EXTENDED HEATING, VENTILATING AND AIR CONDITIONING DIAGNOSTICS IN SCHOOLS IN MAINE

BY - Terry Brennan
Camroden Associates
RD#1 Box 222
Oriskany, New York 13424

Gene Fisher
Robert Thompson
USEPA
Office Of Radiation Programs
Washington, Dc

William Turner
H.L. Turner Group
Harrison, Maine

ABSTRACT

An extensive effort to assess the effects of HVAC system operation on the indoor radon levels was conducted. Many schools in the EPA School Evaluation Program have been found to have disabled or malfunctioning outside air on the ventilation system. The outside air in the Maine schools had been disabled. This condition was corrected using professional HVAC and control contractors. Measurements were made of radon levels, total and outside airflows, pressure differentials across the building shell and sub-slab radon levels. Exhaust ventilation, built up air handlers and unit ventilators were investigated. A heat recovery ventilator was added to a room that had leaky window sash as the outside air supply for a passive roof vent system. The passive vents have been blocked off.

INTRODUCTION

In August, 1990, extended radon diagnostics were performed in two Maine Schools. The purpose was to assess the effects of returning the heating, ventilation and air conditioning (HVAC) system to the original operating specifications would have on indoor radon levels. This effort was part of the 1990 School Evaluation Program[1]. Measurements of radon, air pressure differences across the building shell and carbon dioxide levels[2] were made to help judge the system changes. While a large amount of data was collected, these measurements were open to a number of interpretations because the radon levels found in the schoolrooms during the extended diagnostics week were much lower than were found by the screening measurements made in April, 1990.

In December of 1990, followup measurements were made at the Gray High School and Russell Elementary School in Gray, Maine. The purpose of these measurements was to provide a basis upon which to judge the effect of the HVAC improvements on radon levels, air pressure relationships and carbon dioxide concentrations in occupied rooms. December was a good time to make this assessment because it represented a worst case scenario. That is, the outside air dampers in the unit ventilators and built up air handlers were closed to minimum and the competing stack effect was at the maximum. Both conditions are the result of the low outdoor temperatures found in Maine at that time of year. The measurements were carried out by a team of people. The team included : Gene Fisher and Bob Thompson USEPA Office of Radiation Programs, Washington, D.C. ; Bruce Harris, USEPA, AEERL, Radon Branch, Research Triangle Park, NC; Bill Turner, Fred McKnight, H.L. Turner Group, Harrison, Maine; Terry Brennan, Camroden Associates, Oriskany, New York; and Gene Moreau, Bob Stillwell, Maine Department of Health Engineering, Augusta, Maine.

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PROCEDURE

The evaluation consisted of a visual inspection and measurement of key performance related variables in the Gray High School and the Russell Elementary School.

An extensive set of measurements were made in the High School. The following measurements were made :

continuous radon (pulse ionization and semi-conductor)
continuous air pressure differences (variable capacitance)
carbon dioxide survey (infrared spectrometer)

Continuous radon monitors were placed in rooms 2, 7, 17, 31, 32, 33, the Guidance Office and the Conference Room. The monitors used were eight Honeywell continuous radon monitors and two femto-Tech continuous radon monitors (room 33 and room 7). The Honeywell units provide mean radon levels for 4 hour intervals and the femto-Techs for 1 hour intervals. Air pressure differences were monitored across the floor slab in rooms, 33, 7, the Conference Room and the Guidance Office. Variable capacitance chambers manufactured by Setra were connected to a data logger provided by EPA to collect pressure difference data. Calibration curves were made for each sensor using a micromanometer. Ventilation rates, outside air fractions and ventilation effectiveness were estimated by making a survey of carbon dioxide levels in the occupied classrooms. These could then be compared to carbon dioxide measurements made in the same rooms at the end of the previous school year. Data was collected from 12/18/90 until 1/16/91. This afforded the opportunity to see the classrooms operated both normally and with school in recess for the Christmas Vacation.

Additionally, measurements of sub slab radon were made in the High School and the nearby Middle School. A carbon dioxide survey was also made in the Middle School. The Middle School is very close to the High School but does not seem to have nearly the elevated radon levels that the High School does. These measurements were made to determine whether the Middle School radon levels were lower due to lower source term, construction characteristics or HVAC operation and design. The radon levels under both schools were in the range of 2000 to 4000 pCi/L. There is no evidence that the source strength is the variable causing the large difference in the radon levels in the two schools.

RESULTS

Overview Of Results

The results of this investigation can be briefly summarized in a few lines. The evidence supporting these conclusions are then presented.

1) average radon levels that do not distinguish between occupied and unoccupied

conditions can be misleading

2) the operation of the air handlers, both outside air and exhaust only, has a definite reducing effect on the radon concentrations in the rooms

3) the decay rate of the radon after the air handler turns on is less than would be expected given the amount of outside air that is introduced because the radon is still entering due to negative building air pressure

4) repairing the outside air functions of the air handler made dramatic improvements in the carbon dioxide levels in the rooms where outside air was introduced.

5) while effective and reliable at solving radon problems, soil depressurization in rooms with inadequate ventilation leaves children sitting in high concentrations of CO2 and other indoor air contaminants for which CO2 levels are an indicator.

Effect Of Outside Air Improvements On Radon Levels And Dynamics

Introduction--

Continuous radon levels were monitored in eight rooms of the High School. Rooms 33 and 7 are going to be used to illustrate the effects of the air handler operation on radon levels in classrooms. The resolution of the femto-Tech units in these rooms allows one hour radon levels to be used in the analysis. These rooms are representative of the two different air handling systems - exhaust fans only and unit ventilators with passive relief. Room 33 is in the new wing of the high school, contains a unit ventilator and has repeatedly shown the highest average radon levels and spikes. Room 7 is in the old wing, which has exhaust only ventilation and has shown high radon levels. The only fan powered outside air that can potentially enter Room 7 is from the gym air handlers, when they are running. Otherwise, outside air to Room 7 consists of whatever is drawn in through leakage in the building shell, window wall and corridor.

The next two major sections will examine first Room 33, the unit ventilator room and then Room 7, the exhaust only room, in detail.

Room 33 - Unit Ventilator Ventilation--

The results of the continuous monitoring in Room 33 are shown in Figure 1. Notice that the "rain spike" in this room on Christmas eve rises from 8 to 90 pCi/L and