DESIGN, CONSTRUCTION AND VENTILATION OF A LOW-POLLUTION HOME

Virginia Salares, Ph.D.
Environmental Consulting Ltd.
R.R. 2, Kinburn, Ontario K0A 2H0

Greg Allen, P.Eng.
Allen & Associates
33 Madison Avenue
Toronto, Ontario M5R 2S2

Oliver K. Drerup
Drerup Construction Ltd.
Box 130, Carp, Ontario K0A 1L0

A home was designed and built primarily for low-pollution for an allergic and chemically sensitive family. Building materials were chosen for non-toxicity or lack of emission of particulates and gaseous pollutants. Construction techniques eliminated infiltration of contaminants from insulation materials as well as radon. A ventilation system was designed to allow continuous influx of fresh outside air and removal of stale air with heat recovery. Both the analytical data and qualitative effects on the health of the occupants indicate that exceptional air quality has been achieved.

INTRODUCTION

In recent years, it has become evident that indoor air pollutants can be found in home environments. It is also known that these pollutants can adversely affect health (1,2). The problem becomes acute when ill health has already set in, particularly if the disease is one that is exacerbated by indoor air pollutants.

In 1984, a house was designed and built for a family with two asthmatic and severely allergic children. Clinical scratch tests showed allergy to all the inhalants tested (house dust, moulds, pollens and animal dander). Reactions to foods, cigarette smoke, perfumes, odours and mouldy places were immediate and pronounced - asthma attacks, hives and eczema. Exposure to chemicals such as ammonia in household cleaners, chlorine in buildings with swimming pools and pesticide sprays precipitated severe asthma attacks that required hospital emergency treatments.

The adverse reactions to many foods and chemicals are consistent with the condition called environmental hypersensitivity(3). The therapeutic modality to the children's asthma was by means of bronchodilators and disodium cromoglycate(4), combined with avoidance of offending foods and chemicals. Although the medications provided relief when needed, increased frequency of asthma attacks and continued deterioration of their physical health dictated that a new approach be taken.

An earlier study had shown that asthmatic patients living in hospital rooms experienced reduced bronchial hyperreactivity(5). Similarly, a controlled study of asthmatic children in their homes showed a reduction of wheezing periods and medication(6). The improvement was attributed by the authors to dust/mite reduction.

Dust avoidance measures alone for the children in this study did not yield any measurable improvement. However, use of an air purifier with filters for removal of particulates and gaseous chemical contaminants in their bedroom led to a marked reduction of bronchial spasms at nights. The observed benefits of the low-pollution room led to a low-pollution whole house concept.

The objective was to build a new house that would neither contain the pollutants already known to exist in older homes or newer homes (dust, moulds, combustion gases and formaldehyde) nor introduce other chemical contaminants. Reduced pollen level in the house during seasonal peaks was considered desirable. Energy efficiency, comfort and ease of maintenance were secondary to low-pollution.

MATERIALS AND METHODS

DESIGN AND LAYOUT

The first requirement of a house without a basement was met by the design of a bungalow on an insulated slab foundation. A basement was not desired for several reasons: higher humidity and attendant mould growth, low natural lighting and higher probability of radon contamination below ground level. A single storey was chosen in order to minimize costs. Square footage was limited to 1824 sq. ft.

In the interior design, clothes closets are situated outside the bedrooms to ensure that dusts, moulds and odours absorbed by clothes in other places would be isolated from the sleeping areas. The children's bedrooms and the living areas have a southern exposure to maximize natural light and comfort.

An attached greenhouse on the south side has doors that separate it from the house to ensure that that any moulds from soil and plants are isolated.

MATERIALS AND CONSTRUCTION METHODS

Building materials were chosen for their non-toxicity. Preliminary screening was made on the basis of the chemical composition. If choices were possible, natural materials or those having the lowest content of non-inert substances or least emission of volatile or gaseous components (e.g., low lead solder instead of 50/50 solder, loose fiberglass batts instead of dense fiberglass) were selected.

Exceptional care was taken in the choice of materials used within the living spaces. Pine and cedar were not used in the interior since these woods, known to contain volatile oils, resins and other extractives(7), triggered asthma or headaches in the children. Cedar was used, however, in exterior trims.

Windows were custom-made to avoid wood preservatives(8) that are used in commercial wooden window frames. Redwood was chosen as it did not produce reactions on the children as did cedar or pine. Fungicide-free and non-odorous caulking was selected (CSL Silicones Ltd. #166/343 from Webco Sealants, P.O. Box 1711, Guelph, Ontario N1H 6Z9).

Plywood and particleboard, known sources of formaldehyde and other gases(9), were not used. Cabinets, shelves and interior doors were constructed of solid birch. All wood inside and outside were finished with non-toxic sealants (Crystal Aire from Pace Industries, Inc., 710 Woodlawn Dr., Thousand Oaks, California 91360 and LIVOS paints, Natural Structures & Supplies, Inc., P.O. Box 92, Apohaqui, N.B. E0G 1A0).

Ceramic and quarry tiles were chosen for flooring for their inertness, eliminating the chemical offgassing of synthetic floor coverings(10) and dusts and mites or mould growth from carpeting(11, 12). The ceramic tiles were set on cement without additives (e.g., water-reducing agents, accelerators)(13).

Plaster walls and ceilings using gypsum and lime coat (without plasticizer or bonding agents) on plaster lath(14) eliminated the need for latex or oil-based paints.

A continuous vapour barrier (Tu-Tuf from Sto-Cote Products, Inc., Drawer 310, Richmond, Ill. 60071) enveloped the house on the walls and ceilings beneath the plaster lath. An unbroken piece was ordered to size under the slab. Edges were carefully lapped, caulked and taped to prevent infiltration of substances from the insulation or of radon.

Double wall framing, a modified form of the Saskatchewan wall system, consisting of two sets of 2 x 4 studs and a 5 inch cavity in between accomodated 12 inches of fiberglass batt insulation (R 44). Spruce was used for both exterior and interior framing. The vapour barrier was installed on the interior of the inside stud wall.

For the attic insulation, mineral wool was chosen for its inertness and larger particle size(15) instead of blown-in fiberglass.

A polyolefin (Tyvek) served as the outer sheathing, covered with metal lath and stucco. Roofing material was pre-painted steel, chosen in preference to asphalt-based materials for ease of maintenance and durability.

HEATING AND VENTILATION

Fresh air is continuously brought in by a fan with the motor outside of the air stream. Some house air is mixed with the fresh air for tempering purposes. The air is heated by a hot water copper coil supplied by an Aqua ElektroStandard Heat pump from Sweden (Fiberglas Canada Inc., 4100 Yonge St., Willowdale, Ont. M2P 2B6), then filtered with a passive, electrostatic filter for dust and pollen removal. The filter housing can hold gaseous adsorption media, which have not been necessary since the outside air is good and there are no sources of pollution from the house. The air is distributed to the bedrooms and living areas.

The heat pump module puts the room in which it is located (the mechanical room) under negative pressure. This, in turn, depressurizes a dropped ceiling and kitchen bulkheads which extend throughout the house, making it possible to exhaust from the laundry, kitchen, bathrooms, closets and the spaces under the sink and behind the refrigerator. The dropped ceiling/bulkheads also house the heating and central vacuum ducts. The heat pump reclaims the heat from the exhaust air back into the hot water tank for space heating or domestic use.

RESULTS AND DISCUSSION

Air quality tests carried out by Energy, Mines and Resources Canada for the R-2000 Home Monitoring Program over a three year period were as follows:

	1985	1987	1988
Formaldehyde, ppm			
Living room	0.021	0.053	0.034
Bedroom	0.016	0.020	0.021
Radon, WL*			
Living room	0.004		
Laundry	0.002	0.005	0.006

* WL - Working Level of radon
Health and Welfare Canada guideline for formaldehyde is 0.10 ppm. Interim guideline for radon is 0.10 WL.

The measured formaldehyde level in the bedroom (0.016 - 0.021) is within the known levels of outdoor air (0.005 - 0.03 ppm)(16, 17). The result is not surprising in view of the rigorous exclusion of sources of chemical offgassing from building materials and furnishings. Although volatile organic compounds have not been measured, it is highly unlikely that significant levels would be found.

The slightly higher levels of radon and formaldehyde in 1987 and 1988, coincident with increased humidity in the house, were traced to a clogged filter in the heat pump, which has been corrected since. The slightly higher formaldehyde level in the living room compared to the bedroom is believed to be due to wood aggregate components of a ten year-old piano.

The formaldehyde and radon levels can be used as indicators of the gaseous pollutant levels in the house. The very low measured levels indicate very low degree of chemical contamination. Thus, the design and construction has enabled the control of moulds, dusts, pollens, radon and chemical pollutants.

Apart from the analytical results of the air testing, some comments must be given on the impact of the house on the children.

Marked improvement of the children's health has resulted from living in the house. The younger child, who could not attend regular school owing to almost daily asthma attacks in the school environment, after a three year recuperation period in the controlled environment of the home, is now attending regular school. Un-polluted housing has resulted in remarkably reduced frequency of asthma attacks, no medication being used and no emergency trips to the hospital over the last five years.

CONCLUSIONS

A low-pollution home has been built by a combination of careful selection of non-toxic and non-polluting building materials, tight building techniques and continuous air filtration and ventilation. Emphasis has been placed on controlling the sources of pollutants rather than on dilution. The continuous ventilation prevents mould growth, exhausts stale air and provides a supply of fresh air. The low pollution objective has also resulted in a home that is energy efficient, comfortable and aesthetically pleasing.

ACKNOWLEDGMENTS

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BUILDING WITH LOW-EMITT
PRODUCTS: WHERE DO WE S

W. Gene Tucker
Air and Energy Engineering Res
U. S. Environmental Protection
Research Triangle Park, NC

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INTRODUCTION

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EXAMPLES OF MATERIAL A

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