Ventilation Standards and High Performance Buildings

The most recent version of the residential standard (Standard 62.2-2004), changes the delivery mechanism required from an assumption that infiltration would provide the ventilation necessary to a requirement for continuous, mechanical ventilation—a distinct improvement.

By David T. Grimsrud, Ph.D., Fellow ASHRAE

How do we give credit for higher-grade buildings in a ventilation standard?

A recent e-mail exchange between Joseph Lstiburek, Ph.D., P.Eng., Fellow ASHRAE, and member of ASHRAE Standing Standards Project Committee (SSPC) 62.2, and Max Sherman, Ph.D., Fellow ASHRAE, and chair of the standards project committee that wrote the original version of ASHRAE's residential ventilation Standard 62.2, has provoked discussion. The key points of the exchange have been edited and summarized below.

Lstiburek argues that houses built to U.S. Department of Energy's Building America (BA) recommendations should not have to use the ventilation rates prescribed by ANSI/ASHRAE Standard 62.2-2004, *Ventilation for Acceptable Indoor Air Quality in Low-Rise Residential Buildings*:

The logic is that BA houses have excellent source control and distribution and excellent combustion safety. Since 62.2 does not address these issues sufficiently, it can be argued that the 62.2 rates are based on houses that do not have excellent source control and distribution. Therefore, houses that address these weaknesses assumed in the 62.2 rates can be ventilated at reduced 62.2 rates.

From Sherman:

You argue that BA houses are better and do not need as much ventilation, but again in many cases you have the sign wrong. BA houses are tighter and more insulated and, therefore, get less infiltration than the default in 62.2 and so should probably have more mechanical ventilation. Building America houses often have conditioned attics and crawlspaces probably allowing more volatile organic compounds (VOCs) and toxins into the indoor air. BA houses often contain more manufactured wood products, which are known to emit VOCs. I am aware of no study that examines these differences, so I do not know how significant they really are, but they could easily be more significant than the difference between an induced draft and sealed combustion furnace. Due diligence on BA's part would be to sort this out. In the meantime, prudence might indicate increasing, not decreasing, rates.

Lstiburek responds:

- *Better ventilation systems should count for something.*
- *Better enclosures should count for something.*
- *Better source control should count for something.*
- *Location should count for something.*
- *One of the functions of Building America is to account for these factors.*

Sherman:

If BA is delivering performance, then it very much needs to meet 62.2—and some would argue (it should go) beyond. I would challenge you to prove that the IAQ is better in an under-ventilated BA home than in a properly ventilated conventional home. If anything, people have higher expectations in a BA home not lower ones.

Lstiburek:

In the meantime, I will support Standard 62.2 as a minimum standard. However, I will continue to promote better means, methods, and systems. In my professional opinion, these better means, methods and systems involve supplying air from a known location/source, filtering and distributing the air, constructing a superior enclosure, controlling the driving forces acting across the enclosure, selecting appropriate equipment and appliances, selecting appropriate materials and ventilating the enclosure at a rate lower than that prescriptively specified by Standard 62.2.

Sherman:

We do agree that:

1. If you are going to bring supply air into a single place, you'd better distribute it;

Reference	Results	Design	Buildings	Population	Ventilation Type	Effect Measured
2, 10	Reduced ventilation rates increased the concentration of house dust mites because of higher relative humidity.	Cross-sectional	Houses (n = 96)	Families With At Least One Asthmatic Member	No Data	Medical Diagnosis Of Asthma; Skin Prick Test For Allergies
3	At high CO_2 concentration the prevalence of nocturnal breathlessness was increased.	Case Control	Flats (n = 45), Houses (n = 43)	Adults (n = 88)	Natural, Mechanical	Self Administered Questionnaire And Clinical Examination Of Asthma Or Atopy
4	Infestation of house dust mites higher with low air-change rates.	Case Control	Houses (n = 29)		Natural	House Dust Mites Allergen Concentration
5	Low air change rate increased risk of bronchial obstruction.	Case Control	Houses (n = 172)	Children (n = 172)	Natural, Mechanical	Doctor Diagnosed Bronchial Obstruction
6	Installation of mechanical ventilation reduced dust mite infestation and relative humidity.	Case Control	Houses (n = 40)	Children (n = 27), Adults (n = 13)	Natural, Mechanical	Symptoms; Clinical; Pulmonary Functions; House Dust Mite Concentration
7	New apartment buildings, single-family homes with crawlspace/slab foundations, elevated indoor humidity, and reported winter window condensation were associated with recurrent wheezing in infants. Air-change rate did not seem to affect the risk.	Case Control	405 Apartments, 135 Houses	181 Cases and 359 Controls All Less Than 2 Years Old	Mechanical Ventilation in 71% of Case Homes, 64% of Control Homes	Questionnaire Evaluation By Parents Reporting 3 Or More Episodes Of Wheezing Followed By Use Of Inhaled Steroids Or Symptoms Of Bronchial Hyperactivity.
8	Case children with rhinitis and eczema had lower ventilation rates measured in the child's bedroom than control children. No difference was seen between children with asthma and controls. A dose-response relationship is suggested.	Case Control	390 Homes (346 single family, 44 multifamily)	198 Cases (Children With Two of Three Symptoms of Wheezing, Rhinitis, Eczema) Compared to 202 Health Controls	65% Natural Ventilation, 35% Mechanical Exhaust or Balanced	Comparisons of Ventilation Rates and Doctor-Diagnosed Asthma, Rhinitis and Eczema

Table 1: Epidemiological studies on ventilation rates in single and multifamily residences.

2. *Efficiency is not a "dumb thing" if it makes performance (including health & safety) better;*
3. *You cannot judge performance without criteria and standards are consensus criteria;*
4. *62.2 is a good place to start, but should continue to be improved;*
5. *Markets can be powerful forces for change when the market forces are aligned to provide the desired performance.*

I apologize to the authors for the severe truncation of their discussion.

Before addressing the central issue of their exchange—adjusting requirements for an improved class of buildings—it is useful to review how rates in ventilation standards evolve.

One can see current trends by examining the residential rates in the Standard 62 series.

The 1981 version of Standard 62 specified residential ventilation requirements of about 0.45 to 0.50 air-changes per hour (ACH), depending on the room count and size of the house. The 1989 revision of Standard 62 reduced that requirement to 0.35 ACH, largely for energy reasons. That is retained in the 2001 version of the standard.

The most recent version (Standard 62.2-2004), changes the delivery mechanism required from an assumption that infiltration would provide the ventilation necessary to a requirement for continuous, mechanical ventilation—a distinct improvement.

The new rate requirement depends on the size and number of bedrooms (a surrogate for number of people expected to occupy the house). Requirements for a 1,500 ft^2 (139 m^2) two-bedroom house and a 3,500 ft^2 (325 m^2) four-bedroom house are 0.35 ACH, and 0.29 ACH, respectively. This includes an assumed contribution of 2 cfm per 100 ft^2 (1 L/s per 9 m^2) for infiltration.

Thus, there has been a trend toward lower rates without support of the proposition that these rates are acceptable. The strongest justification for changing rates would be epidemiological studies that link health effects to particular ventilation rates.

What is the epidemiological basis for the ventilation rates? Wargocki and colleagues (EUROVEN) review epidemiology studies that link ventilation and health effects in several building types.[1] The summary describes five papers contained in *Table 1* that link residential ventilation rates and measurable health outcomes.

The consensus of the study group who performed the review, including 11 European scientists with expertise in medicine, epidemiology, toxicology, and engineering, is that rates greater than 0.5 air-changes per hour (ACH) reduce the infestation of house dust mites (HDM) in areas of the world with Nordic climates.

Since infestation of HDM are causally linked to development of asthma and triggers for asthma attacks, the recommendation can be recast to state that ventilation rates less than 0.5 ACH increase the risk of asthma in occupants of residences located in regions with Nordic climates. This

would include many parts of the northern U.S. and Canada.

Table 1 includes two studies[7,8] not available at the time of the EUROVEN review. These results do not contradict the EUROVEN summary statement, but rather add substance to the review's conclusion. Differences in health outcomes reported in the seven studies are not large. However, taken together, they support a conservative expression that health risks increase in residences when ventilation rates are reduced.

It is shocking that searching the building research literature from the past 25 years yields only seven studies that attempt to address the question of the health basis for residential ventilation standards. We must do more to address this fundamental issue affecting the population we serve. The ongoing dampness in buildings and health study in Sweden should serve as a model for the kind of the epidemiological study we need.[9] Health scientists and building scientists need to work together on these issues.

Epidemiology is a coarse measurement instrument and requires a strong measurement signal to demonstrate causality. Since ventilation is a general control strategy, its effects are more diffuse than a strategy such as source removal. Consequently, the association between whole house ventilation rates and health outcomes always will be difficult to demonstrate.

Standard 62.2 is a minimum standard. It has issues that must be addressed by the SSPC. We invite suggestions for change. Suggestions should contain evidence that the change will improve air quality in residences.

In the meantime, we must be cautious of reducing our minimum standards for ventilation rates until health-based studies demonstrate the efficacy of these reductions.

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Asthma, Allergies in Children, Parents

Asthma and allergies among small children are associated with a number of risk factors in the indoor environment. In investigations of building-related health problems, many factors have to be considered, including "dampness" emissions from building materials, and ventilation rates.

With the aim of identifying health-relevant exposures in buildings, an epidemiological study "Dampness in Buildings and Health" (DBH) started in 2000 in Sweden.[9] The health focus of the study is on asthma and allergic symptoms among small children and their parents. The study's first step was an epidemiological cross-sectional questionnaire on housing and health involving 14,077 preschool children in the county of Värmland in Sweden from March through April 2000.

Self-reported moisture-related problems in the building were strongly associated with asthma, allergic symptoms, and airway infections among children and adults.

Other factors associated with symptoms among the children were allergic heredity, smoking in the family, male gender, urban living, a brief time of breast feeding, pet keeping, daycare attendance, non-farming life and some food habits.

The second step in the study was a nested case-control study including 198 children with symptoms and 202 healthy controls. A detailed clinical examination by physicians in parallel with extensive inspections and measurements in the subjects' homes were conducted from October 2001 to April 2002.

The influence of selection bias in case-control studies has been studied, and questionnaires on self-reported symptoms and building characteristics have been validated. Examples of identified risk factors for allergic symptoms are inspector-observed dampness, a low ventilation rate, endotoxin, Penicillium and phthalates in dust.

In the third phase, a five-year followup study will be carried out during 2005. The same questionnaire as used in DBH-phase 1 will be distributed to the 10,852 children/parents who responded to the first questionnaire in 2000.

Finally, in a fourth phase, controlled experimental studies in climate chambers and in vitro tests regarding findings from DBH-Phase 2 are planned to be conducted during 2004–08.