ASHRAE JOURNAL

Indoor Air Quality For Residential Buildings

By Max Sherman
Fellow ASHRAE

ASHRAE has long been in the business of ventilation, but most of the focus of that effort has been in the area of commercial and institutional buildings. Residential ventilation traditionally was not a major concern because it was felt that between operable windows and envelope leakage, people were getting enough air. In the quarter of a century since the first oil shock, houses have become much more energy efficient. At the same time, the kinds of materials and functions in houses were changing in character in response to people's needs. People also were becoming more environmentally conscious not only about the resources they were consuming but about the environment in which they lived.

All of these factors contributed to an increasing level of public concern about residential indoor air quality and ventilation. Where once there was an easy feeling about the residential indoor environment, there was now a desire to define levels of acceptability and performance. Many institutions, both public and private, have interests in indoor air quality, but ASHRAE, as the professional society that has had ventilation as part of its mission for more than 100 years, was the logical place to develop a consensus standard. That standard is ready now for its first public review.

ASHRAE Standard 62.2P, *Ventilation and Acceptable Indoor Air Quality in Low-Rise Residential Buildings* defines the roles of and minimum requirements for mechanical and natural ventilation systems and the building envelope intended to provide acceptable indoor air quality. It applies to spaces intended for human occupancy within single-family houses and low-rise multifamily structures, and it generally excludes institutional buildings.

Currently, two of the most important and contentious areas that ASHRAE works in are energy efficiency and indoor air quality. Any reader of *ASHRAE Journal* will be familiar with ANSI/ASHRAE Standard 62-1989, *Ventilation for Acceptable Indoor Air Quality* and ANSI/ASHRAE/IESNA 90.1-1989, *Energy Efficient Design of New Buildings Except Low-Rise Residential Buildings* because rarely an issue goes by without some significant mention of them. Standard 62-1989 is the parent standard from which the residential version originated.

In the early 90s, a new committee was formed to update Standard 62-1989. One of the recognized needs of the revision was to expand the residential section. The product of that committee's work was a completely new document, known simply as "62R." (See Steve Taylor's article in the Febuary 1996 *ASHRAE Journal*.) While that ill-fated document never made it past its first public review, it did contain an entire chapter on residential ventilation and actually began to provide useful guidance to the builder. The large number of comments on that section convinced the Society to begin an effort to produce a stand-alone residential ventilation standard by authorizing Standard Project Coinmittee (SPC) 62.2P to begin work.

In developing the proposed standard, the committee recognized that many different kinds of houses exist, in many different climates, and with many different styles of construction. To accommodate these differences, the major requirements were designed with several alternate paths to allow users flexibility. Some requirements are performance based, with specific prescriptive alternatives. The draft recognizes that there are several different ways to achieve a specified ventilation rate and allows both mechanical and natural methods.

Three primary sets of requirements are in the draft including a host of secondary ones. The three primary sets involve whole-house ventilation, local exhaust, and source control. Whole-house ventilation is intended to dilute the unavoidable contaminant emissions from people, materials and background processes. Local exhaust is intended to remove contaminants from those specific rooms (e.g., kitchens) in

About the Author

Max Sherman is a senior scientist at Lawrence Berkeley National Laboratory in Berkeley, Calif., and the group leader of its Energy Performance of Buildings Group. He is the chairman of ASHRAE Standard Project Committee 62.2P, Ventilation and Acceptable Indoor Air Quality in Low-Rise Residential Buildings.

Natural Ventilation	Climate		
Application	**Mild**	**Temperate**	**Severe**
Toilet	Yes	Yes	No
Utility	Yes	Yes	No
Kitchen	No	No	No
Bathroom	No	No	No
Whole-House	**Yes**	**No**	**No**

Table 1: Climatic acceptability of natural ventilation.

which sources are expected to be produced by design. Other source control measures are included to deal with those sources that can be reasonably anticipated and dealt with.

The secondary requirements focus on properties of specific items needed to achieve the main objectives of the proposed standard. Examples include sound and flow ratings for fans and labeling requirements. Some of the secondary requirements, as well as the guidance in the appendices, help keep the design of the building as a system from failing because of the ventilation systems that were installed. For example, ventilation systems that push moist air into the building envelope can lead to material damage unless the design of the envelope is moisture tolerant.

It often is difficult to read a standard and understand the purpose of a particular requirement, let alone the rationale for it. Even those who have been close to the process may misstate or confuse particular issues. Articles in the press have mischaracterized aspects of the standard. In the course of developing the draft, many people have asked good questions either implicitly or explicitly. I have recreated the important questions and answered them below:

Why do we need a new standard? Isn't what is in Standard 62-1989 good enough?

The half page of residential requirements in Standard 62-1989 has many shortcomings. First and foremost, it is not in code language and could not be adopted easily as a code. Secondly, it is very vague. Some have interpreted it to mean almost nothing, while others have interpreted its rate requirements to be rather severe. Finally, it leaves out many issues that were felt both by the 62R public review and by the current committee to be important in the residential environment. In short, it does not come close to meeting the charge that ASHRAE has laid out.

Why couldn't the residential parts be handled in the Continuous Maintenance with the rest of Standard 62-1989?

ASHRAE felt that it was important to separate the residential parts from the commercial and institutional parts for several reasons. The target audiences were very different and users of the residential parts wanted a document that addressed their needs. The technical expertise for the committee resided in different people and thus there was not enough expertise on the old Standing Standard Project Committee 62. Finally, the basic

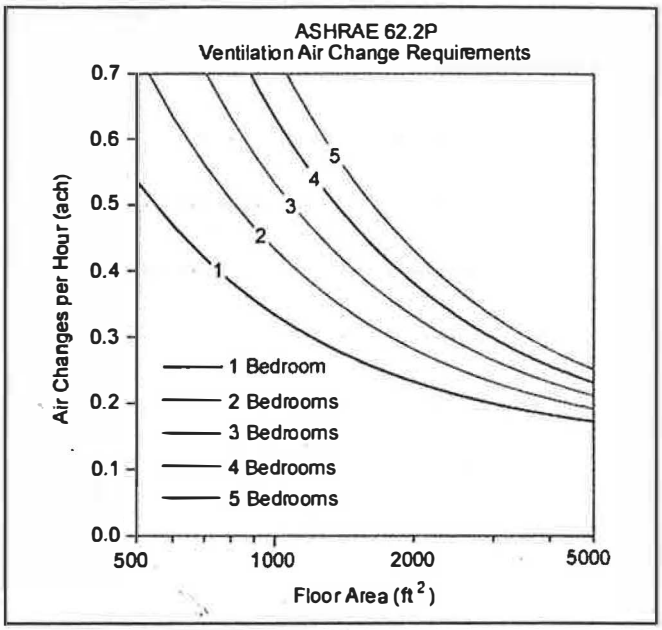

Figure 1: Minimum delivered ventilation for different size houses.

assumptions about who controlled the sources and the systems, who was responsible for design, operations and maintenance, and what kinds of excursions might be tolerable were very different in a home environment.

How do the rates in 62.2P compare with Standard 62-1989?

The total whole-house rate in the draft depends less on the floor area and ceiling height of the house than does that of Standard 62-1989. Expressed in airflow, the rates fall in a narrower band of flow. In general, the airflow requirements in the draft are lower for larger houses and higher for smaller houses than that of Standard 62-1989. The local exhaust rates are mainly the same as for Standard 62-1989. In both cases, however, the proposed standard contains more detail and is more clear on how to apply the rates.

What are the whole-house rates that the draft intends to deliver?

The proposed standard works both in flow rate per person and flow rate per unit floor area, but we can bring all of that together to get an equivalent air change rate for a typical house. *Figure 1* shows the equivalent air exchange rates required by the standard.

***Figure 1* is in terms of bedrooms, not people. Why is that?**

The proposed standard assumes that the design occupancy is two people for the first bedroom, plus one for every bedroom after that. Where different design occupancies are known, they should be used. The actual number of people at any one time can be above or below the design value.

Does that mean that the house will be under ventilated when there are more people?

No. The draft has a requirement for total ventilation capacity

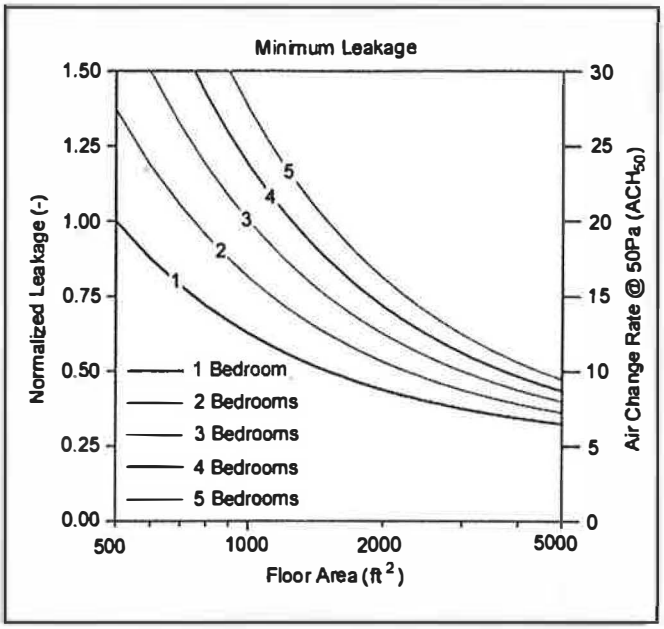

Figure 2: Minimum leakage levels needed to meet whole-house ventilation requirements by infiltration alone. Approximate conversion to air changes at 50 Pa is included for convenience.

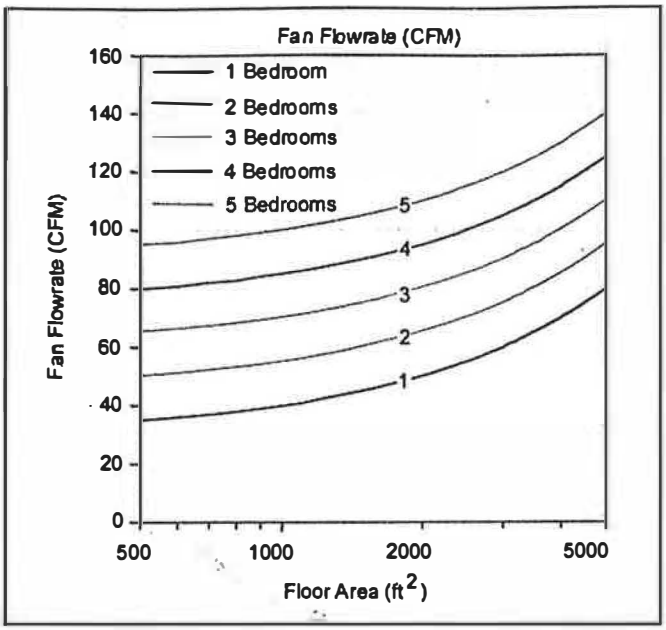

Figure 3: Minimum size of whole-house ventilation fan, assuming continuous operation and default infiltration credit.

in excess of these base rates. This requirement gives occupants the ability to increase their ventilation when they determine it to be necessary, as might be the case for high occupancy or activities such as cleaning, painting, etc.

When does 62.2P credit occupant use of windows?

The ventilation capacity requirement can be satisfied by windows almost all the time. Use of windows can help to meet other requirements under some circumstances. An infiltration credit is in the standard that accounts for the operation of windows during mild weather. The whole-house requirement may be met exclusively with windows in mild climates. The local exhaust requirements in toilets and utility rooms can be met with windows in most climates. If known barriers to window operation exist, such as being in a noise abatement zone, they should not be used. Because of the poor pollutant removal efficiency of operable windows, they do not meet the local exhaust requirements in kitchens or baths. *Table 1* indicates the climatic acceptability of operable windows.

Does the proposed standard give credit for infiltration?

Yes. The draft allows infiltration to provide some or all of the required ventilation. The default credit is based on a relatively tight house, but if an airtightness measurement is made, the actual tightness can be used.

Is the infiltration credit larger in more severe climates?

No. The infiltration credit is based on the weather in a presumed critical week. This critical week is when the weather gets extreme enough that occupants decide not to open their windows for the season. The driving forces for this week and envelope tightness are used to calculate the infiltration credit. Where the critical week may be on the calendar will be different in different climates, but the credit size is independent of climate. The energy cost of infiltration, however, is climate dependent.

Can there be a big enough infiltration credit to eliminate whole-house mechanical ventilation?

Yes. There is no maximum infiltration credit, but an envelope tightness measurement is required to get anything over the default credit. Such a strategy may not be the best choice for new construction, but much of the current stock of buildings is quite leaky and could meet the whole-house requirement through infiltration alone. *Figure 2* indicates the minimum leakage necessary to meet the whole-house requirements of the standard on infiltration alone.

Will the proposed standard replace ANSI/ASHRAE 136-1993, *A Method of Determining Air Change Rates in Detached Dwellings*?

Yes and No. Both standards address how infiltration can be used to meet ventilation requirements, but different assumptions are made. Standard 136-1993 looks at long-term (i.e., seasonal or annual) exposures to pollutants and so tolerates periods of low ventilation. 62.2P uses the time base of a week rather than a year and is less tolerant of periods of low ventilation. The net effect is that the draft gives less credit for infiltration than does Standard 136, especially in severe climates.

How big a fan is needed to mechanically ventilate a house?

The calculation depends on the size of the house, but using the default infiltration credit the whole-house mechanical ventilation requirement typically falls in the 60 cfm to 100 cfm (30 L/s to 50 L/s) range. A larger infiltration credit would reduce, or potentially eliminate, the fan requirements. *Figure 3* shows the

minimum fan size that will meet the whole-house venilation requirements, assuming default infiltration credit.

What has changed for kitchen ventilation?

The draft requires that an exhaust fan be installed in the kitchen (and also the bathroom). Windows are not deemed sufficient to control the moisture and cooking by-products. Because of the low capture efficiency at low airflows, vented range hoods are required if the installed exhaust capacity does not provide at least five kitchen air changes per hour (see *Table 2*).

Application	Continuous Flow	Intermittent Capacity
Kitchen	5 air changes per hour	100 cfm (50 L/s)
Utility	20 cfm (10 L/s)	50 cfm (25 L/s)
Bathroom	20 cfm (10 L/s)	50 cfm (25 L/s)
Toilet	20 cfm (10 L/s)	50 cfm (25 L/s)

Table 2: Minimum local exhaust airflow rates.

Are there new rooms that require local ventilation?

Yes, potentially. Rooms with unvented combustion appliances require local ventilation to remove the products of combustion. Laundry/utility rooms require local ventilation because of the materials normally stored there and the activities that normally take place there. In some climates, a window can supply this ventilation. A clothes dryer also may supply this ventilation (see *Table 2*).

Can recirculating fans meet any local ventilation requirements?

No. The local ventilation requirements specify that the air must be exhausted outside. Supplemental filtration, however, is not prohibited. The standard also requires that all clothes dryers be vented to the outside.

Does this mean that houses have to have six fans to meet the proposed standard?

No. A large house may have several rooms that require exhaust, but even in those situations in which mechanical whole-house and local ventilation is required, the standard can always be met with one or two fans, if remote-mounted, branched exhaust fans are used. Certainly, there will be cases in which one may choose to install six individual fans, but the draft standard allows flexibility of design. The designer will need to consider first cost, energy cost and value to the customer in making that determination.

What specifications do the various fans have to meet?

Because people will disable noisy fans, most surface-mounted fans must meet sound requirements of 1.0 sone to 1.5 sones. Because different fan and duct arrangements may not deliver the proper amounts of air, fans must either have their installed flow rate measured or must meet prescriptive requirements on sizing and rating. Finally, ducted supply systems and the central air handler must meet minimum filtration efficiency of 60% for 3-micron particles.

Can the central air handler be used to supply the whole-house ventilation?

Yes, but only if it has a timer control. Systems that pull in outdoor air through the air handler fall into the category of intermittent, whole-house ventilation. The draft allows various types of intermittent ventilation schemes to be used to meet the whole-house requirement. A key provision, however, is that they must be controlled to operate at least one hour in twelve and that the minimum daily on time can be estimated. The draft describes how to increase the intermittent ventilation rate to make it equivalent to the continuous requirements.

Can humidistats or other IAQ sensors be used to control the ventilation system?

Only as supplementary control methods. It is rare in a residential environment that the need for base ventilation is determined by a single pollutant or single class of pollutant. Control of the whole-house ventilation system with, for example, a humidistat can lead to inappropriate ventilation rates. Continuous whole-house ventilation is the preferred method.

Are there special considerations in hot, humid climates?

Yes. Outdoor moisture is of particular concern in hot, humid climates. Ventilation often increases rather than decreases indoor humidities. Mechanical cooling (or dehumidification) is often the only way to reduce indoor moisture levels. Because of the risk of condensation in or on the building envelope, whole-house exhaust ventilation should not be used unless a moisture tolerant envelope design exists. In houses without mechanical cooling, whole-house mechanical exhaust and natural ventilation is allowed.

Can any required mechanical ventilation cause problems for vented combustion appliances?

Probably not. Depending on the tightness of the envelope, exhaust fans can depressurize the house and cause naturally aspirated combustion appliances in the conditioned space to backdraft. The problem is less critical in a leaky house, but even in a tight house the minimum airflows required by the proposed standard are unlikely to cause any problems. Clothes dryers alone, for example, normally exhaust more than is required to meet 62.2P. The real depressurization culprits often are large downdraft or commercial-size kitchen ventilation systems that are becoming popular in upscale homes. These flows can be 10 times higher than any requirements of the draft.

What are the requirements for naturally aspirated combustion appliances in the conditioned space?

First, there must be a carbon monoxide alarm. If the two largest exhaust devices are not too big, there are no other requirements. Otherwise, the appliance must either have a spill switch to stop operation in case of backdrafting or it must pass a house depressurization test, as given in an appendix. If all else fails, 62.2P allows for a compensating supply fan to be installed. Sealed combustion appliances or appliances outside the pres-

sure envelope need not worry about these requirements.

What are the requirements relating to attached garages?

Because of the health hazards associated with pollutants from the garage getting into the house, the committee has added several requirements. The door to the house must have an automatic closing device to minimize the direct communication between house and garage. There may not be any return ducting or air handlers in the garage, and the house must have a carbon monoxide alarm.

Are there really as many new requirements as it seems?

Not really. Very few of the requirements in the proposed standard are not related directly to requirements in relevant codes, standards or guidelines currently in use. Many of the requirements in the draft standard are already code in parts of the United States, but perhaps none of them is code everywhere. The draft is the committee's best estimate of the minimum set of requirements necessary to achieve the objective. For some jurisdictions, adopting it as a code would entail many new requirements, for others it may be almost none.

Does the document contain more than just requirements?

Yes. More pages of guidance are in the appendices than there are pages of requirements in the body of the draft. Users of the standard need some guidance in selecting among the alternative paths and in understanding the ramifications of some choices. The draft has informative appendices on Operations and Maintenance, Air Filtration, Pollution Sources Exposures and Control, and on HVAC Systems.

What data was used to develop this draft?

As in most consensus standards, the primary data source is the assembled knowledge, experience and expertise of the technical experts comprising the committee. Between the committee and other participants there are centuries of experience on relevant topics. A significant amount of the archival research work can be found in the proceedings of the 1999 ASHRAE Annual Meeting in the reviews by Grimsrud and Hadlich.

Does the draft address energy issues?

Not primarily. Conditioning ventilation air has, of course, an energy cost, which can be quite large in very cold or hot, humid climates. The committee considered energy impacts in its debate, but acted only when it was clear that there was always a better way to do something. Many of the allowed ventilation systems (e.g., natural ventilation, infiltration or intermittent whole-house ventilation) can be quite energy inefficient in some circumstances. Fans themselves have differing efficiencies. Heat recovery ventilation can be cost-effective in some circumstances. These issues are important in the overall design of a good house but are beyond the scope of this standard.

Is it a done deal?

No. The draft must undergo public review, the purpose of which is to inform the committee about issues, concerns or problems that individuals may see in the standard. While the committee would be happy if everyone accepted it as is, there is a recognition that issues large and small may have been missed or not given enough thought. Thoughtful, constructive and concise public review comments will be of great value to the committee.

Taken as a package, ASHRAE Standard 62.2P represents a significant step forward for ASHRAE in applying professional consensus standards to the residential area. Houses meeting this standard will have improved indoor air quality, reduced moisture problems, and provide better value to the homeowner and occupant than those that do not.

The Public Review Process

Standard 62.2P will undergo the American National Standards Institute (ANSI) public review process that is used for ASHRAE standards. The review could occur as early as this summer and will be announced in *ASHRAE Journal*. Instructions for submitting comments are provided in each public review draft and will be available at *www.ashrae.org* under *Standards/Public Review Draft Standards*.

This article covers the issues addressed in the draft. These issues also will be discussed at a forum and SPC 62.2 committee meeting on June 20 at the ASHRAE Annual Meeting in Seattle. ■

Bibliography

ASHRAE Standard 119-1988, *Air Leakage Performance for Detached Single-Family Residential Buildings*.

ASHRAE Standard 136-1993, *A Method of Determining Air Change Rates in Detached Dwellings*.

Grimsrud, D.T. and D.E. Hadlich. "Residential pollutants and ventilation strategies: volatile organic compounds and radon," *ASHRAE Transactions* (in press for 1999 ASHRAE Annual Meeting).

Hadlich, D.E. and D.T. Grimsrud. "Residential pollutants and ventilation strategies: moisture and combustion products," *ASHRAE Transactions* (in press for 1999 ASHRAE Annual Meeting).

Taylor, S. "Determining ventilation rates: revisions to standard 62," *ASHRAE Journal*, February 1996.

Acknowledgments

This work was supported by the Assistant Secretary for Energy Efficiency and Renewable Energy, Office of Building Technology of the U.S. Department of Energy under contract no. DE-AC03-76SF00098. ■