ASHRAE JOURNAL

Ventilation Through the Years: A Perspective

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What does ASHRAE recommend for ventilation rates and why? How is recommended airflow determined for a space and for a mechanical ventilation system? The answers to these questions have evolved over the years.

Standard 62-1973

ASHRAE first published Standard 62-1973, *Standards for Natural and Mechanical Ventilation*, to replace the 1946 version of the ventilation section of ASA Standard A53.1, *Light and Ventilation*. According to its scope and purpose, Standard 62-1973 defines "...ventilation requirements for spaces intended for human occupancy and specifies minimum and recommended ventilation air quantities for the preservation of the occupant's health, safety, and well-being." Both minimum allowable rates and a recommended range of ventilation rates were listed for each of 271 space types, in terms of ventilation air per occupant. Space type categories included residential (10 types), commercial (87 types), industrial and agricultural (116 types), institutional (47 types) and organizational (11 types).

Based upon the best available scientific knowledge and technical knowledge (professional judgement), minimum rates ranged from 5 cfm (2.5 L/s) per person (in auditoriums, for instance) to 40 cfm (20 L/s) per person for research-institute animal rooms. The rates listed apparently resulted from assumptions regarding the presence or absence of smoking and presumably other factors, such as activities and other sources within the space.

Acceptable ventilation air quality was defined by contaminant concentration limits, including a specific allowable level for each of seven specific contaminants and one-tenth the Threshold Limit Value for all other contaminants. Using this definition, return air could be cleaned and recirculated as ventilation air, reducing the outdoor air requirement to as little as 15% of the tabulated rates, but no less than 5 cfm (2.5 L/s) per person.

While the standard listed a typical estimated occupant density for each space, it did not allow consideration of space or system occupancy variations over time (i.e., occupant diversity). The standard did not include requirements related to space air change effectiveness or ventilation system efficiency. Designers assumed (erroneously for most systems) that all intake air was effectively delivered to each occupied zone. Outdoor intake airflow was simply calculated as the sum of individual space airflow requirements.

Standard 62-1981

In part as a reaction to the energy crisis of the mid-1970s, ASHRAE published Standard 62-1981, *Ventilation for Acceptable Indoor Air Quality,* to replace the 1973 standard. With a change in title and scope, Standard 62-1981 specified "...indoor air quality and minimum ventilation rates which will be acceptable to human occupants and will not impair health." This version included only minimum ventilation rates, eliminating the higher, more energy-intensive recommended ranges found in the 1973 version. It sharply reduced the variety of commercial and institutional spaces, listing only 65 space types, along with seven residential space types. Specific industrial space types were eliminated, replaced by three industrial ventilation rates based on activity level.

The "science" of ventilation had not changed significantly from 1973. With no information to the contrary and with the pressure of the energy crisis, the authors of this version adopted a 5 cfm (2.5 L/s) per person "floor" as the base ventilation rate for all non-smoking spaces. They adjusted the minimum rates upward from the "floor" for some spaces—based again on professional judgement—adding airflow for odors related to people-activity and non-people sources in each space. Most resulting rates were significantly lower than those in the 1973 version. Recognizing environmental tobacco smoke as an important indoor contaminant source, this version specified both a "smoking" and "non-smoking" minimum rate for each space type.

A new definition for acceptable *indoor air quality* replaced the earlier concentration-based definition of acceptable *ventilation* air. The new definition included both a "health" component ("...no known contaminants at harmful concentrations...") and a "comfort" component ("...a substantial majority ... do not express dissatisfaction"). Similar to the 1973 version, this standard allowed designer

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to use return air-cleaning devices to reduce outdoor airflow, provided the air cleaners reduced 34 specific contaminants to specific acceptable minimum levels. Outdoor airflow could not be reduced to less than 5 cfm (2.5 L/s) per person, regardless of cleaning effectiveness.

A performance-based procedure, introduced as an alternative to the table-based prescriptive procedure, allowed designers to determine space ventilation rates based on the concentration of the same 34 contaminants used to find recirculation limits and a subjective odor/irritation evaluation by visitors to the completed space.

As before, the standard listed typical estimated occupant densities, but it included no requirements related to space air change effectiveness or ventilation system efficiency.

Standard 62-1989

ANSI/ASHRAE Standard 62-1989, *Ventilation for Acceptable Indoor Air Quality*, simplified the smoking versus non-smoking rates of Standard 62-1981, and incorporated new requirements to reflect rapidly changing technology and new knowledge about indoor contaminants. This version specifies "...minimum ventilation rates and indoor air quality that will be acceptable to human occupants and are intended to minimize the potential for adverse health effects." Standard 62-1989 does not allow reduced rates for non-smoking areas. It lists 82 commercial and institutional space types, along with five residential spaces and includes no industrial ventilation requirements.

By 1989, new research[1,2,3] showed that 80% of *visitors* to an occupied space express odor satisfaction at an outdoor air ventilation rate of 15 cfm (7.5 L/s) per person, while 80% of *occupants* express odor satisfaction at 5 cfm (2.5 L/s) per person. (Since people adapt quickly to many odors, *visitors* judge odor acceptability within 15 seconds after entering the space while *occupants* judge acceptability 15 minutes or more after entering the space.) These studies confirmed the long-established people-odor minimum rate[4] and offered a rational explanation for the "floor" minimum rate of 5 cfm (2.5 L/s) per person used previously.

In this version, partly in response to rising complaints related to "poor indoor air quality," the authors chose to use visitor satisfaction (15 cfm [7.5 L/s] per person) as the base ventilation rate instead of occupant satisfaction (5 cfm [2.5 L/s] per person). Then, they adjusted the rates (usually by adding airflow) based on professional judgement related to the non-people sources in each space. Standard 62-1989 notes that the rates specified are sufficient to account for "...a moderate amount of smoking." (This note has been the subject of much recent controversy within ASHRAE; it has been removed via an addendum approved in June 1999.)

The definition for acceptable indoor air quality still includes a "health" component ("...no known contaminants at harmful concentrations *as determined by cognizant authorities*...") and a "comfort" component ("...a substantial majority...do not express dissatisfaction"). Adding the reference to "cognizant authorities" allowed the authors to remove the indoor contaminant tables from the standard. Without a list of specific indoor air contaminants and acceptable levels, the standard leaves proper application of recirculated air cleaning to the user, which could discourage the use of this technology.

Similar to Standard 62-1981, this version retains two paths to compliance, allowing the designer to calculate ventilation rates based upon performance (indoor air quality achieved) or upon implementation of prescriptive measures, including compliance with tabulated minimum ventilation rates and calculations to account for ventilation system efficiency.

However, with the elimination of the list of specific indoor air contaminants and levels, the indoor air quality procedure becomes more open-ended in terms of contaminants-of-concern and judgmental in terms of allowable contaminant concentrations. As a result, the performance path has been perceived as too complicated and perhaps too risky by some designers.

Standard 62-1989 again lists typical estimated occupant density for each space type. It allows designers to account for space population diversity by using average population rather than design peak population for intermittently occupied spaces. However, it includes no other provision to allow accounting for system population diversity, i.e., people entering and leaving the building.

The standard discusses *air change effectiveness* for each space but does not tell designers how to account for poor in-space ventilation delivery. Also, whereas previous versions had ignored delivery of ventilation air throughout multiple-space systems, this version requires proper accounting for *ventilation system efficiency*. However, many designers ignore this requirement, probably due to the limited explanation provided. As a result, low system-level intake airflow can lead to inadequate space ventilation (less than the prescribed rates) in many systems.

Addendum 62n

In June 1999, BSR/ASHRAE Addendum n to Standard 62-1989 became available for public review. Written in mandatory language to facilitate building-code adoption, this addendum replaces "guidelines" with code-minimum requirements but it does not alter the scope or purpose of the standard nor its definition of acceptable indoor air quality. It changes the Standard 62-1989 prescriptive method (the ventilation rate procedure) for calculating space and system ventilation rates to clarify vagaries, correct inaccuracies, strengthen inadequacies, enhance enforceability, and increase design flexibility.

It includes, for the first time, minimum ventilation rates both for people-related sources and non-people sources, and specifically states that the rates do not apply in smoking-permitted spaces. Addendum 62n expands the list of commercial and institutional space types to 78 while removing residential spaces and health care-related spaces to an appendix, anticipating that future ASHRAE standards will better specify ventilation requirements for these space types.

Ongoing research throughout the 1990s[5] has confirmed the long-standing people-odor dilution requirements (5 cfm [2.5 L/s] per person for occupants, 15 cfm (7.5 L/s) per person for visitors) and have confirmed that Standard 62-1989 rates, especially 20 cfm (9.4 L/s) per person for offices, usually result in acceptable indoor air quality. Various field studies[6,7,8] support the historical

Topic	1973	1981	1989	62n
Space Type	Residential (10) Commercial (87) Institutional (47) Organizational (11) Industrial (116)	Residential (7) Commercial (54) Institutional (11) Organizational (0) Industrial (3)	Residential (5) Commercial (64) Institutional (18) Organizational (0) Industrial (0)	Residential (0) Commercial and Institutional (78) Organizational (0) Industrial (0)
Space (breathing zone) Ventilation Rate	Minimum rates and recommended ranges either for people (cfm/p) or building (cfm/ft²), depending on space type	Minimum rotes either for people (cfm/p) or building (cfm/ft²), depending on space type	Minimum rates either for people (cfm/p) or building (cfm/ft²), depending on space type	Minimum rotes both for people (cfm/p) and minimum rotes for building (cfm/ft²)
Accommodating Smoking	No distinction between minimum or recommended rates for spaces with and without smoking	Separate minimum rotes for spaces with and without smoking	Minimum rotes for spaces with moderate smoking only (no specific rotes for spaces without smoking)	Minimum rates for spaces without smoking only (no specific rates for spaces with smoking permitted)
Visitors versus Occupants	Not applicable	Non-smoking minimum rates seemingly based on occupant sotisfoction	Minimum rotes seemingly based on visitor satisfaction	People-reloted minimum rates based on occupant satisfaction are combined with building-reloted rotes
Space Population Diversity	Ignored space population diversity	Ignored space population diversity	Allows ventilation airflow based on average population in intermittently occupied spaces	Allows credit for space population diversity using Equation 6-2
System Population Diversity	Ignored system population diversity	Allows credit for system population diversity	Ignores system population diversity	Allows credit for system population diversity using Equation 6-6
Space Air Change Effectiveness	Ignored space air change effectiveness (1.0 assumed)	Ignored space air change effectiveness (1.0 assumed)	Mentions space air change effectiveness but does not require specific accounting (1.0 assumed)	Requires air proper accounting for air change effectiveness (defaults available, 0.80 assumed below)
Ventilation System Efficiency	Ignored	Ignored	Requires outdoor air intake calculation (Equation 6-1) to account for ventilation system efficiency	Requires simple default-bosed outdoor air intake calculation using Equation 6-5 to account for ventilation system efficiency
Typical minimum supply airflow, cfm/ft², for spaces without smoking				
Office, 7 people, 1,000 ft²	15 cfm/p × 7p = 105 cfm	5 cfm/p × 7 p = 35 cfm	20 cfm/p × 7p = 140 cfm	(6 cfm/p × 7p + 0.06 cfm ft² × 1000 ft²) ÷ 0.80 = 128 cfm
Retail, 30 people, 1,000 ft²	7 cfm/p × 30 p = 210 cfm	5 cfm/p × 30 p = 150 cfm	0.30 cfm/ft² × 1000 ft² = 300 cfm	(7 cfm/p × 30 p + 0.12 cfm/ft² × 1000 ft²) ÷ 0.80 = 412 cfm
Classroom (K–3), 30 people, 1,000 ft²	10 cfm/p × 30 p = 300 cfm	5 cfm/p × 30 p = 150 cfm	15 cfm/p × 30 p = 450 cfm	(6 cfm/p × 30 p + 0.14 cfm/ft² × 1000 ft²) ÷ 0.80 = 400 cfm

Table 1: Tenets of ASHRAE Standard 62.

Standard 62 tradition of "additivity" in determining minimum ventilation rates, that is, the tradition of beginning with a base ventilation rate for people-odor and adding airflow as judged appropriate to accommodate building-related odors.

In this addendum, however, the table of prescribed rates includes both a base people rate and an additional building rate, rather than a single people rate, adjusted by the authors to account for expected non-people pollutant sources. The ventilation airflow for each space must be calculated by adding the people-related airflow to the building-related airflow. By using both prescribed rates rather than a single combined rate, designers can better match ventilation airflow to the actual occupant density and occupiable area for each space. (Many practitioners felt that high-density spaces, such as auditoriums, were overventilated using the people-only rates of Standard 62-1989. This new approach will help to minimize such overventilation.)

Departing from Standard 62 tradition, Addendum 62n does not include typical estimated occupant density for each space type. Many designers and some model building codes used the "typical" estimated densities in Standard 62 instead of actual design densities, often leading to significant overventilation in some spaces and underventilation in other spaces. Designers can account for space population diversity (people moving from space to space) using average population over a time period appropriate for the space volume and expected contaminant load. While perhaps, at first glance, somewhat more complicated than the Standard 62-89 intermittent occupancy method, this approach is straightforward to apply, results in more accurate accounting and reduces the likelihood of abusive underventilation in some spaces. Designers can also account for system population diversity (people entering and leaving the building) to further avoid overventilation.

The addendum requires proper application of space *air change effectiveness* to assure that ventilation air at the prescribed rate actually arrives in the breathing zone. It includes default effectiveness values to avoid any complex calculations or mandatory field measurement of space air change effectiveness. Like Standard 62-89, this addendum requires that designers account for *ventilation system efficiency* to assure that outdoor air intake satisfies the outdoor airflow requirements of each space. Default ventilation system efficiency values based on system type simplify calculations and reduce the likelihood of underventilated spaces in a multiple-space system.

Earlier versions of the standard—some of which ignored ventilation system efficiency altogether—apparently used conservatively high prescribed space ventilation rates to assure adequate delivery of outdoor air of each space. Proper air change effectiveness and ventilation system efficiency accounting actually may increase outdoor air intake in many systems compared with the 1989 version, even though individual space minimum airflow decreases.

Addendum 62n clarifies the important distinction between system outdoor intake airflow and space minimum airflow based on the prescribed minimum rates. It clearly distinguishes between minimum ventilation airflow required in the breathing zone of each space and the system intake airflow required to deliver the adequate ventilation air to each space. In terms of confirmation and/or enforcement, any airflow, space or system that is determined using this addendum can be verified both on the drawings and in the field after installation. Using the mandatory calculations, required supply airflow to each space as well as required outdoor airflow at the system intake can be determined. These airflow values can be easily specified and measured. Previous versions may have required actual tracer gas studies to verify airflow compliance.

Table 1 summarizes some of the key differences among the various versions of Standard 62. Ventilation-related requirements and our understanding of contaminants, odors and system operation, evolve with time. Addendum 62n seems to be a logical next step in the evolutionary process.

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