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Project Summary

Large Buildings Characteristics as Related to Radon Resistance: A Literature Review

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This report presents results of a literature review to identify the database for specific large building characteristics that is available regarding radon entry. The primary sources for the review were the Ei Compendix database (235 abstracts) and a database consisting of literature related to indoor air work by EPA's Air Pollution Prevention and Control Division.

This Project Summary was developed by EPA's National Risk Management Research Laboratory's Air Pollution Prevention and Control Division, Research Triangle Park, NC, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

Radon can enter a building in several ways. When there are no pressure differences, radon can enter buildings by diffusion-driven transport. Radon can be emitted from well water directly supplied to a building from radium-bearing formations. Building materials can also be a source of radon. However, it is uncommon that any significant radon concentration would occur in large buildings by these mechanisms. Pressure-driven transport, occurring when a lower indoor air pressure draws air containing radon from soil or bedrock into the building, is the most common way radon enters large buildings. This occurs in many large buildings when they operate at an indoor air pressure lower than that of the subsoil. The following four conditions must exist if radon is to enter a building through pressure-driven transport: 1) radon in the subsoil, 2) a pathway from the source through the substructure into the building, 3) radon entry points and 4) a driving force into the building.

Prior to 1993, most radon research in large buildings focused on developing diagnostic and mitigation techniques for school buildings. The belief exists that techniques developed for school buildings can be used as the basis for developing diagnostic and mitigation techniques for other types of large buildings. The complexity and diversity of large building designs is an added complication in radon mitigation. Much in the available literature on large building characteristics is directed toward energy conservation and heating, ventilation, and air-conditioning (HVAC) system design and operation. The development and application of energy conservation techniques for large buildings have been vigorously pursued since the mid-1970s and have resulted in significant energy savings. Some of these techniques may have contributed to sick building syndrome, building related illness, and a general decrease in indoor air quality.

Radon diagnostic and mitigation strategies are needed for large buildings. Studies are in progress to develop, validate, and provide guidance for radon diagnostic procedures and radon mitigation strategies applicable to a variety of large buildings commonly found in the State of

Florida. To help meet these needs, an understanding of existing characteristics of large buildings is necessary.

Summary of Findings

Few large building studies have evaluated radon entry and/or mitigation. Most large building characterization studies are related to energy conservation. Environmental studies have centered on indoor air quality (IAQ) as it relates to sick building syndrome and building related illness. Large building characteristics of importance in relation to radon entry include: HVAC system operation and maintenance, building foundation, floor space to footprint ratio, separation of lower level from upper floors, floor bypasses, and location. Location has been suggested as the most important characteristic related to radon entry. The literature provided information on HVAC system operation and maintenance mostly in large building characterization studies that were related to energy conservation. There were minimal data on other radon related characteristics. One author concluded, "...a significant body of knowledge exists about the infiltration, air leakage, and ventilation characteristics of residential buildings, however, little measured data exists on the quantities for commercial buildings."

Large buildings have diverse characteristics which make it difficult to place them into a manageable number of categories for radon mitigation studies. The Department of Energy characterized nearly four million commercial buildings, one million of which may be considered to be large, greater than 10,000 ft^2 (929 m^2). Average footprint size was available for buildings up to three stories tall. It was not possible to determine from the data the footprint size for buildings taller than three stories. This is significant because the building characteristic that is most strongly linked to radon entry is location. The much higher floor space to footprint ratio for large multistory commercial buildings over small buildings may account for the low incidence of high radon levels in large buildings. Of the 80,000 building measurements conducted in federal buildings, 95% were under 4 pCi/L.

Approximately half of the commercial buildings (large and small) surveyed in the U.S. incorporate characteristics that could increase radon entry if the radon source was present and the pathway available. For example, basement substructures may significantly contribute to radon infiltration. The use of National Institute of Standards and Technology parameters for describing building and HVAC characteristics developed in conjunction with IAQ investigations may provide some insight relative to radon entry into large buildings especially as it relates to operation and maintenance of HVAC systems.

An extensive search for literature on large buildings in Florida concluded that little information relevant to commercial building characteristics in regard to radon was available. Because of Florida's warm climate, high humidity, high water table, and the scarcity of sources for aggregate for construction, large buildings in Florida generally differ from those built in other states.

HVAC systems have a significant impact, positive or negative, on radon concentrations in large buildings because of pressurization or depressurization, introduction of dilution air, and air distribution. Well designed and installed HVAC systems can be adjusted to effectively mitigate radon in large buildings. However, a bias toward energy conservation, poor maintenance, and inefficient operation of these complex systems can negate any potential for radon mitigation. HVAC system performance characteristics are typically measured in terms of a number of different parameters such as air distribution, ventilation effectiveness, thermal comfort, building pressurization, energy and maintenance costs, and outdoor air exchange rates. Experience has shown that a properly designed, well-constructed, properly functioning, and well-maintained HVAC system will minimize most IAQ and comfort complaints, but may not be sufficient to solve all strong source/open pathway situations.

Energy use is a factor in radon entry as it relates directly to whether or not the building is under positive or negative pressure. Energy use is significantly influenced by occupancy, building shell, mechanical equipment, and weather. Evaluation of end-use electrical consumption at commercial sites may give some insight to HVAC system operation and maintenance which can be inferred to impact on radon entry. Information may relate to energy conservation, ventilation, and building depressurization. Protocols, standards, and codes which guide and regulate the design, installation, commissioning, operation, and maintenance of HVAC systems (considering both radon infiltration/mitigation and IAQ) are unavailable.

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The complete report, entitled "Large Buildings Characteristics as Related to Radon Resistance: A Literature Review," (Order No. PB97-167134; Cost: $25.00, subject to change) will be available only from:

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