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RADON RISK PERCEPTION - A CANADIAN PERSPECTIVE

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ABSTRACT

Canadian radiation protection regulations and guidelines are based on the recommendations of the ICRP and other international bodies, and are often similar to U. S. Regulations. One major difference is the intervention guideline for radon in houses. The EPA intervention guideline is an annual average of 4 $pCi.L^{-1}$, but decisions are often made on short-term measurements. In contrast, the Canadian Department of Health and Welfare guideline is 800 $Bq.m^{-3}$ (22 $pCi.L^{-1}$) based on measurements of 1 year duration. These different guidelines are not the result of technical differences in the preferred model for lung dosimetry, but rather due to a different perception of what radon risks is worth averting. The reasons are partly historical, and partly due to a risk/benefit evaluation of averting lung cancer risks by expenditures on radon mitigation versus expenditure to reduce other environmental risks, particularly smoking.

INTRODUCTION - EARLY ACTION LEVELS

In the 1970's both Canada and the US had major remedial action projects under way to deal with communities contaminated with radioactive by-products of uranium mining and refining, and radium extraction. In these locations often the first sign that a house was built near or on radioactive wastes was an elevated radon concentration. Action Levels based on radon progeny concentration were established for these projects. If the radon concentrations (or internal gamma fields) were higher than the action level, the wastes were located by gamma surveys in boreholes, dug up, and removed to an approved disposal location.

At Grand Junction, Co., the cause was uranium mill tailings which had been used as a sand substitute throughout the town. The guidelines (Code of Federal Regulations. "Surgeon General's Guidelines for Exposure Levels in Buildings constructed on or with Mill Tailings", 1972) were in terms of radon progeny energy concentration (WL), but the equivalent radon concentration is also given for comparison with today's criteria. (The conversion factor is derived in Appendix 1). The guidelines were in addition to background, which had to be determined separately. In this area of uranium mineralisation, background was about 10 mWL, or more than double the nominal value of 4 mWL used at that time. The WL measurements were averages over one week at three month intervals.

> Remedial Action required $>$50 mWL + background $\approx$ 60 mWL (600 $Bq.m^{-3}$)
> No Remedial Action required $<$10 mWL + background $\approx$ 20 mWL (200 $Bq.m^{-3}$).
> In practice the grey zone between these two figures was ignored, and the Action Level was effectively $>$20 mWL).

In Canada at Port Hope, Ontario, the cause was improper and poor disposal of radium extraction wastes, and recycling of materials from demolished radium extraction buildings. The guidelines from the Atomic Energy Control Board were in terms of radon progeny (WL) but the equivalent radon concentration is also given. WL measurements were initially single 5 minute air samples.

Prompt remedial action >150 mWL (1500 $Bq.m^{-3}$)
Remedial Action Level >20 mWL (200 $Bq.m^{-3}$)
Investigation Level >10 mWL (100 $Bq.m^{-3}$) - more measurements needed.

These Levels included "background", for they were based on the distribution of short-term WL measurements in houses.

JUSTIFICATION FOR ACTION LEVELS

The Canadian Remedial Action level was based on the measured distribution of single short-term measurements in many "uncontaminated" houses. Only 1% were >20 mWL, so this value was a good indication of a contaminated house.

Any house with a single measurement of >150 mWL was given immediate priority for remedial action without waiting for the completion of a series of measurements to determine the long-term average.

The Investigation Level was based on the distribution of repeated measurements in the same house. In a house with a long-term average of 20 mWL, 35% of short-term measurements lay between 10 to 20 mWL. More measurements were needed to decide if the long-term average radon concentration was background or higher.

Similar criteria were adopted for clean-up work in uranium mining communities, such as Elliot Lake and Bancroft, Ontario; and Uranium City, Saskatchewan. Most (but not all) of elevated radon concentrations found in homes at these sites were due to "natural" causes - not mining wastes.

The Remedial Action Level for these communities was redefined as > 20 mWL *Long term average*. The other short-term measurement Action Levels remained the same as a priority guide.

A justification for this Action Level could be:
20 mWL long-term average in home ≈ 1 WLM/a
Uranium miner exposure limit = 4 WLM/a
Unrecorded exposure in homes over 20 mWL ≥20% of limit, a systematic error in occupational dosimetry too large to ignore.

In keeping with this interpretation, the Ontario Building Code was modified to require new housing in uranium mining areas to have radon-resistant foundations. The Design Criterion was < 20 mWL (200 $Bq.m^{-3}$) long-term average including background.

ACTION AGAINST BACKGROUND RADON

By the early 1980's it was known that elevated radon levels in houses were not limited to uranium mining areas, but could occur almost anywhere. The existing standards for radon mitigation were based on action against "above background" levels. New philosophies and standards would be needed for action against the background itself.

Regulatory authorities had several difficulties in framing an appropriate response.

How can conventional radiation protection philosophy intended to limit incremental risks to workers from *practices* be used to set standards for *interventions* against background radiation?

The natural radon problems were caused and experienced by persons who are not radiation users. There were no regulatory carrots or sticks, so the only actions would be voluntary ones.

The wide range and quasi-random variation in radon concentration from house to house, meant that identification would have to be carried out on a house by house basis. At that time charcoal measurements of radon by post had not been developed, so measurements required deployment of a field team at high cost.

Annual dose equivalents from high background houses comparable to the limits set for the incremental doses resulting from *practices*.

Possible solutions to these problems included:

Do nothing. Issue no guidance - "Levels only applicable to licensed activities".
Adopt an existing action level as a guideline for public exposure eg. 20 mWL.
Review the distribution of radon exposures, the associated *avertible risks*, and derive an appropriate guideline.

AVERTIBLE RISK - THE CANADIAN APPROACH

Radon concentrations in the major urban centres of Canada had been surveyed in 1979/1980, and the population-weighted distribution was estimated to be log-normal with GM = 4 mWL, GSD = 2.5. Applying the standard ICRP risk factors for radon progeny exposure to this distribution predicted that $\approx 10\%$ of the lung cancers seen in the population could be caused by radon. Most of the remainder could be caused by tobacco smoking.

However, as most of the population is exposed to low radon progeny concentrations, 85% of these radon-induced lung cancers would be caused by exposure to concentrations of *less than 20 mWL*. As there was no expectation that radon progeny concentrations of 20 mWl could be reduced at any reasonable cost, these cancers were regarded as "not avertible". This leads to the conclusion that radon in houses is not an avertible *Public Heath* risk.

A 20 mWL Action Level was technically feasible, but as only 15% of the radon related lung cancers were produced by higher concentrations, even *100% implementation of a 20 mWL Action Level* would only reduce the *total* lung-cancer rate by approximately 1.5%. A voluntary program would be unlikely to approach even 25% implementation. Clearly, a large reduction in lung cancer death rate is not likely to be achieved by reducing radon concentration in homes.

Taking into account that the death rate from heart and lung diseases caused by smoking is larger than that from lung cancer, reducing the number of smokers by 1% would be a larger contribution to public health than truncating the radon exposure distribution at 20 mWL. The risk from radon in dwellings is much smaller than that from smoking. This argument is illustrated in Appendix 2.

Radon in dwellings is an avertible *individual risk*. At some concentration, the dose-rate to the individual will be high enough for intervention to be regarded as desirable. If the costs are beyond the financial capacity of the home-owner, this implies expenditure of public funds on the work.

The distribution of risk for lifetime exposure in a house is not the same as the distribution of house concentrations, as shown below.

Concentration range (mWL)	Percent of houses	# of radon LCD's
0 - 20	96.0	340 (85%)
20 - 100	3.9	60 (13%)
100 +	0.1	10 (2%)

The risk is much higher in the houses with the highest concentrations - 2% of the radon related lung cancer deaths are predicted to be caused by just 0.1% of the houses.

This disproportion suggests a high Action Level should be chosen to focus attention on the importance of reducing individual risks by reducing the highest radon concentrations.

The dose-rate to a member of the public "high enough for intervention to be desirable" can be taken to be the occupational dose limit. The uranium miner exposure limit is 4 WLM/a, which is equivalent to long-term concentration ≈ 80 mWL or 800 $Bq.m^{-3}$. This sets an upper limit to suggested Action Levels.

GUIDELINE FOR RADON IN CANADA

It is recommended that remedial measures be taken where the level of radon in a home is found to exceed 800 $Bq.m^{-3}$ as the annual average concentration in the normal living area. Because there is some risk at any level of radon exposure, home owners may wish to reduce levels of radon as low as practicable.

Federal-Provincial Conference of Deputy Ministers of Health December 1988.

Appendix 1

Units and conversions

1 WL = Alpha energy released by decay of progeny initially in equilibrium with 100 $pCi.L^{-1}$ radon.

In houses, progeny are usually at 37% of equilibrium, so:

$$100\ pCi.L^{-1}\ (3700\ Bq.m^{-3}) = 370\ mWL$$
$$20\ mWL \approx 200\ Bq.m^{-3}$$

The EML suggested that a *conservative* estimate of equilibrium for charcoal measurements was 50%:

$$100\ pCi.L^{-1}\ (3700\ Bq.m^{-3}) = 500\ mWL$$
$$20\ mWL \approx 150\ Bq.m^{-3}$$

Appendix 2

Table 1A Ontario Deaths 1988

Cause of death	Number
Circulatory disease	29 673
Other Cancers	12 609
Lung cancer	4 118
Respiratory disease	4 484
Car Accidents	4 453
Suicide	1 203
Fires	1 103
Industrial Accidents	129
Drowning	119

Table 2A Effect of radon on Lung cancer in Ontario - 1988

Total Lung cancer deaths	4 118
Estimated number due to smoking	3 340
Estimated number due to radon	410
Number due to radon at <20 mWL	340
Potentially Avertible lung cancers	70