RESEARCH AND IDEAS

AIR QUALITY MEASUREMENTS IN AIRTIGHT HOUSES

As evidenced by the number of lines devoted to it in past issues of EDU, indoor air quality is one of the major concerns surrounding the proliferation of airtight energy-efficient housing. While we are far from having all the answers about this important topic, the research pace is picking up.

The latest data is presented in a report just released by the National Research Council of Canada (Building Research Note #212). In a survey conducted by Rob Dumont of the Prairie Research Station in Saskatoon, 46 houses were monitored for formaldehyde, nitrogen dioxide, and radon daughters. These indoor air contaminants generally receive the most attention.

Formaldehyde is emitted by a number of building products and household furnishings such as particleboard, carpets, and others. Nitrogen dioxide is given off by gas cooking stoves, other gas-burning appliances, wood stoves, and cigarettes. Radon is given off by soil and groundwater and can enter a house through pathways in the basement and/or through tapwater. The most widely accepted guidelines for safe levels of these substances in indoor air is contained in the document "Ventilation for Acceptable Air Quality," published by the American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) and U.S. Environmental Protection Agency (EPA). Values for acceptable levels are given in Table 1.

TABLE 1 - GUIDELINES FOR GENERALLY ACCEPTABLE LEVELS OF SELECTED AIR CONTAMINANTS

Contaminant	Level	Reference
Formaldehyde	0.12 mg/m3 0.1 ppm at 25°C	ASHRAE 62-1981
Radon	4 pCi/l	U.S. EPA
Radon daughters	0.01 working levels	ASHRAE 62-1981
Nitrogen Dioxide	100 ug/m3 50 ppb at 25°C	U.S. EPA

Previous Study

In a previous 1982 study performed by Dumont and Harold Orr, 51 houses were surveyed to determine levels of formaldehyde and radon daughters. The survey included houses of varying ages and airtightness levels. Of particular interest in that initial survey was the relationship between formaldehyde levels and the airtightness of the houses. As shown in Figure 1, houses with high formaldehyde readings were generally among the more airtight of the sample. The only houses with formaldehyde levels above the ASHRAE standard were those with measured air leakage below 2.0 air changes per hour at 50 pascals of pressure. (Dumont notes that the measured airtightness of the

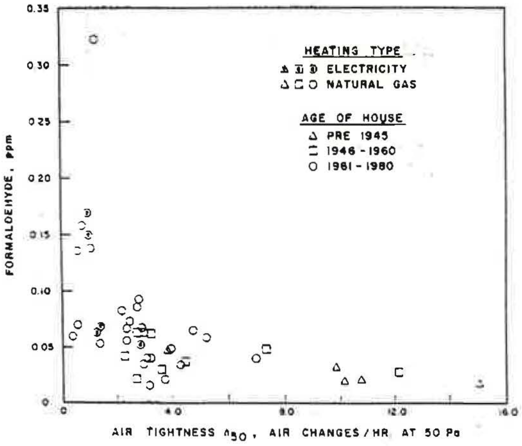

Figure 1
Formaldehyde Readings As a Function of Air Tightness, 1982 Study.

house is not necessarily representative of the air change rate since some of the houses had mechanical ventilation.)

High radon levels were also associated with the more airtight homes. Figure 2 shows measured radon daughter levels as a function of airtightness.

Current Survey

In the current survey, the houses chosen had all been built since 1978. They were chosen because they were all reasonably airtight (pressure test reading of less than 2.5 air changes per hour at 50 pascals). Here's what was observed:

1. 18 of the 46 houses had formaldehyde levels above the ASHRAE limit (Figure 3). The houses with higher formaldehyde readings tended to also have higher relative humidity. The relationship between formaldehyde levels and humidity is probably caused by two factors: 1) the houses with higher humidity probably had lower ventilation rates; and 2) formaldehyde offgassing rate is known to increase with higher humidity.

Higher formaldehyde readings were also associated with the houses that did not have mechanical ventilation systems. 50% of the houses with no mechanical ventilation system showed formaldehyde levels greater than 0.1 ppm. Only 27% of those that had mechanical ventilation showed levels greater than 0.1 ppm. Dumont also measured the amount of particleboard in each house to see if any correlation could be found between area of particleboard and formaldehyde concentration. Only a very weak correlation was found, probably because of complicating factors such as the age and brand of the particleboard, the type of covering on the particleboard, plus the presence of tobacco smoke and other sources of formaldehyde.

2. 11 of the houses had radon levels higher than the 4.0 picocuries per litre ASHRAE standard.

3. Values for nitrogen dioxide concentrations ranged from 0.7 to 13.3 ppb, well below the ASHRAE guideline of 50 ppb. Three of the four houses with readings above 10 ppb had either wood stoves or fireplaces. The fourth house, with a reading above 10 ppb, had 2 smokers with cigarette consumption levels of 1 pack each per day. The houses with no wood appliances and no smokers averaged 3.5 ppb, and those with both wood appliances and smokers averaged 5.6 ppb.

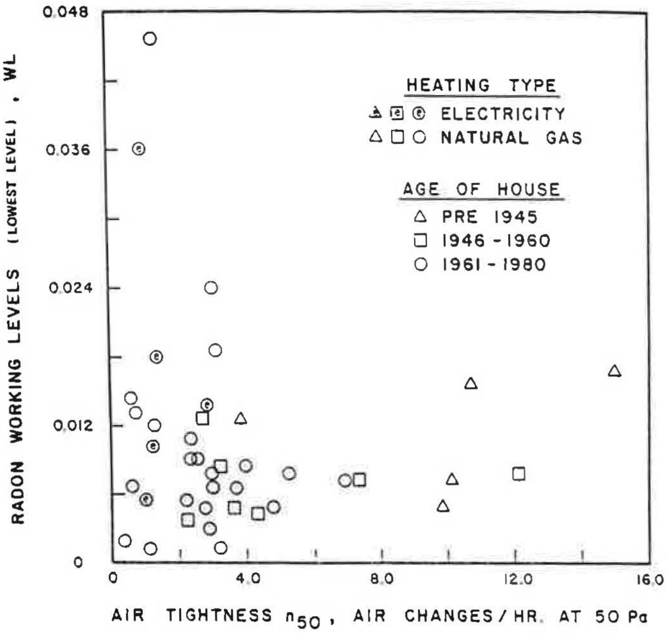

Figure 2
Radon Readings As a Function of Air Tightness, 1982 Study.

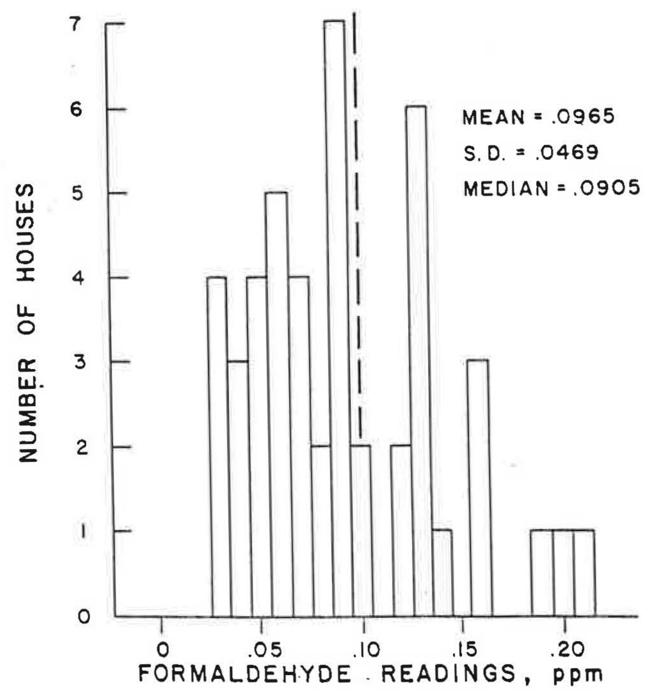

Figure 3
Formaldehyde Readings, 1983 Study.

CONCLUSIONS

This survey supports the contention that indoor air quality may be below par in the present stock of new houses. If nothing else, it shows that in some houses, concentrations of formaldehyde and radon exceed recommended guidelines. Combined with the data obtained from the previous 1982 study, it also suggests that the problem might be more apparent in tighter houses.

However, one must be cautious before jumping to firm conclusions. The entire issue of indoor air quality is fraught with uncertainty. For example, an article in the August 1984 ASHRAE Journal stated that a recent workshop on formaldehyde concluded that formaldehyde levels in manufactured housing ranged from 0.38 to 0.90 ppm. These are not necessarily airtight homes. The article further stated that the Department of Housing and Urban Development has recently proposed new regulations that would limit indoor levels of formaldehyde to 0.4 ppm -- a higher concentration than Dumont found in any of the airtight homes surveyed.

Information about radon and nitrogen dioxide is even thinner than that for formaldehyde and there is still considerable debate within the research community as to what are the maximum safe levels of exposure to these two contaminants.

WHAT SHOULD BE DONE?

An obvious question is whether or not we should continue to build airtight houses. While returning to leaky houses may seem like an easy solution, one should keep in mind that leaky houses are poorly ventilated much of the time. Studies have shown that the ventilation rate of leaky houses can be near zero during mild, windless days. Even if the problem of indoor air quality is more pronounced in airtight houses, it exists in leaky houses as well. The most effective solution is a reliable and effective mechanical ventilation system which can be as simple as a single exhaust fan with passive fresh air intake, or as complex as a supply-and-exhaust system with heat recovery and economizer system.

Another air quality control measure is source control. By eliminating materials and products which emit pollutants, one naturally mitigates pollutant concentration in the air. Some plywood and chipboard manufacturers are producing products that don't contain formaldehyde resins; the Gas Research Institute is developing a gas cookstove with lowered nitrogen dioxide emissions; radon can be somewhat controlled by carefully sealing all pathways in the basement and by isolating basement floor drains from the living space.

For more information on the NRC study, contact Rob Dumont, National Research Council of Canada, Division of Building Research, Saskatoon, Saskatchewan, S7N 0W9; (306)975-4200.

FEATURE SOLAR/SUPERINSULATED HOUSE PLANS

Called "Operation Solar," a new series of six sets of house plans produced by Northeast Utilities, Hartford, Connecticut, is a fine display of marketable energy-conserving house design. Using popular conventional design types -- cape, colonial, country, ranch, raised ranch, and saltbox -- the NU designs incorporate expanded south glazing, but none have an extreme "solar" look. Although some of the designs include sunspaces and extra thermal mass, the solar components, for the most part, consist simply of a concentration of windows on the south side.

When reviewing the six sets of plans, we looked for those features and qualities which reflect energy-conserving design and construction -- high R-value insulation systems, minimum air leakage, a mechanical ventilation system, and good