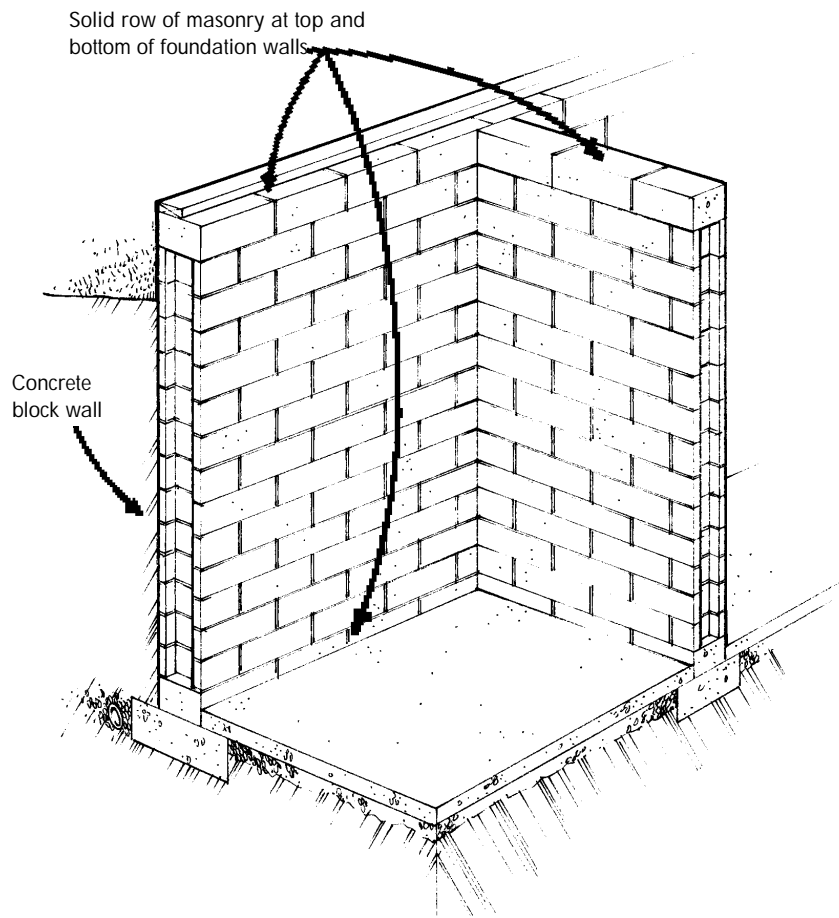


Figure 19: Eliminating voids at the top and bottom of new concrete block foundation walls

Reduce Forces That Draw Radon into a Home

1 2 3
STEP Reducing the pressure difference between the home and soil may reduce the amount of radon drawn indoors. Options include:

- Install an insulated duct to provide outdoor air to a gas or oil furnace, boiler or water heater (see **figure 20**). To reduce heating costs and avoid comfort problems, equip this combustion-air duct with an approved automatic damper or diffuser which activates only when the furnace, boiler or water heater turns on.
- If the home will have a forced-air heating system, install an insulated duct from the outdoors to the main return-air duct (see **figure 20**). This fresh-air duct will partially offset the air lost from exhaust fans vented to the outdoors such as the kitchen fan, bathroom fan, clothes dryer or central vacuum system.

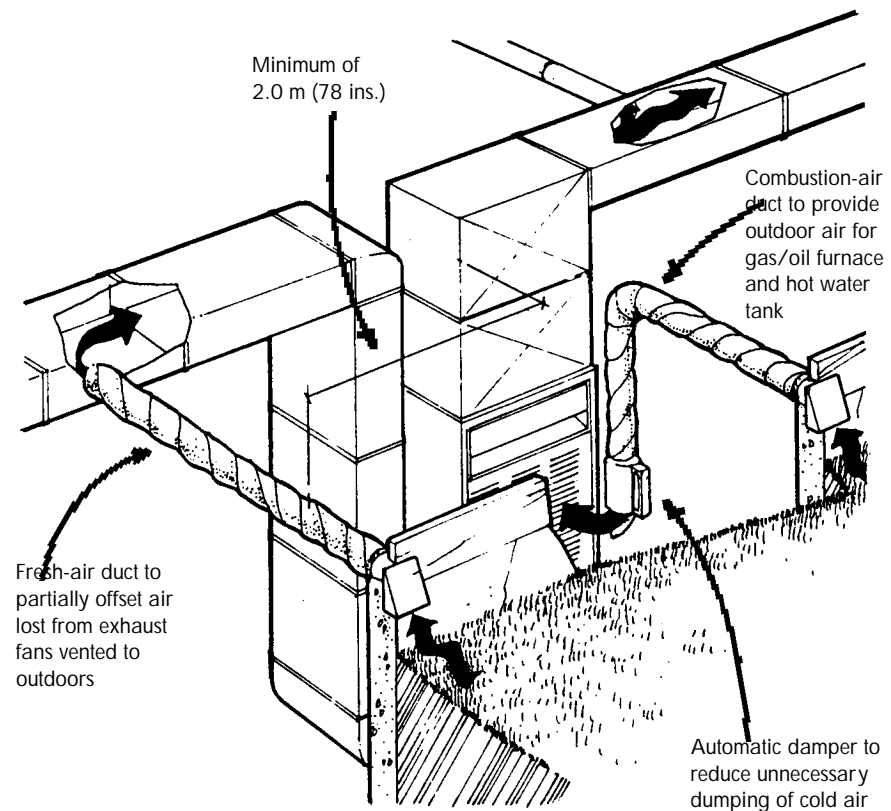


Figure 20: Reducing pressure differences with fresh-air and combustion-air ducts

- Choose a direct-vent gas or oil furnace, boiler or water heater rather than a conventionally-vented unit. Besides reducing the negative pressure in a home, direct-vent combustion appliances reduce energy costs and are less prone to spill combustion products into the home.
- If a wood or gas fireplace is to be installed, choose one that is equipped with glass doors that fit tightly and has a supply of outdoor air for combustion.
- Install a balanced ventilation system such as a heat recovery ventilator (HRV). A balanced system relies on both supply and exhaust fans to provide ventilation (see **figure 14, page 20**). An HRV will reduce the energy penalty associated with providing more ventilation to a home.
- Avoid installing ducts for a forced-air heating or ventilation system in the basement floor slab. If a crack develops in the slab between the soil and ductwork, radon could be drawn into the home.
- Pay extra attention to ensure that the air-vapour barrier (especially in the attic) is well-sealed. This will reduce the effects of weather which can depressurize the home. A well-sealed air-vapor barrier will also reduce heating costs and minimize hidden moisture damage to the structure of the home.

Make Provisions for Active Soil Depressurization

1 2 3
STEP The radon prevention methods listed in this section may not always be sufficient to achieve low annual average radon levels - 150 Bq/m³ (4 pCi/L) or less. As a result, consider making provisions for an active soil depressurization system (refer to **page 16**). It is more practical and less expensive to install the following components of a active soil depressurization system during, rather than after, construction of your new home.

- Before pouring a slab, ensure that the entire sub-slab area is filled with a layer of clean, coarse gravel at least 100 mm (4 in.) thick.
- A short length of PVC pipe of at least 100 mm (4 in.) diameter should be cast into the floor slab (see **figure 21, page 29**). The pipe should be capped and labelled so that it is not left open. To aid in completing the system after construction, run another section of pipe from the basement to 450 mm (18 in.) above the ceiling line in the attic. This pipe should be capped at both ends.

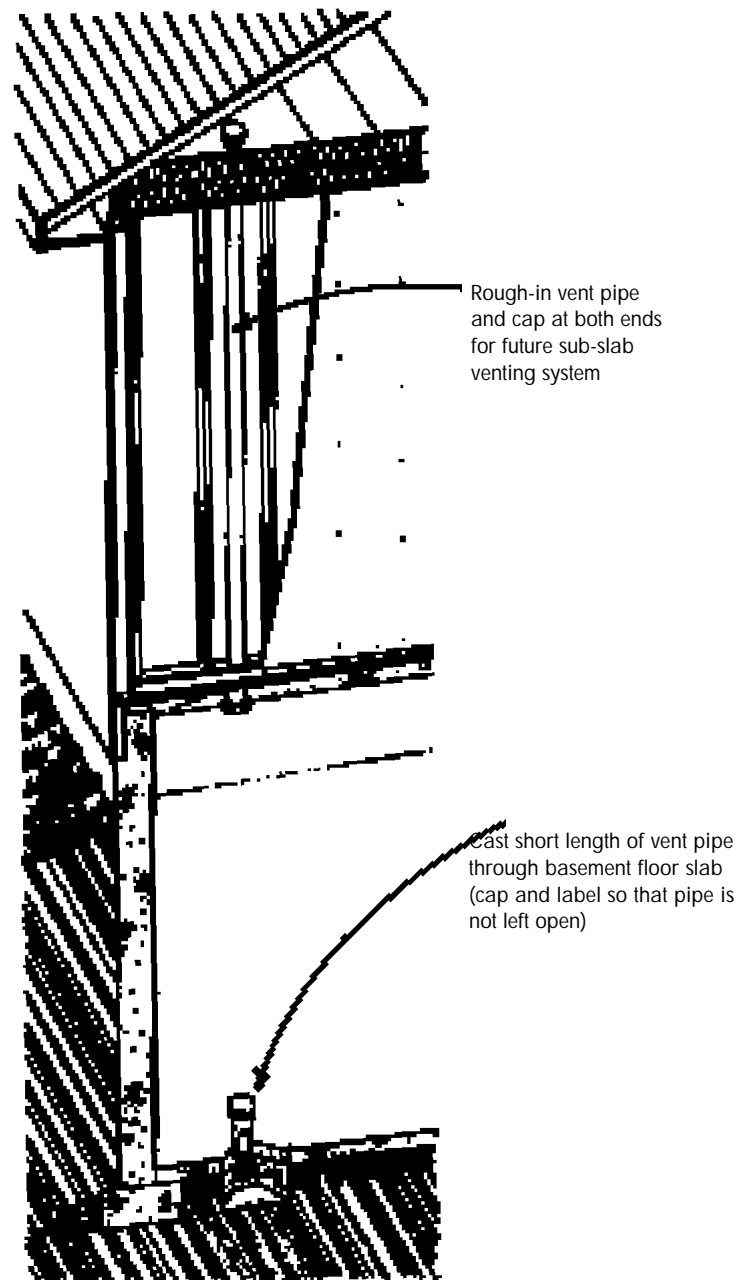


Figure 21: Making provisions for active soil depressurization

-
- Install an electrical outlet in the attic. Locate this outlet near the vent pipe so that an exhaust fan can be easily installed.
 - After the home is completed and occupied, measure the radon levels. If the levels exceed the guidelines given in this booklet, uncap the pipes, add the missing section of pipe, and install an exhaust fan. The fan should be designed for continuous operation in high humidity environments – in-line fans suitable for radon reduction systems are available from heating, ventilation and air-conditioning wholesalers. This system will ventilate the sub-slab area and should result in significant reduction of the radon levels. Retesting to confirm this is recommended (see “Follow-up Measurements” on page 33).

It is important to locate the fan outside the living space. If the pressurized portion of the system downstream of the fan passes through the living space, a leak in the system could spill soil gas with high radon concentrations into the living space.

An alarm to warn the occupants if the airflow in the system is restricted or blocked is a wise addition. Also, parts of the system which runs through unheated attic space may have to be insulated to reduce condensation and blockage by frost or the build-up of ice.

DEALING WITH CONTRACTORS

Finding a Contractor

Many of the techniques used to reduce radon on a long-term basis require the services of a professional contractor. Radon is a relatively new issue. There are not many contractors in most regions of Canada with experience in radon reduction methods.

To find a contractor, ask the company which supplied your radon detector for recommendations. Also ask for recommendations from friends, relatives and neighbours who have recently had work done to their homes.

Try to compile a list of at least 2 or 3 contractors and then make inquiries about their reputation. Contact your local Better Business Bureau (BBB). Note that not all contractors are members of the BBB and that membership itself does not necessarily guarantee high quality work. If the contractor is a member, the BBB will advise you of the contractor’s “Business Performance Record” according to its record.

Finally, inquire whether the contractor or his staff have received any special training on radon and radon reduction techniques.

For further information on how to deal with a contractor, or to ensure that a company is properly licensed, contact your provincial or territorial authority for consumer issues.

What the Estimate Should Say

Once you have selected two or three contractors, have them visit your home and review the results of your radon tests. Ask the contractor for a detailed, written proposal on what they suggest to reduce the radon levels in your home.

Before giving you an estimate, a good contractor will give the area to be worked on a thorough examination. Accompany them on the tour. Watch for the contractor’s attention to detail and do not be afraid to ask questions related to the material and installation procedures. Consider the following when evaluating the contractor:

- How many homes has the contractor worked on to reduce radon levels? Were any of the homes similar to yours? What were the radon levels before and after their work? Were the reductions in radon levels measured independently?

-
- Can the contractor supply referrals? This may be difficult because most homeowners consider the radon reductions work done by the contractor for them to be confidential. However, a contractor who has done work on a large number of houses should have a few clients willing to act as referrals.
 - Is the contractor able to clearly explain the proposed work? If the contractor's proposal differs from the recommendations given in this booklet, are the reasons given clear? Does the proposed design include features that would warn you if the reduction system were to malfunction?

Important information that should appear in the contractor's written estimate includes:

- the name, address and telephone number of the contractor;
- the cost and details of material (including quantity, size, capacity, brand name, style, colour, etc.);
- the cost of labour;
- the total cost of job including all applicable taxes and permit fees;
- the estimated starting date and completion date for the work;
- a statement that liability insurance and applicable worker's compensation coverage is carried by the contractor to protect you in the event of injury to persons or damage to property while the work is being carried out;
- responsibility placed on the contractor for patching holes, clean-up after the job and incidental damage;
- details of warranties or guarantees; and
- a description of what the homeowner is expected to do (e.g. make the work area accessible).

When evaluating proposals from contractors, the lowest estimate may not be your best choice. Make sure that the various bids cover the same work. If the proposed work differs, ask the contractors to explain why.

An unusually low bid may simply mean that the contractor has made a mistake or does not know enough about the work to estimate properly. In these cases, the contractor may cut corners or add unjustified extras to the bill to avoid losing money. In extreme cases, the contractor may simply abandon the job.

Signing the Contract

The next step is to ask the contractor you have chosen to prepare a contract based on their proposal.

Do not sign the contract until you have read it carefully. Never sign an incomplete contract. Check all standard terms and conditions – read the fine print. Make sure everything in the contract matches the original proposal.

In some provinces or territories, you may be able to change your mind and cancel a contract within a specified time limit if you signed an agreement with a door-to-door salesperson. For information about your cancellation rights and responsibilities, contact your provincial or territorial authority for consumer issues.

Follow-up Measurements

After taking action to reduce radon levels, it is recommended that a short-term measurement be made to give an initial indication of the success of the work. Refer to **page 7** for advice on measurement methods. If this initial short-term measurement indicates adequate reductions, then it should be followed by a long-term measurement of at least 3 months (preferably during the heating season) to evaluate to what degree the reductions are sustained.

When doing follow-up measurements, deal with a testing company that has no affiliation with the contractor who performed the radon reduction work. This eliminates a potential conflict of interest and will give you more confidence in the test results.

After these initial measurements are completed, consider making further long-term measurements on a regular basis. This will enable you to monitor whether the performance of the radon reduction work is maintained over the years.

QUESTIONS AND ANSWERS

The following are frequently asked questions about radon and their answers:

- Q. We occasionally notice an unusual smell in our basement. Could it be due to radon?
- A. **No. Radon has no odour.**
- Q. Food items that we have stored in the basement have spoiled. Is radon the cause?
- A. **No. Radon is chemically inert and cannot react with things and spoil them.**
- Q. Shortly after moving into our home, several members of our family developed persistent coughs. Could radon be the reason?
- A. **No. Exposure to radon is not associated with persistent coughs.**
- Q. I have recently developed headaches which my doctor cannot explain. Could radon be the cause?
- A. **No. The only known health effect from radon is an increased risk of developing lung cancer.**
- Q. Should I be concerned about radon in my children's school or my workplace?
- A. **There has been only limited testing for radon in schools and workplaces in most regions of Canada. Preliminary studies suggest that schools and large public buildings usually have lower radon levels than homes in the same community. However, the only sure way to know whether a school or workplace has elevated radon levels is to test.**
- Q. Is radon more of a problem in older or newer homes?
- A. **The age of a home has not been found to be a reliable indicator of whether it will have high radon levels.**

- Q. My neighbour's house was tested and had high radon levels. Does this mean that the radon levels in my home will also be high?
- A. **Not necessarily. Radon levels can vary significantly even in similar homes that are built close to one another. You should test your home to be sure of its radon level.**
- Q. My house has high radon levels. Can it be fixed? How much will it cost?
- A. **Virtually all homes can have their radon levels significantly lowered. Although costs can vary considerably, experience has shown that reducing radon in most homes can cost from a few hundred dollars to about three thousand dollars.**
- Q. I intend to purchase (or sell) a house, what are my options regarding radon testing?
- A. **Your choices include:**
- **Disregard or ignore any potential problem.**
 - **When listing the home for sale, the seller could indicate to their broker whether the home has been tested for radon and, if it has, what the test results were.**
 - **The purchaser could make their offer conditional on testing by an approved contractor to indicate whether the radon levels are acceptable (the purchaser would pay for the testing). If the levels are too high, the offer becomes null and void.**
 - **The purchaser could make an offer that includes a hold-back of a specified amount of money pending test results. If the test results are above an acceptable level, the hold-back can be used to compensate the purchaser for expenses to reduce the radon levels.**
 - **The purchaser could make an offer lower than would be normal because of high test results.**
- Each of the above approaches has potential advantages and disadvantages. Consult your realtor and lawyer for specific advice.**

Q. I am going to build a new home. Can the soil be tested for radon before construction?

A. The radon concentration in the soil can be measured. Unfortunately, these tests can be expensive and with present technology are not a reliable predictor of what the radon levels will be in a new house.

Q. Should I test our water supply for radon?

A. You should always test the air in your home first. If the radon levels are high and you use water from a well, a radon test of the water may be worthwhile.

WHERE TO GET MORE INFORMATION

Provincial and Territorial Radon Contacts

For information about radon in your region, contact your provincial or territorial government listed below:

British Columbia

Radiation Protection and Tobacco Enforcement Branch
British Columbia Ministry of Health
Suite 210, 4940 Canada Way
Burnaby, BC V5G 4K6
(604)660-6633

Alberta

Occupational Health and Safety Services
Alberta Labour
902-10808 99th Avenue
Edmonton, AB T5K 0G5
(403)427-2691 (in Calgary, call 297-2188)

Saskatchewan

Radiation Safety Unit
Occupational Health and Safety Division
Saskatchewan Labour
1870 Albert Street
Regina, SK S4P 3V7
(306)787-4538 (in Saskatoon, call 933-7775)

Manitoba

Manitoba Health
800 Portage Avenue
Winnipeg, MB R3G 0N4
(204)945-6190

Ontario

Call your local Medical Officer of Health

Quebec

CLSC (Centre local de services communitaires)

or:

Ministere de l'environnement et de la faune du Quebec

5199 est, rue Sherbrooke

Suite 4800

Montreal, QC H1T 3X3

(514)873-1978/873-4133

New Brunswick

Radiation Protection Services

Department of Health and Community Services

P.O. Box 5100

Fredericton, NB E3B 5G8

(506)453-2360

Nova Scotia

Senior Radiation Health Officer

Nova Scotia Department of the Environment

P.O. Box 2017

Halifax, NS B3J 3B7

(902)424-4077

Prince Edward Island

Department of Health and Social Services

Division of Environmental Health

P.O. Box 2000

Charlottetown, PE C1A7N8

(902)368-4970

Newfoundland and Labrador

Medical and Hygiene Services

Department of Labour

Government of Newfoundland and Labrador

Confederation Building

St. John's, NF A1C 5T7

(709)576-2644

Yukon

Yukon Housing Corporation

710A Jarvis Street

Whitehorse, YT Y1A 2H5

(403)667-5868

Northwest Territories

Department of Health and Social Services

Government of the Northwest Territories

P.O. Box 1320

Yellowknife, NT X1A 2L9

(403)873-7709

Federal Radon Contacts

For further information about issues discussed in this booklet, contact:

Canada Mortgage and Housing Corporation

Canadian Housing Information Centre

700 Montreal Road

Ottawa, ON K1A0P7

(613)748-2367

If you have questions about *The Canadian Guideline for Radon in Homes*, contact:

Health Canada

Radiation Protection Branch

Postal Locator: 6302D1

775 Brookfield Road

Ottawa, ON K1A1C1

(613)954-6671

Further Sources of Information

CAIRS is a nongovernmental agency providing radiation safety programs and offering radon testing services:

CAIRS – Canadian Institute for Radiation Safety
1106–555 Richmond St. W.
Toronto, ON M5V 3B1
(416)504–6565 or 1–800–263–5803
e-mail: cairs.info@cairs.ca

or:

CAIRS National Laboratories
102–110 Research Drive
Saskatoon, SK S7N 3R3
(306)975–0566

The Environmental Protection Agency (EPA) is an agency of the United States Federal Government. For a list of radon-related EPA publications, contact:

ORD Publications Office
Center for Environmental Research Information
U.S. Environmental Protection Agency
26 West Martin Luther King Drive
Cincinnati, OH 45268–1072

NOTE – The opinions of CAIRS and the EPA may vary from the recommendations in this booklet

This illustrated booklet is for you if you are concerned about radon gas in your home. It describes the health effects of radon, how to detect it and ways to reduce exposure to radon in your home.

Visit us on the Internet:
www.cmhc-schl.gc.ca



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