The National Radon Program – a Continuing Success Story in Canada

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ABSTRACT: Based on the latest scientific information and following a broad public consultation, the Canadian radon guideline was lowered from 800 to 200 Bq/m^3 in 2007. The revised guideline provides advice that is more broadly applicable and more protective than the previous guideline. To support the implementation of the revised guideline, a National Radon Program was developed. The National Radon Program consists of 5 components: 1) establishment of a national radon laboratory as a centre of excellence for radon testing 2) radon testing projects to increase the understanding of radon levels across Canada, 3) development and maintenance of a radon database and a framework methodology for mapping radon potential in Canada, 4) radon research and 5) the development and implementation of a radon education and public awareness strategy to inform Canadians on the risks associated with long-term exposure to elevated levels of radon. Significant progress has been made in all areas of the National Radon Program since its inception in 2007. Details of the National Radon Program's successes and major achievements over the past five years, ongoing activities and new challenges are highlighted and discussed in this paper.

Key words: radon, radon-222.

INTRODUCTION

Recent scientific studies have conclusively linked an increased risk of developing lung cancer to levels of radon found in homes. These studies prompted the Canadian federal government to collaborate with provincial and territorial governments to review the Canadian radon guideline. Based on the latest scientific information and following a broad public consultation, the guideline was lowered from 800 to 200 Bq/m^3 in June 2007. The revised guideline provides advice that is more broadly applicable and more protective than the previous guideline. In addition to residential homes, the guideline also applies to public buildings with a high occupancy rate by members of the public. Efforts are being made to harmonize workplace exposure limits with this guideline as well. A recommendation for techniques to be employed in new construction to minimize radon entry and to facilitate post-construction radon reduction, should this subsequently prove necessary, has also been made an integral component of Canada's revised guideline.

To support the implementation of the revised guideline, a National Radon Program was developed in collaboration with the Federal Provincial Territorial Radiation Protection Committee (FPTRPC), an intergovernmental Committee established to advance the development and harmonization of practices and standards for radiation protection within federal, provincial and territorial jurisdictions of Canada. The National Radon Program (NRP) consists of 5 components: 1) establishment of a national radon laboratory as a centre of excellence for radon testing, 2) radon testing projects to increase the understanding of radon levels across Canada, 3) development and maintenance of a radon database and framework methodology for mapping radon potential in Canada, 4) radon research and 5) the development and implementation of a radon education and public awareness strategy to inform Canadians on the risks associated with long-term exposure to elevated levels of radon. Significant progress has been made in all areas of the NRP since its inception in 2007. As a relatively new national program still in the early stages of implementation, the Canadian NRP has benefited from lessons learned from other programs implemented internationally. While this has significantly aided the Canadian NRP, challenges have still been encountered. Details of the successes and major achievements accomplished over the past five years, ongoing activities and new challenges are highlighted and discussed in the following pages.

ACHIEVEMENTS AND ACTIVITIES

A key Program achievement was the lowering of the Canadian radon guideline for indoor air from 800 to 200 Bq/m^3, officially announced in 2007. The revised guideline includes the following guidance:

> Remedial measures should be undertaken in a dwelling whenever the average annual radon concentration exceeds 200 Bq/m^3 in the normal occupancy area. Dwelling is defined as a personal residence or a public building with a high occupancy rate by members of the public such as schools, hospitals, long-term care residences, and correctional facilities. Normal occupancy area refers to any part of the dwelling where a person is likely to spend greater than four hours per day.
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> The higher the radon concentration, the sooner remedial measures should be undertaken. Health Canada recommends the following timeframes for remediation: for a radon level between 200 and 600 Bq/m^3 remediate within 2 years, for a radon level of 600 Bq/m^3 or above remediate within 12 months.
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> When remedial action is taken, the radon level should be reduced to a value as low as practicable. As low as practicable refers to what can be achieved with conventional radon reduction methods in a cost-effective manner.
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> The construction of new dwellings should employ techniques that will minimize radon entry and will facilitate post-construction radon removal, should this prove necessary in the future.

The revised radon guideline was based on recent scientific evidence of a health-based risk associated with radon exposure at residential levels. The relative risk for developing lung cancer for a non-smoker is doubled for a lifetime exposure at 200 Bq/m^3. This was thought to represent a risk level at which non-smokers would be willing to take remedial action. Current research indicates that as the radon concentration decreases from 800 to 200 Bq/m^3, the number of lives saved steadily increases. It is not clear that there would be any further increase in benefit below 200 Bq/m^3, as the radon contribution to total dose begins to merge with that from the overall radiation background. The new Canadian radon guideline provides a balance between risks regarded as too high to ignore and a practical value.

Canada's National Radon Laboratory (NRL) was established at the Radiation Protection Bureau, Health Canada, shortly after the revised guideline was announced in 2007. The NRL serves as a centre of excellence and expertise for radon measurement in Canada. To better serve the Canadian radon stakeholders, such as other levels of government, industry and the public, the

NRL developed radon guidance documents for measurement and mitigation. Two measurement guidance documents were developed in 2008, one for homes and one for public buildings. Both are available on the Health Canada website. The purpose of these documents is to provide protocols and guidance for radon testing and the evaluation of the levels measured in order to determine whether remedial action is required. The scope of these documents is limited to guidance regarding types of measurement devices, device placement, measurement duration, and the interpretation of measurement results. In 2010 Health Canada worked with experts in the field of radon mitigation to develop a radon mitigation guide entitled *Reducing Radon Levels in Existing Homes: A Canadian Guide for Professional Contractors*. A summary of the guide is currently available on the Health Canada website.

The Canadian Commission on Building and Fire Codes (CCBFC) is responsible for the development of Canada's national model codes. The Canadian National Building Code (NBC) sets out technical provisions for the design and construction of new buildings and is subject to revision every 5 years. The Commission is aided in its work by various standing committees that have responsibility for and provide expertise in a number of areas. The standing committees for the codes are open to suggested code changes from any source, making this a natural avenue for suggesting changes related to the prevention of radon ingress in new home construction. In 2009, following a proposal by Health Canada for such changes, the Canadian Commission on Building and Fire Codes (CCBFC) approved a request from two standing committees to strike a joint task group, consisting of members representing affected stakeholder groups. Following a thorough review the task group recommended that all new homes in Canada be built with an aggregate layer and a sealed vapor barrier under the slab to reduce potential radon and soil gas entry, as well as a rough-in for a radon reduction system consisting of a capped pipe set through the slab to make the home ready for active sub-slab depressurization if required. These recommendations were subsequently approved and became part of the 2010 Canadian National Building Code released in November 2010. Responsibility for the design and construction of new homes and buildings, as well as the adoption and enforcement of the Code, lies with the provinces and territories. The NBC is widely used as the basis for most municipal bylaws and provincial building codes and has been drafted such that it can easily be adopted or enacted for legal use by any jurisdictional authority in Canada. In fact, many provincial/territorial governments simply adopt all the changes to the NBC. At the time this paper was written all but two of the provinces and territories had, or indicated intention to, adopt the codes for protection against radon ingress. With the implementation of the revised NBC, Canadians buying homes built to the 2010 Code provisions will face less risk from radon exposure.

With increasing public awareness of the risks from radon exposure and information encouraging radon testing and remediation, a need was created for the availability of radon measurement and mitigation services and products in Canada, as well as standards or a means by which to ensure the competencies of providers of these services to the public. As a result, the NRP included, as a component of the NRL function, the development of a Canadian certification program for radon measurement and mitigation professionals, as well as laboratories.

Soon after the announcement of the revised guideline the Radiation Protection Bureau of Health Canada began discussions with the U.S. National Environmental Health Association National Radon Proficiency Program (NEHA-NRPP) to expand their current radon proficiency programs to include a Canadian component. NEHA currently offers examinations and professional certification for radon service providers in the United States and have done so for well over a decade. NEHA-NRPP offered to develop a Canadian certification program based on their existing U.S. program and incorporating current Canadian guidance. Over the last two years Health Canada's Radiation Protection Bureau has worked with NEHA-NRPP, as well as the American Association of Radon Scientists and Technologists (AARST), to perform a detailed review of the existing U.S. program and to determine what changes and additions were needed to create a Canadian course curriculum and qualifying examinations for radon measurement and mitigation professionals.

The Canadian certification program is expected to be launched in the spring of 2012. Canadian specific exams for measurement and mitigation service providers have been developed in collaboration with NEHA-NRPP that address the primary differences between the Canadian and American radon industries including long term testing in Canada versus the short term testing in the United States, the use of metric units in Canada, the provision for both near ground side discharge and roof line discharge for active sub-slab depressurization mitigation systems in Canada, and the availability of the exams and other certification program documentation in both official languages of Canada (French and English). Like the U.S. program, the Canadian-specific certification program criteria for approving new testing devices, calibration requirements for equipment, proficiency testing for service providers, and required training and overall quality assurance requirements for laboratories and service providers. However, the Canadian certification program has more stringent quality assurance requirements than its American counterpart, including a requirement for provision of quality assurance plans and quality control data to NEHA-NRPP.

In the fall of 2007 Health Canada began a federal building testing project which is scheduled to continue through to March 2013. The purpose of this testing project is to identify federal workplaces with radon levels above the Canadian radon guideline of 200 Bq/m^3. This will allow federal employers to address the need for remediation, should it be necessary, and thereby allowing them to ensure they meet the requirements under the Canadian Occupational Health and Safety Regulations of the Canada Labour Code. Under this initiative the NRL provides the radon detectors and instructions, covers costs of shipping the detectors as necessary, and provides the analyses and results; each individual department is responsible for deploying detectors in the buildings. All radon tests are conducted using long-term (3-month) radon detectors. Communication materials were developed for dissemination to employees explaining the risk of exposure to radon, the purpose of the testing, types of detectors, and the testing procedure to be used. Health Canada disseminated the information related to this initiative to senior managers, as well as building occupational health and safety committees and/or facility or property managers and requested the assistance of departments. The goal is to test approximately 10,000 federal buildings by the end of this project. As of December 2011 approximately 8000 buildings had been tested. The results of this project to date indicate that approximately 5% of buildings have average radon levels above the radon guideline of 200 Bq/m^3.

In the late 1970s, Health Canada carried out a cross-country residential radon survey in 19 cities using a grab sampling technique[(10)]. The observed radon concentration in Canadian homes followed a log-normal distribution with a geometric mean of 11.2 Bq/m^3 and a geometric standard deviation of 3.9. Only about 3% of the 14,000 Canadian homes tested showed radon concentrations in excess of 200 Bq/m^3. Based on this radon distribution, the theoretical estimates indicated about 10% of lung cancers in Canada resulted from indoor radon exposure[(11)].

To gain a better understanding of radon concentrations in homes across the country a national residential radon survey was launched in April 2009. The purpose of the project entitled, *Cross-Canada Survey of Radon Concentrations in Homes*, was to gather long-term (3-month or longer) indoor radon measurements from across Canada in order to obtain a more accurate estimate of the proportion of the Canadian population living in homes with radon gas levels above the guideline of 200 Bq/m^3, and to identify previously unknown areas where radon gas exposure may constitute a health risk.

The survey was designed to recruit 18,000 participants across Canada over two years, 9000 being recruited each summer with measurements to be made in the 2009-10 and 2010-11 fall/winter (October to March) periods. Participants were recruited over the telephone by a contracted market research firm. Once they agreed to participate, recruits were then mailed a radon detector test kit and asked to deploy the detector in the lowest lived-in level of the home where someone spends at least 4 hours a day. In order for results to be indicative of annual radon exposure, the test needed to be conducted for a period of at least three months. After the detectors were analyzed, the NRL issued a letter of test result to each participant. Participants whose results were above the radon guideline of 200 Bq/m^3, also received a copy of the joint Health Canada/Canada Mortgage and Housing Corporation (CMHC) publication entitled *Radon : A Guide for Canadian Homeowners*. The guide provides information about radon and in addition, describes how to reduce radon levels in the home.

In this two year survey, the long-term radon measurements were completed in a total of 13,807 homes. The observed radon concentration in Canadian homes follows a log-normal distribution with a population weighted geometric mean of 41.9 Bq/m^3 and a geometric standard deviation of 2.8. Results have also shown that approximately 7% of Canadian homes can be expected to be above the Canadian radon guideline, considerably higher than originally thought based on the survey conducted in the late 1970s. The new data supports previous findings of high radon levels in homes in the provinces of Manitoba and Saskatchewan, but it has also provided information showing elevated levels in areas previously unknown, such as the province of New Brunswick.

Based on the more accurate radon distribution characteristics obtained from the recent cross-Canada radon survey, a reassessment of Canadian population risk for radon induced lung cancer was undertaken. The theoretical estimates show that 16% of lung cancer deaths among Canadians are attributable to indoor radon exposure[(12)]. The results strongly suggest the ongoing need for the National Radon Program, and in particular, the need to focus on education and awareness at all levels of government and in partnership with key stakeholders, to encourage Canadians to take action to reduce their risk from indoor radon exposure.

In 2008, following the revision to the Canadian radon guideline, a national radon education and awareness (E&A) program officially began. The E&A program is focused on raising awareness of radon, the potential health risks from exposure and encouraging Canadians to test their homes and to reduce radon levels, if necessary.

The development of a national radon outreach program requires the effective use of risk communication principles. Achieving effective communication with the public depends on four things: the message, the messenger, the audience and the context. Because radon is naturally occurring, invisible and does not have immediate health effects, it is often perceived as a low risk despite the fact that it is one of the most significant environmental health hazards. The communication of radon risk and prevention poses serious challenges because it is not widely known and is not perceived as a health risk by the public. Baseline public opinion research in Canada from 2007 indicated that while 52% of those surveyed said they had heard of radon, only 17% knew it was radioactive and 5% or fewer could indicate any other single fact about radon.

Health Canada recognized early on that certain critical success factors needed to be established to ensure the radon E&A program was effective, including:

- Development of simple, clear and action oriented key messages
- Engagement and partnership with key stakeholders that consist of multiple highly respected organizations that can deliver radon messages through established channels to targeted audiences
- Availability of radon measurement and remediation products and services to enable Canadians to take action in response to the outreach program
- Continued review and evaluation of the program to maximize results and enable the development of new and effective outreach efforts

To achieve these critical success factors the early stages of the radon E&A program were focused on developing key messages and incorporating them into outreach and communication materials such as brochures, factsheets and on-line information. At the same time Health Canada actively engaged with stakeholders, including but not limited to: federal, provincial and territorial government organizations; non-governmental organizations such as the Canadian Lung Association and the Canadian Cancer Society; industry and academic associations such as the Canadian Medical Association, Canadian Home Builders Association and Canadian Radiation Protection Association; and international stakeholders such as the United States Environmental Protection Agency and AARST. Initial engagement with stakeholders was focused on informing them of the NRP and responding to their questions or comments about the Program and how they may be impacted or could get involved.

Along with the development and distribution of radon resources and materials, Health Canada made stakeholder engagement and partnership development a priority with the objective of increasing both the reach and credibility of the radon key messages. These efforts have paid off tremendously both at the national and provincial and community level. Many stakeholder partners now regularly incorporate radon awareness products and outreach activities into their programs. A large majority of stakeholders have added links to the Health Canada radon web pages and have incorporated key messages and guidance into their efforts.

Health Canada has seen a significant increase in all measureable areas of its outreach program. For example, there has been a 100% increase in public inquiries each year, a 40-50% increase in web visits each year, participation in over 200 events and conferences across the country since 2008, and close to 500,000 radon brochures, guides and factsheets distributed since their development in 2009. Effective communication internally and externally with stakeholders, as well as regular evaluation and measurement against objectives, has been key in enabling the NRP to make as much progress as it has in the last five years.

As the E&A Program has progressed Health Canada has begun to create more customized resources and materials to target specific audiences. For example, to more effectively target smokers, a group at a higher risk from long term radon exposure, a radon factsheet for smokers was developed and is now distributed at appropriate events, through stakeholder partners and to physicians along with smoking cessation information.

In addition to the above mentioned components, scientific research is another important component of the NRP. One of the first research projects under the Program investigated the effectiveness of sub-slab depressurization in the Canadian climate. In this study an active sub-slab depressurization system was installed in a home in the Ottawa area and the radon level was successfully reduced from 2000 to 60 Bq/m^3, well below the Canadian guideline level[13].

Most of the research activity has been focused on solving practical problems or answering questions raised by the general public, such as studies on long-term monitoring of soil radon gas variations to ensure a single soil radon gas survey could provide a representative soil radon gas characteristic of a survey site[14], the reliability and quality of radon detectors available in the Canadian market[15], radon diffusion characteristics of vapor barrier membranes used in home construction[16], radon exhalation from granite countertops and other building materials[17] as well as the development of alternative methods for retrospective and quick estimation of long-term radon exposure[18]. Most recently there have been research studies on different sub-slab depressurization techniques, such as roof line and near ground level exhaust, and their application and effectiveness in Canadian weather conditions[19].

In recent years, exposure to thoron (another isotope of radon: radon-220) and its possible health effects have gained increasing attention among health physicists. Research projects have been undertaken as part of the NRP to assess thoron levels and thoron risk to the Canadian population. Based on limited thoron surveys conducted in 5 cities, it has been estimated that thoron could contribute about 8% of the radiation dose due to indoor radon exposure in Canada[20, 21]. To gain a better understanding of the thoron contribution to the indoor radon exposure, a simultaneous radon and thoron survey in 4000 homes distributed in 32 metropolitan areas of Canada is planned to start in the fall of 2012.

CONCLUSION - Moving Forward 2012 and Beyond

Significant progress has been made in all areas of the National Radon Program since its inception in 2007. Going forward, the NRP will continue to build on the strong base developed in the last five years. Short and medium term program objectives include the completion of the federal building radon testing project and cross Canada residential radon/thoron survey; work with provinces and territories to continue to build on the successful stakeholder partnerships to help motivate Canadians to take action to reduce their indoor radon exposure; collaboration with stakeholders and partners to encourage the adoption of the revised building codes across the country for prevention of radon ingress in new home construction; the successful implementation of a Canadian certification program to increase number of certified radon service providers; continued research on radon remediation with an emphasis on large buildings; continued efforts to increase public awareness of radon; and the development of provincial and community-based radon programs. Continued progress in the areas mentioned above is necessary to ensure the success and sustainability of the Program.

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