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School Buildings with Air Exchange Rates That Do Not Meet Minimum Professional Guidelines or Codes and Implications for Radon Control

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ABSTRACT

In the past two years, a substantial number of schools in the United States have tested for radon. Some of them have found radon levels elevated above the EPA action level of 4 pCi/L. In order to decide whether increased ventilation or building pressurization is an appropriate response, the mechanical system must be investigated and an estimate of the air exchange rate made. Air exchange rates in schools have been estimated using a combination of carbon dioxide measurements in occupied rooms, airflow measurements of exhaust and outside air, and fan pressurization of the building shell. Not all of these tests were performed in all schools. Experience in investigating elevated radon in dozens of public schools has revealed that a large fraction of them do not have ventilation rates that meet minimum guidelines as outlined in ASHRAE 62-1989, Ventilation for Acceptable Indoor Air Quality, *and, in some instances, state code. In many cases, they do not even meet the professional guidelines that were accepted at the time the school was designed and built. Causes for this condition include inappropriate responses to escalating energy prices in the late 1970s, lack of funds to maintain equipment, and complaints of thermal discomfort caused by some ventilation systems.*

INTRODUCTION

Investigations of school buildings containing rooms with radon levels greater than the Environmental Protection Agency's guideline of 4 pCi/L have been conducted by the authors in more than two dozen schools. The bulk of this work was done under the EPA School Evaluation Program. The authors wish to acknowledge the EPA for its support. The technical details of these investigations are presented in Brennan et al. (1991) and Fisher et al. (1990). The purpose of this paper is to highlight information uncovered by this work, making it imperative that radon in schoolrooms be viewed in a larger public health framework.

The investigation of the buildings can be divided into two parts (Brennan et al. 1990): an investigation of the foundation and an investigation of the heating, ventilating, and air-conditioning (HVAC) systems. As part of the HVAC investigation, estimates are made of the outside air ventilation rate. This is done to determine whether minimum outside air quantities are being delivered to the rooms and to estimate the impact increased ventilation has on indoor radon levels. The authors believe that characterizing the ventilation system is critical to the selection of a radon control strategy. Figure 1 shows the logic currently being used to select a radon control strategy. Using this principle, an HVAC approach was recommended in 23 of 26 schools because of low ventilation rates.

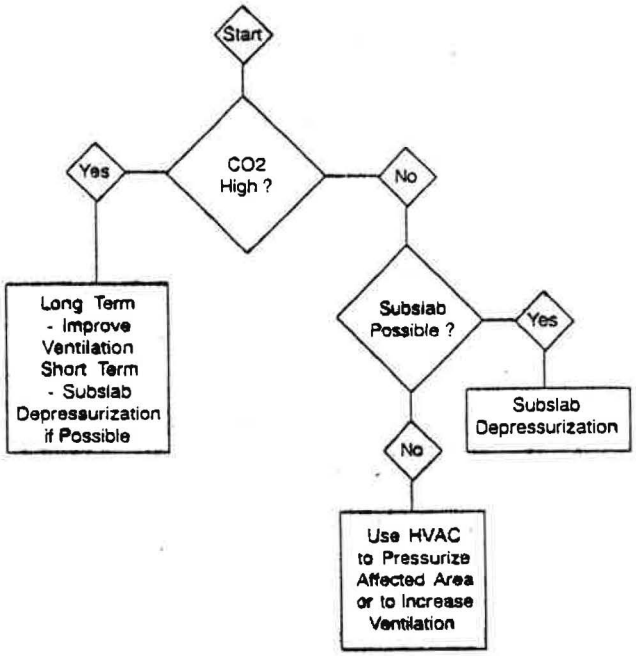

Figure 1 Simplified SEP recommendation logic—1990

METHODS

Air exchange rates were estimated in the schools using a number of techniques. This paper will focus on the results of

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carbon dioxide levels in occupied classrooms. These measurements were made in the late afternoon before classes were dismissed. An infrared CO_2 detector was used to make the measurements. The detector was field calibrated using a soda lime filter for zero and 2000 ppm span gas. Carbon dioxide was used as an outside air rate indicator so that the levels could be compared to *ASHRAE Standard 62-1989, Ventilation for Acceptable Indoor Air Quality*, guidelines (ASHRAE 1989).

RESULTS

A histogram of carbon dioxide measurements from the schools is shown in Figure 2. The mean CO_2 concentration was 1,480 ppm with a standard deviation of 686 ppm. The geometric mean is 1,341 ppm. The current ASHRAE guideline for classroom outside air rates is 15 cfm (7 L/s) per person. The levels of CO_2 expected if the rooms met this guideline would be 1,000 ppm. A large fraction of the rooms, 74%, is above this guideline. In fact, the bulk of the rooms are above the levels that would be expected if the outside air rate was at ASHRAE's historic low recommendation of 5 cfm (2.33 L/s) per person. Three rooms pegged the detector at 5,000 ppm CO_2. This is above the NIOSH guideline for CO_2 levels as an indoor air contaminant.

Figure 3 shows the radon screening measurements vs. carbon dioxide measurements for all the classrooms where both were available. It should be noted that the radon measurements are time integrated and the CO_2 measurements were essentially grab samples made near the end of a day. The important part of this figure is that many rooms with elevated radon levels also have elevated CO_2 levels and that many rooms with low radon levels have elevated CO_2 levels. Most of the rooms with radon levels less than 10 pCi/L and CO_2 levels greater than 1,000 ppm can have both problems addressed by the use of increased ventilation if the source term of radon is not increased by depressurization. Even the rooms with higher radon levels can be remedied using outside air if the room is pressurized. It is these data that form the basis of the authors' belief that radon control in schools is part of a larger indoor air quality issue in schools.

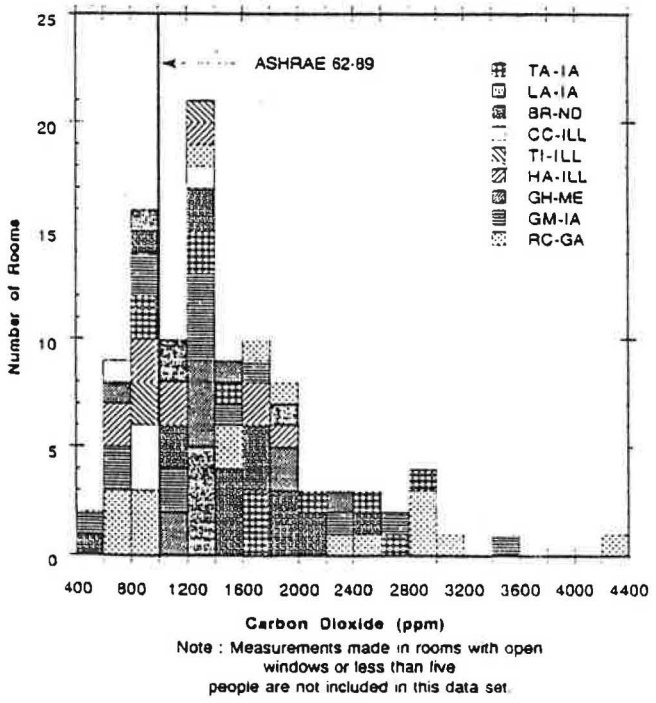

Figure 2 Histogram of carbon dioxide measurements made in occupied classrooms, Sep-1990

CONCLUSIONS

The sample of rooms in this work is not random, nor is the argument made that it is representative. However, the large fraction of rooms with elevated carbon dioxide levels, irrespective of radon levels, indicates that U.S. schools have many rooms that are underventilated. It is clear that the potential for indoor air quality problems is great. Indoor radon control in schools should be viewed in this broader context.

REFERENCES

ASHRAE. 1989. *ASHRAE Standard 62-1989, Ventilation for acceptable air quality.* Atlanta: American Society of Heating, Refrigerating, and Air-Conditioning Engineers.

Brennan, T., G. Fisher, W. Turner, and R. Thompson. 1991. "Extended heating, ventilating, and air-conditioning diagnostics in schools in Maine." In *Proceedings of the 1991 International Symposium on Radon and Radon Reduction Technology.* Philadelphia.

Brennan, T., W. Turner, and G. Fisher. 1990. "Building HVAC/foundation diagnostics for radon mitigation in schools and commercial buildings: Part 1". In *Indoor Air '90, The Fifth International Conference on Indoor Air Quality and Climate.* Toronto, Canada.

Fisher, G., T.B. Brennan, and W. Turner. 1990. "The school evaluation program." In The *1990 International Symposium on Radon and Radon Reduction Technology*, Vol. V. Atlanta: Environmental Protection Agency.

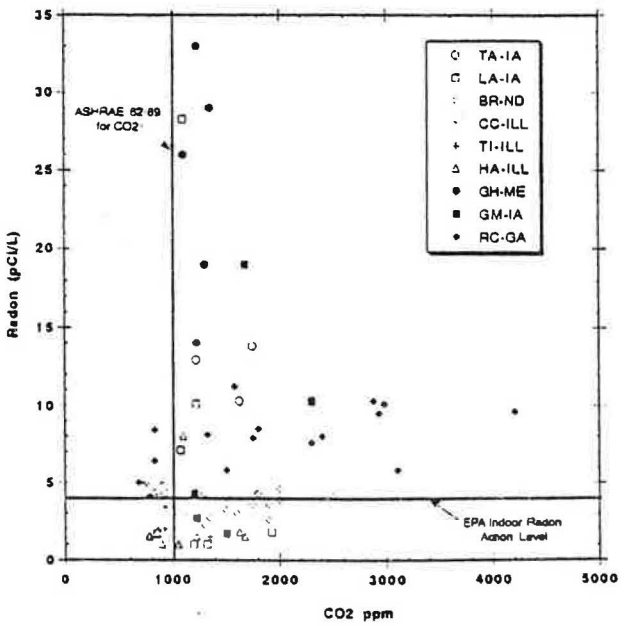

Figure 3 Room carbon dioxide vs. radon screening measurements in school rooms