Research & Development Highlights

Ventilation and Air Quality Testing in Electrically Heated Housing

Introduction

Hydro Quebec, like many other North American utilities, is considering a program to insulate, weather-strip, and air seal older houses, in an attempt to reduce the electric power required for heating. These measures will result in a reduced house air change rate. Hydro Quebec and CMHC were interested in seeing how indoor air quality could be affected by a lower air change rate. To help in these calculations, Hydro selected 30 houses in the Trois-Rivieres area and tested them thoroughly over the heating season. Special tests measured such factors as pollutant source strength and the effects of householder activity.

Research Program

The houses chosen for this study had the same house leakage distribution as found in an earlier study by Hydro Quebec.

Air quality measurements were conducted over a one week period on all houses. Data was tabulated for:

- Average air change rate;
- Indoor air particulates;
- Total Volatile Organic Compounds (VOC's);
- Formaldehyde;
- Radon;
- **GO₂** and
- Water vapour

and compared with Health Canada standards for acceptable long-term and short-term limits. Effort was made to determine possible causes for those houses with high pollutant levels. The data was analyzed to determine the source strength of these contaminants in each house.

Furthertestingwasundertakenon8houses, some of which had innovative ventilation systems. Continuous monitoring over a year gathered data on CO_2 and humidity levels, house energy consumption and weather conditions. Homeowner activities such as cigarette consumption, clothes drying, and wood burning were also monitored for their effect on air quality.

Ventilation systems were compared based on how they affected indoor CO_2 and humidity levels when the system was operational and again when it was turned off or sealed closed. The five systems included:

- "turbine" exhaust systems powered by wind and natural chimney effect house #1,2.
- upgraded bathroom fans -house #3,6;
- internal fan circulation system - house
- a fan drawing air from the bedrooms, mixing with fresh outdoor air, and supplying this mixed air to the hail by the bedrooms house *#5;* and
- balanced air intake and exhaust ventilation system - house #8;

Findings

Results from the week-long, 30 house study revealed that three pollutants generally gave the highest readings. GO_2, respirable particulates (RSP's), and formaldehyde approached the allowable short-term limits. A number of houses exceeded the allowable long-term exposure guidelines.

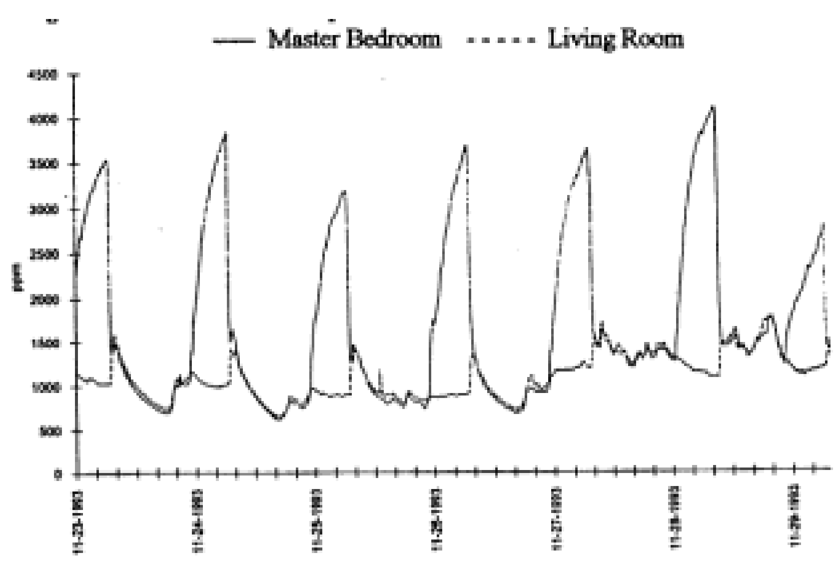
The daily CO_2 level in the living room ranged between *570-1,507* PPM with an overall average of 929 PPM. Spot tests showed that living room readings were indicative of CO_2 levels for the rest of the house, indicating a high rate of mixing from room to room. Living room monitors recorded that all houses were well below the Health Canada long-term level of 3,500 PPM but 27% exceeded the more exacting ASHRAE standard of 1,000 PPM. Interestingly, bedroom monitoring systems revealed that rooms where the door was closed for the night had levels up to 5,000 PPM by morning, while open-door bedrooms had increased levels of only 300 PPM over that found in the rest of the house. This can clearly be seen in Figure 1 for house *#5.* This finding indicates a need for better distribution of air for isolated rooms in houses without forced air circulation systems.

Most remedial systems tested were able to reduce contaminant levels to some degree. The fresh air tempering system used in house *#5* worked quite well, leading to a marked decrease in CO_2 levels in the closed-door bedroom from peaks of 4,000 PPM to 1,500 PPM and means of 2,000 PPM to 1,100 PPM.

The unbalanced fan system in house #4 was used to produce more mixing of air between the basement and upper floors. While humidity and CO_2 levels were already low here, this system helped reduce the amplitude variations of pollutant concentrations and hence peak levels, as well as aiding in the even distribution of heat from the wood stove.

The air distribution system with balanced intake and exhaust used in house #8 worked well. House #8 maintained humidity and CO_2 at very low levels compared to the other 7 houses.

Exhaust fan upgrades in houses #3 and #6 was not as successful as other measures due to operation limitations. While the fan did decrease CO_2 and humidity levels in house #3, it was controlled by outside temperatures and only worked in the spring time when humidity levels were not a problem. It is expected that it will have a greater impact in



the fall when humidity levels will be higher. The exhaust system in house #6 was controlled by an indoor humidity sensor but, due to the noisiness of the fan, the homeowner shut it off.

The use of turbines in houses #1 and 2 increased house ventilation rates, and consequently reduced house pollutant concentrations.

Implications to the Utilities and Retrofit Industry

There is a difficulty in predicting indoor air quality levels in housing, as source strengths seem to be unique to each house. This leads to a difficulty in implementing an air tightening program: prescriptive protocols will be inappropriate for a certain percentage of housing stock. Instead houses must be examined on an individual basis to determine the optimum strategy in each case.

All mechanical ventilation systems have been shown to reduce contaminant levels in housing, regardless of their complexity. Even simple exhaust fans will work in certain cases. Systems that are non-intrusive and systems focussed on the problem areas have the best chance for success.

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Research Report: Ventilation and Air Quality Testing
in Electrically Heated Housing (1994)
Research Consultant: Stricker Associates and Hydro
Quebec

A full report on this research project is available from the Canadian Housing Information Centre at the address below.

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Figure 1. Difference in CO, Levels between Rooms on Same Floor, House #5