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ASHRAE STANDARD 62: VENTILATION FOR ACCEPTABLE INDOOR AIR QUALITY

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ASHRAE Standard 62 contains design procedures and guidelines for ventilation rates in "all indoor or enclosed spaces that people may occupy, except where other applicable standards and requirements dictate larger amounts of ventilation than this standard." Standard 62 is the basis for ventilation requirements in many codes for commercial, institutional, and residential buildings in North America. The Standard is reviewed every 5 years or less, and updated as needed to incorporate new information or improve its usefulness to building designers and code officials. This paper highlights some of the key features of the design procedures in Standard 62 and summarizes the status of the review process.

INTRODUCTION

The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) is a technical society with a worldwide membership of more than 50,000 persons dedicated to the application and advancement of knowledge relating to the heating, ventilation and air conditioning of buildings, and to the processes of refrigeration. ASHRAE produces Standards and Guidelines that address test procedures for evaluating products, product specifications, and system operating performance. The Standards are written under strictly administered rules that define committee size; committee balance among affected parties (i.e., manufacturers, users, interest groups, and the general public); public review of draft Standards; and appeal processes for unresolved differences. Writing procedures for ASHRAE Standards have been coordinated with and accepted by the American National Standards Institute (ANSI). ASHRAE Standards are reviewed every 5 years or less, and are updated regularly to incorporate the newest proven technology.

ASHRAE's first ventilation standard was ASHRAE Standard 62-73, Standards for Natural and Mechanical Ventilation[1]. This Standard provided a prescriptive approach to ventilation by specifying both minimum and recommended outdoor air flow rates to obtain acceptable indoor air quality for a variety of indoor spaces. This Standard is still referenced in many building codes in the United States.

The revised version of that Standard, Standard 62-1981, Ventilation for Acceptable Indoor Air Quality[2], recommended air flow rates for smoking-permitted and smoking-prohibited conditions in most spaces. The 1981 Standard also introduced an alternative Indoor Air Quality Procedure to permit innovative, energy-conserving ventilation practices. The alternative procedure allowed design engineers to use whatever amount of outdoor air they deemed necessary if they could show that the levels of indoor air contaminants were held below recommended limits. Some users of Standard 62-1981 found the application of different ventilation rates for smoking and non-smoking areas confusing, and the recommended maximum concentration of formaldehyde was challenged.

The current version, Standard 62-1989[3], retains the two procedures for ventilation design, the Ventilation Rate Procedure and the Indoor Air Quality Procedure. There are two major changes in this version of the Standard compared to the 1981 version. First, the minimum outdoor air flow rate has changed from 2.5 liters/second per person in "clean" environments to 7.5 liters/second per person. Second, the distinction between "smoking allowed" and "smoking prohibited" has been removed. Other additions provide opportunities for energy conservation.[4]

ASHRAE has recently formed a new committee to begin the process of reviewing and updating Standard 62. This paper highlights some of the key features of the current Standard and summarizes the status of the review process.

THE CURRENT STANDARD: 62-1989[3]

The purpose of Standard 62 is "to specify 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." While this Standard is primarily considered a design standard, the foreword to the document states: "...the conditions specified by this Standard must be achieved during the operation of buildings as well as in the design of the buildings if acceptable indoor air quality is to be achieved." To facilitate this, the Standard includes requirements that ventilation design documentation be provided for system operation.

For purposes of this Standard, acceptability of indoor air is based on both health and comfort considerations (the comfort term refers to sensory rather than thermal comfort). The foreword of the Standard states: "For substantive information on health effects, the Standard must rely on recognized authorities and their specific recommendations. Therefore, with respect to tobacco smoke and other contaminants, this standard does not, and cannot, ensure the avoidance of all possible adverse health effects, but it reflects recognized consensus criteria and guidance." Health and sensory comfort criteria are specified in the Standard for a relatively few contaminants. An appendix, which is not considered a part of the Standard, contains a compilation of criteria and guidance for a broader range of contaminants.

Health-based criteria and guidelines are listed for the following contaminants: sulfur dioxide, particulate matter smaller than ten micrometers in diameter (PM_{10}), carbon monoxide, ozone, nitrogen dioxide, lead, chlordane, and radon. The single contaminant listed for sensory comfort criteria--carbon dioxide--is listed as a surrogate for human (body) odor.

The Ventilation Rate Procedure prescribes the rate at which ventilation air must be delivered to a space and various means to condition that air. Ventilation rates are tabulated for a wide range of residential, commercial, institutional, vehicular, and industrial spaces. These rates are described in terms of either liters/second of outdoor air per person of occupancy, or liters/second per square meter of floor area. The ventilation rates in this table are derived from physiological considerations, subjective evaluations, and professional judgements.

This procedure also describes how to evaluate whether outdoor air quality is acceptable for ventilation, allows for reduction of outdoor air quantities when recirculated air is treated by contaminant removal equipment, and establishes criteria for variable ventilation. The tabulated values of outdoor air requirements "prescribe supply rates of acceptable outdoor air required for acceptable indoor air quality. These values have been chosen to control CO_2 and other contaminants with an adequate margin of safety and to account for health variations among people, varied activity levels, and a moderate amount of smoking." An appendix contains a discussion of the basis for the minimum value of 7 liters/second (15 cubic feet/minute) per person, to maintain indoor carbon dioxide levels below the 1,000 parts per million concentration that is associated with acceptability of occupant odor.

Building designers use the Ventilation Rate Procedure in the vast majority of cases because it is relatively straightforward. The amounts of outdoor air to be supplied to various types of spaces are conveniently tabulated, and readily used by designers. Unfortunately, these numbers are sometimes used without a very broad understanding of ventilation and how it relates to indoor air quality. Some designers and building code officials interpret the tables to refer to the total air supplied to the space. In most cases, of course, total air supplied is mostly recirculated air; recirculation is used primarily to reduce equipment sizes and energy consumption, and to facilitate good air mixing and control of thermal comfort.

The Ventilation Rate Procedure also includes a statement that is often overlooked: "Where unusual indoor contaminants or sources are present or anticipated, they should be controlled at the source or the procedure of 6.2 shall be followed." The procedure of Section 6.2 is the Indoor Air Quality Procedure.

The Indoor Air Quality Procedure is presented as an alternative to the Ventilation Rate Procedure. Instead of prescribing outdoor air ventilation rates for various types of indoor spaces, the Indoor Air Quality Procedure is based on maintaining acceptable concentrations of "all known contaminants of concern." In principle, this procedure provides a better basis for protecting public health. However, it requires knowledge of contaminants that will be present, acceptable concentrations of these contaminants to protect health and ensure sensory comfort, and sources of these contaminants.

Use of the Indoor Air Quality Procedure is very limited at present. Consensus on acceptable concentrations is available for only a very limited number of contaminants, and there are very limited data on emission rates of contaminants from sources. Furthermore, Standard 62 contains very little information on how to use this procedure.

As more information becomes available on sources and their emissions, and the health and comfort effects of those emissions, use of this procedure may very well increase. With further development it could be a very useful design tool for evaluating trade-offs between increased ventilation, source management, and air cleaning as options for achieving occupant health and comfort.

UPDATING STANDARD 62

As part of ASHRAE's policy to review standards every 5 years, a new committee was formed in January 1992 to review Standard 62-1989, and to develop revisions as needed. The committee consists of 25 designers, equipment manufacturers, regulators, and researchers. The 13 voting members of the committee are:

Peter H. Billing, National Forest Products Association
William S. Cain, John B. Pierce Laboratory/Yale University
David T. Grimsrud, University of Minnesota
Shirley J. Hansen, Hansen Associates, Inc.
Hal Levin, Hal Levin and Associates
Michael F. Mamayek, Illingworth Corporation
Bjarne W. Olesen, Virginia Polytechnic Institute & State University
Andrew K. Persily, National Institute of Standards and Technology
Jonathan Samet, University of New Mexico
Michael S. Sherber, Carrier Corporation
Steven T. Taylor, McKenneys, Inc.
W. Gene Tucker (Chair), U.S. Environmental Protection Agency
Arthur E. Wheeler, Wheeler Engineering

Additional members of the committee are:

Richard A. Daynard, Northeastern University
Richard W. Dixon, State of Florida
P. Ole Fanger, Technical University of Denmark
Edward Fickes, Consultant
Michael J. Hodgson, Connecticut Health Center
Philip R. Morey, Clayton Environmental Consultants
Paul T. Ninomura, State of Washington
Francis J. Offermann, Indoor Environmental Engineering
Wayde Robertson, Robertson Manufacturing and Engineering
Max H. Sherman, University of California/Lawrence Berkeley Laboratory
Joseph K. Ting, State of New York
Bede W. Wellford, Honeywell, Inc.

The committee is currently addressing eight issues in preparation for deciding what aspects of the Standard need most attention. These issues are listed below along with the chairman of the subcommittee responsible for dealing with each issue:

How can the scientific basis for the health and comfort aspects of Standard 62 be improved? (Samet)

How can the roles of source control and air cleaning be better integrated into the Standard? (Offermann)

How can the Indoor Air Quality Procedure be improved? (Wheeler)

How can the energy impacts of various levels of ventilation be treated more *explicitly in the Standard? (Taylor)*

How can the coverage of residential ventilation be improved in Standard 62? (Wellford)

What editorial changes need to be made (e.g., format changes, improved definitions, clarifications of procedures, use of code language)? (Sherber)

How should ventilation effectiveness be defined and incorporated into the standard? (Persily)

Should Standard 62 go beyond design and deal more explicitly with air quality management during all phases of the life of a building? (Mamayek)

Special emphasis is being placed on reviewing the scientific information that can be used as the basis for the health and sensory comfort guidance that the document uses to define acceptable indoor air quality. Another special emphasis is on making clearer links between sources of contaminants and control of indoor air quality by ventilation, source management, or air cleaning. Progress in these two areas is key to improving the soundness and usefulness of the two design procedures.

The Indoor Air Quality Procedure was originally developed to determine how much ventilation might be reduced below the rates specified by the Ventilation Rate Procedure. Energy conservation was the primary driving force. It now seems that the Indoor Air Quality Procedure will be most useful for evaluating the cost-effectiveness of increasing ventilation above minimum prescribed rates. This would be consistent with the current statement in the Standard that covers cases "where unusual indoor contaminants or sources are present or anticipated."

To determine whether more outdoor air will be required than the amounts specified in the Ventilation Rate Procedure, building designers and operators need information on emission rates of contaminant sources in the building. They also need guidelines on the total emission rate from all sources that should not be exceeded when ventilation is supplied at rates specified by the Ventilation Rate Procedure.

Perhaps a useful form of such information would be tables of maximum emission rates from non-occupant indoor sources, for the various contaminants (or source emission mixtures) of concern. If these emission rates were not exceeded, ventilation rates prescribed by the Ventilation Rate Procedure would suffice. In spaces where sources were stronger, trade-offs between source management (e.g., lower-emitting sources) and increased ventilation would have to be considered.

The maximum desirable emission rate for all non-occupant indoor sources affecting the space, given the ventilation rates prescribed by the Ventilation Rate Procedure, might be defined simply as:

$$G = (C - C_o) \bullet ACH \bullet H \bullet X$$

G = maximum desirable emission rate from non-occupant indoor sources when ventilation is supplied at the rate prescribed by the Ventilation Rate Procedure, mg/h of contaminant per m^2 of occupied space

C = maximum acceptable indoor concentration of contaminant, mg/m^3

C_o = outdoor air concentration of contaminant, mg/m^3

ACH = ventilation rate prescribed by the Ventilation Rate Procedure expressed in air changes per hour of outdoor air, h^{-1}

H = ceiling height, m

X = correction factor for air mixing effectiveness

The correction factor for air mixing effectiveness, X, could be defined as the ratio of contaminant concentration in the return air to the concentration in the occupied space. If so, its value would typically range from 0.5 to 1.0, although it could be somewhat higher than 1.0 for certain ventilation schemes and locations of major sources with respect to return air registers. A table of design values for this correction factor could be developed, similar to the table of such values in the European ventilation guidelines[5].

Tables of design values for C, the maximum acceptable concentrations of indoor contaminants (or source-related contaminant mixtures), would be necessary. Where data on the outdoor concentrations of contaminants, C_o, were not available, the designer would need default values; these values would be derived from the literature on measured concentrations in various types of urban, suburban, and rural locations.

Once the value of G was determined, the maximum desirable emission rate for all non-occupant indoor sources would be established. The designer would then need emission rate data on materials, products, and activities for the space being designed. At present, such information is seldom available to the designer, and is often unaffordable to the builder. To make the Indoor Air Quality Procedure practical, Standard 62 may have to list default values of emission factors for various sources (based on the literature), and give examples of how to use the procedure to calculate total emissions and compare them with values of G.

The following illustrative examples show how emission limits for non-occupant indoor sources of air contaminants might be determined using the Indoor Air Quality Procedure. [Note: All numbers in the examples below are arbitrary except the C values for nitrogen dioxide and particles which are EPA ambient air quality standards, and the 0.35 ACH for residences which is the Standard 62 recommendation.]

Contaminant	C (mg/m^3)	C_o (mg/m^3)	ACH (h^{-1})	H (m)	X	G (mg/h per m^2 space)
Example: Typical Commercial/Institutional Space						
Total organic vapors ("TVOC")	1	0.3	1	3	0.8	2
Particles (<10 μm)	0.05	0.03	1	3	0.8	0.05
Example: Typical Residential Space						
Total organic vapors ("TVOC")	1	0.1	0.35	2.5	0.5	0.4
Particles (<10 μm)	0.05	0.02	0.35	2.5	0.5	0.01
Nitrogen dioxide	0.1	0.03	0.35	2.5	0.5	0.03

In the commercial/institutional example above, if total organic vapor emissions from materials, products and activities were more than the maximum G = 2 milligrams per hour per square meter of occupied space, evaluations of additional options for control of indoor air quality would be required. Options would include increased ventilation (above that prescribed by the Ventilation Rate Procedure), control of sources (e.g., lower-emitting materials), air cleaning, or some combination of those options.

SUMMARY

Standard 62-1989 provides state-of-knowledge guidance from the scientific and technical communities to the building design and building code communities on ventilation system design and operation practices that will help provide good air quality in commercial and residential buildings. Its state-of-knowledge guidance is the best available basis for ventilation system requirements in mechanical sections of building codes for North America. This standard is being continually reviewed and updated to reflect new information, especially on public health aspects of indoor air and sources of indoor contaminants.

The current review is focused on eight issues that have been raised over the past several years in various technical meetings and in feedback to ASHRAE from the design community. Special emphasis is being given to the health and comfort basis of the Standard and to describing the complementary roles of source control and air cleaning for providing good indoor air quality. The review committee is also committed to simplifying and clarifying the Standard where possible, in response to requests from design engineers and building code officials.

It is unreasonable to expect ventilation, which acts primarily by dilution and displacement of indoor contaminants, to provide acceptable indoor air quality by itself. Perhaps it is most reasonable to expect ventilation to provide, as a minimum, that portion of indoor air quality control that relates to thermal comfort and sensory comfort from occupant odor. The ventilation rates required for control of occupant odor are substantial and provide sufficient dilution for emissions from many sources. Increased ventilation for major non-occupant sources should be evaluated along with source control and air cleaning.

The Ventilation Rate Procedure might therefore be best suited to supplying effective ventilation for control of occupant odor, thermal comfort, moisture from high-moisture areas such as kitchens and bathrooms, and conditions that discourage the growth and dispersion of microbial contaminants. Options for control of contaminants from sources other than occupants might best be evaluated by a more fully developed version of the Indoor Air Quality Procedure.

Various other ways of using the Ventilation Rate and Indoor Air Quality Procedures are possible. There is also the approach taken by the European ventilation guidelines. Under those guidelines, three design levels are offered for perceived indoor air quality (which is similar to sensory comfort, as used in this paper). Ventilation rates are calculated separately for health and perceived air quality; the higher rate is recommended for design. These and other approaches will be considered by the committee that is responsible for reviewing and updating ASHRAE Standard 62.

REFERENCES

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