IMPLICATIONS OF CHEMICAL HYPERSENSITIVITY FOR HOUSING DESIGN

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Abstract

Individual sensitivity to chemical and biological indoor air pollutants will vary considerably, due to such factors as age, stress, nutrition, infection, and genetics. Housing must therefore accommodate a wide range in chemical and biological tolerance and, in any event, should not expose individuals to overloads that could precipitate a state of hypersensitivity in previously healthy people. A number of design and construction features can be used to advantage, in standard housing, to obtain this needed flexibility, without compromising cost or energy conservation. Among the most important are the aerodynamic separation of combustion systems from indoor air, and the provision of a continuous internal air barrier, along with controlled ventilation. Effective separation of house and combustion device air flows is required to preclude poisoning from carbon monoxide and other gases. An air barrier will prevent leakage which can flush pollutants from building envelope materials into the interior. Heat reclamation from exhaust air can be incorporated into the ventilation system to conserve energy, if desired.

Introduction

A number of popular misconceptions about indoor air quality are examined in this paper:

1) Only the hypersensitive population needs specialized housing
2) The hypersensitive population is a fixed group
3) Hypersensitivity cannot be triggered in healthy people
4) Pollutant exposures must be high to cause symptoms
5) Reducing indoor air pollution compromises energy conservation

These misconceptions are reformulated in light of new facts concerning the effects of indoor pollutants on health. One important conclusion is that housing intended for the general population should accommodate a wide range of sensitivities to indoor air contaminants.

Several building construction techniques which would allow homes to accommodate a wider range of sensitivities than at present are reviewed. These techniques are fully compatible with the need to conserve energy. Benefits they may allow include:

- reduction in indoor air pollution from combustion devices, building materials and other sources
- flexibility to accommodate a wide range of sensitivities with a minimum of modifications to the home
- reduction of heat loss
- reduction of building envelope damage caused by moisture.

Review of Popular Misconceptions

Only the Hypersensitive Population Needs Specialized Housing

Fact - there is a small sub-population that is sufficiently hypersensitive to low-level chemical and biological exposures that specialized low-pollution housing is presently a medical necessity for them. (3)

This fact has been known for some time. They are generally the people who get immediate symptoms upon entering a dwelling containing pollutants to which they have become sensitized. It has therefore been assumed that specialized low-pollution housing might be necessary for this sub-population, which is assumed to be a fixed group, but that no adjustments are necessary for the rest of the population.

Fact - There is a larger sub-population of risk groups for whom continued exposure to various indoor pollutants may aggravate disease over a longer period. (1)

It is now known that many other population sub-groups may be more sensitive than the general population to various pollutants. For example, persons with many forms of heart disease can be more sensitive than most to aggravation of their disease upon exposure to carbon monoxide or to compounds which metabolize to carbon monoxide and reduce the oxygen-carrying capacity of the blood. Other groups include pregnant women, infants, the elderly, persons with respiratory disease, persons with severe allergy, and smokers.

The Hypersensitive Population is a Fixed Group

> Fact - Chemical or biological tolerance, even in a healthy population, varies widely and is influenced by such factors as genetic heritage, age, nutritional status, stress and infection. (1)

The fact that the population of persons with higher susceptibility to chemical contaminants (e.g. carbon monoxide, formaldehyde) and biological exposures (e.g. dust, mould, virus) is not a static population has important implications for the design of housing.

For example, a person may in their mid-years tolerate certain chemical exposures without apparent effect. The same person may no longer tolerate the same exposures without symptoms, as they advance in age, while living in the same home. A woman who appears to tolerate a home well may become pregnant, and the sensitivities of both the fetus and the mother may be in a different range than those of the rest of the family. A person who at one time tolerates pollutants leaking from a furnace, or backdrafting from a chimney, may no longer be able to tolerate the same exposure, without symptoms, after a bout of viral illness. Other factors such as nutritional intake, genetic heritage, and stress (e.g. shift work schedules) are also known to affect chemical tolerance.

Hypersensitivity Cannot be Triggered in Healthy People

> Fact - Some indoor residential chemical exposures have been sufficient to trigger a state of hypersensitivity in otherwise apparently healthy individuals. (2)

It has often been assumed that if a person has no history of illness and no family history of allergy or other susceptibility to environmental factors, they are not at risk of becoming hypersensitive. Within the last several years it has been reported that, in some otherwise apparently healthy individuals, a state of hypersensitivity appears to have been triggered by chemical exposures within a dwelling.

The chemical exposures that were reported to be involved in the induction of a state of hypersensitivity were not always at levels popularly considered to be harmful. For example, levels of formaldehyde exposure less than 0.1 ppm, a Canadian guideline for residential exposure, have been associated with the precipitation of hypersensitive states.

There is presently no method of predicting which persons in the population might become more sensitive, independent of known risk factors such as allergic disease or respiratory problems.

Pollutant Exposures Must be High to Cause Symptoms

Fact - Once hypersensitivity is triggered, by whatever means, individuals can become intolerant to a wide range of exposures, usually at relatively low levels of exposure that were previously well tolerated. (2)

It has for a long time been assumed by many people that pollutants, or mixes of pollutants, must be present above certain toxic concentrations in order to have an adverse effect. For hypersensitive individuals, it has been acknowledged that symptoms can be present even at levels well below accepted guidelines. The nature of their response to pollutants is also such that reduction of the level of any one single pollutant in the air may not be sufficient to significantly reduce symptoms.

For example, for people who have been sensitized, reduction of formaldehyde levels alone may not be sufficient to terminate symptoms. An overall reduction of all pollutants, to very low levels, may be required, and strict attention should be paid to all pollutant sources, particularly in cases where buildings are being renovated to reduce a single pollution source, such as urea-formaldehyde foam insulation.

Reducing Indoor Air Pollution Compromises Energy Conservation

Fact - Many of the steps taken to build energy efficient houses are also required (or desirable) for improvements in indoor air quality. (3)

Many have assumed that indoor air pollution cannot be reduced without compromising energy conservation, and that techniques for reducing indoor air pollution may involve either higher capital costs or higher operating costs than existing techniques. The following section will discuss several basic techniques which can contribute significantly to both goals -- energy conservation and air quality.

Building Techniques

A number of basic building techniques can contribute to the minimization of both indoor pollution and energy loss.

i) Aerodynamic Separation of Combustion Systems from Indoor Air

Recent studies in Canada have indicated that chimney draft either stagnates or reverses in many houses, leading to accumulation of combustion products in a home. In some cases, dangerous levels of carbon monoxide are released into the indoor air. Over the period 1973 to 1983, over 200 deaths from incomplete combustion of domestic fuels were reported in Canada.

As more and more houses are rendered tighter, to reduce heat loss, the potential for backdrafting episodes increases, if adequate provision is not made for providing air for combustion devices and other air users. Such dangerous conditions might be avoided by making it an accepted rule that all combustion equipment must be 'aero-dynamically separated' from the rest of the indoor air in a home. For example, all new furnaces could be installed with direct combustion air ducts from the outside.

ii) <u>Provision of a Continuous, Repairable Internal Air Barrier</u>

Leaky building membranes can lead to three major types of problems:

- contamination of interior air by flushing pollutants from building materials into the home, through cracks.
- loss of heat, by exfiltration of air through cracks.
- damage to the exterior envelope, caused by condensation within the wall, from exfiltration of moist interior air.

In the recent past, the response to the problems of heat loss and moisture damage has been to tighten the building envelope, eliminating random leakage as depicted in Figure 1 below, and changing the building to a tightly sealed box, as depicted in Figure 2.

Tightening the envelope can also serve to reduce contamination of the interior air from exterior building materials, such as insulation. However, it is necessary to introduce deliberate exhaust and intake openings, as depicted in Figure 3, along with fail-safe ventilation, to avoid a buildup of indoor pollution from other sources within the building.

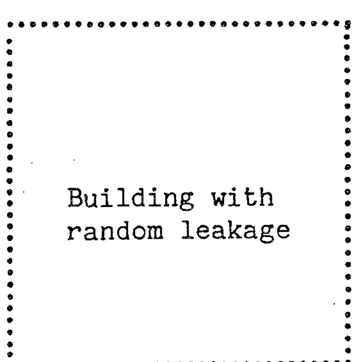

Fig. 1

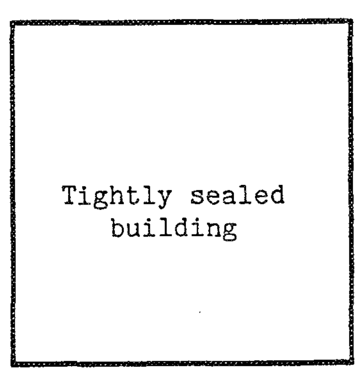

Fig. 2

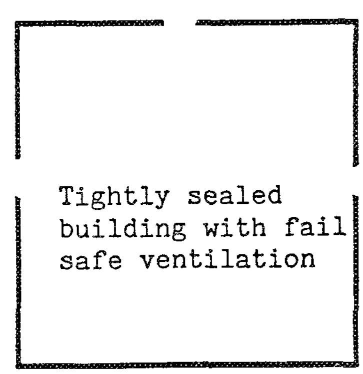

Fig. 3

The 'air' barrier should be a solid, continuous surface, designed to eliminate air leakage and to resist peak pressure variations in windy conditions. Ideally, it would be detailed to allow future access to repair cracks, and located where it will be subject to relatively stable temperature and humidity conditions. It may or may not be separate from a vapour barrier, which is necessary to retard diffusion of moisture (and other chemicals) through the building envelope materials.

Energy loss can be minimized by reclaiming heat from exhaust air, either by direct exchange with intake air, or by heat pump extraction at the exit point. Variable control of intake and exhaust rates allows the creation of different pressure and ventilation conditions, to accommodate either different occupants or different activities within the building. Homes with airtight skins should be built with a 'fail-safe' ventilation system that guarantees ventilation is either continuous, or not able to be interrupted for more than a specified period.

iii) Low Emission Materials and Furnishings

Materials with the least emissions for equivalent performance are the most desirable choice for structural, finish, and furnishing materials in homes that may have to be compatible with a wide range of environmental sensitivities.

Encouraging manufacturers to create such products, and widespread use of them, could have a number of benefits:

- minimize indoor pollution by controlling the sources
- accommodate a wide range of sensitivities
- insure against illness during periods of especially low tolerance, e.g. viral infection
- insure against reduction of chemical tolerance of healthy individuals, through unnecessary chemical exposures
- minimize the cost of ventilation, by curbing pollution at the source.

Conclusions

Popular misconceptions about indoor air quality and housing were reviewed and reformulated in light of new facts concerning the health effects of indoor pollutants.

Some of the new concepts have an important bearing on housing design:

- In addition to the hypersensitive individual, there is a larger sub-population of risk groups for whom continued exposure to various indoor pollutants is inadvisable.

- The sensitivity of occupants to indoor pollutants within their dwelling may change during the period of occupancy. Any one home may have to accommodate a broad range of sensitivities.

- Mixes of indoor pollutants, all at levels below accepted toxic limits, may cause some individuals to become ill. Reduction of levels of single pollutants may not always decrease symptoms of illness.

- Many steps taken to build energy efficient houses are also desirable for improvements in indoor air quality.

If practical and cost-effective techniques for lowering indoor air pollution levels can be developed, these should be considered for application to housing intended for the general population, rather than just for a sub-population, in order to avoid increasing the population of sensitive persons, and to accommodate natural variations in sensitivity over a person's lifetime.

Construction techniques which may be most useful in achieving lower indoor pollution levels include:

- aerodynamic separation of all combustion devices from the indoor air of a home

- provision of a continuous, repairable internal air barrier

- provision of a fail-safe, fresh-air ventilation system, with variable control, combined with heat reclamation from exhaust air.

- selection of low emission materials and furnishings.

These techniques are fully compatible with the goal of energy conservation. Homes incorporating these basic techniques would also be adaptable, with little modification, to either hypersensitive or non-sensitive occupants. They can also be combined with additional methods, such as 'spot' venting of appliances and activities, maintenance with low-emission products, air filtration, and vented storage, to further minimize indoor pollution where necessary.

References

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