RESEARCH HIGHLIGHT

Technical Series 97-114

Estimating the Concentrations of Soil Gas Pollutants in Housing

INTRODUCTION

The reuse of contaminated lands for residential development does not automatically require expensive remediation to meet the guidelines set up by the Canadian Council of Ministries of the Environment (CCME). Site-specific risk assessment is becoming an alternative, as certain types of buildings, houses, or land use practices can permit safe occupation of these lands without costly clean-up. Assessors can only evaluate the risk associated with the residential occupation of contaminated land by understanding the building that occupies the site. If the building and its characteristics are not considered, then the assessment is inaccurate, and the predicted exposure may be out by as much as a factor of 1000. As part of a project to evaluate how residential site risk assessments are currently being performed, CMHC and a consultant knowledgeable in building science have developed a guide for estimating the indoor concentrations of soil gas pollutants in houses – providing guidance to those doing the assessment on the house performance characteristics that must be considered.

THE GUIDE

The guide identifies the key building-related mechanisms that can permit the entrance of soil-borne contaminants, and provides a thorough yet simple method for estimating their indoor concentrations. The method takes into account the concentration of soil gas pollutants, the air-tightness characteristics of the building envelope, and the basic design of the heating and ventilating system. Used as a screening tool, the guide can aid in the identification of possible site-specific problems with building design. The guide is applicable to all building types, but the data presented are specific to low-rise housing. Large buildings are so diverse in the nature of their building envelopes and mechanical systems that they usually require a detailed engineering investigation.

SCREENING PROCEDURE

Field testing and model simulations have shown that the rate of entry of soil gas (or flow rate) into well-designed and well-constructed new buildings is typically less than 5 per cent of a building's ventilation rate – therefore the indoor concentration of a pollutant should not exceed 5 per cent of the soil gas pollutant concentration under the foundation. This 5 per cent factor suggests that most conservative exposure estimates will show a soil gas contaminant concentration dilution of 95 per cent, simply through consideration of the building factors. The guide suggests using this simplified screening process to eliminate the need for further investigation, if a building has the following:

- a well-designed and constructed foundation (typically cast-in-place concrete or preserved wood foundations or equivalent).
- minimal foundation air leakage pathways as a result of careful design and field installation practices.
- an externally connected or trapped foundation drainage system which prevents venting into the building interior.
- a balanced mechanical ventilation system or a system with no major continuous exhaust equipment.

If a building fails in any of the above criteria, the detailed calculation procedure provided by the guide will help to improve estimates of soil gas entry.

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FULL PROCEDURE USING THE MODEL

Soil-originating gases can enter a building by penetrating the below-grade building envelope or by migrating to the soil surface, becoming airborne and then entering the building above grade. For a gas to migrate between the exterior and interior of a building there needs to be an opening to pass through and a pressure gradient to induce flow. Indoor soil gas contaminant concentrations can be represented by a mass balance between their rate of entry and their rate of removal. Essential elements of the equation include:

- the soil gas concentration,
- the above-grade contaminant concentration of the outdoor air,
- the building ventilation rate from outdoor air,
- the rate of soil gas flow into the building (as related to air flow), and
- the contaminant flux into the building.

While the screening factor suggests a soil gas dilution of 20:1, calculations may in fact permit soil gas concentration dilution by a factor of 1000 or more. Where possible, field measurements for the above should be collected from the site and used in the calculation procedure. In the event that data are unavailable, the guide provides typical default values for low-rise housing. The model assumes that the concentration of the soil gas is known or has been calculated by soil gas modeling. While the best soil gas risk assessment model would include both soil and building factors, the behaviour of a gas contaminant within the soil zone is beyond the scope of the current guide.

The guide provides estimates for both natural and mechanical ventilation rates for wood-frame houses, based on age. It also includes adjustment factors for climate and season; as natural air exchange is lower when wind speed or temperature differences are small.

The pressure differential between the interior and exterior of a building can have a significant effect on the flow of a contaminant through a building envelope. A pressure phenomenon known as the *stack effect* occurs in a house during conditions where the indoor temperature differs from the outdoor temperature. Under these conditions, typically during the winter months, the lower portion of a house will be at a negative pressure to the outdoors and the upper portion of a house will be at a positive pressure to the outdoors. This effect will result in air and soil gas flow into the basement – flow can be heightened with the operation of exhaust fans or similar ventilation equipment. The guide provides estimates for typical maximum winter differential pressures across below-grade building envelopes. Appropriate adjustments to these values are given depending on the influence of other mechanical factors such as the existence of fresh air intake ducts, combustion air supply, fireplaces, and central exhaust systems – adjustments for season are also provided.

CONCLUSIONS

Expensive residential site clean ups may not always be necessary if a detailed risk analysis can determine that a building is not prone to contamination by soil gas pollutants. An assessment can also help in the improvement of building design to decrease or eliminate the risk of contamination. A guide is now available to assessors, which outlines the house performance characteristics fundamental to a meaningful residential risk assessment.

The model, outlined in the guide, takes into consideration a known soil gas concentration, the outdoor air concentration of the pollutant, the building ventilation rate, and the rate of air flow and the rate of pollutant entry. It looks at the influence of both building envelope design and mechanical systems design on the infiltration of air and below-grade interior building pressurization – it also helps to define the pressure influences that can result in contaminant entry within a typical house. As house-based factors can readily make a 10-1000 fold difference in the level of risk estimated due to soil-based contaminants, it is critical that assessors include such factors in their risk calculations.

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Research Report: Estimating the Concentrations of Soil Gas Pollutants in Housing

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Housing Research at CMHC

Under Part IX of the ***National Housing Act***, the Government of Canada provides funds to CMHC to conduct research into the social, economic and technical aspects of housing and related fields, and to undertake the publishing and distribution of the results of this research.

This fact sheet is one of a series intended to inform you of the nature and scope of CMHC's research.

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