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THE ASHRAE VENTILATION STANDARD 62-1981: A STATUS REPORT

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Abstract

ASHRAE's first ventilation standard, published in 1973, has been used in many building codes in the USA. The 1981 revision of this standard has been criticized for its approach to indoor air quality. A comparison of the '73 and '81 standards shows more similarity than difference. A review of the '81 standard, currently underway, is expected to better explain the rationale and provide new support for controversial parts of the standard.

Introduction

Many local and state building codes in the United States use the ventilation standard first published in 1973[1] by the American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE). The standard was used for five years without serious objection except that its minimum ventilation rates were recommended for energy conservation. One objective of the review begun in 1978 was to define requirements needed to provide an acceptable indoor environment and minimize energy use. The result was Standard 62-1981, "Ventilation for Acceptable Indoor Air Quality"[2].

This standard came under serious challenge following the public review and resolution of issues because of its recommended limit of 120 $\mu g/m^3$ (0.1 ppm) of formaldehyde vapor. The manufactured housing industry claimed that enforcement of this low limit would ruin the industry. At a special hearing, industry representatives presented their arguments, and the ASHRAE Ventilation Standard Committee presented its rebuttal. The hearing board up-held the Standard Committee, and ASHRAE published the standard in 1981. The American National Standards Institute, however, refused endorsement of the standard. ASHRAE, as a result of all of the controversy, decided to go into early review of the 1981 standard.

Unique Features of Standard 62-1981

Standard 62-1981 differed from Standard 62-73 in several ways. The '73 standard was a purely perscriptive standard with minimum and recommended ventilation rates. The '81 standard specifies minimum rates for smoking and non-smoking applications. Both standards specify contaminant limits, based on the National Ambient Air Quality Standard, for the ventilation air. The ´81 standard also offers an alternate air quality procedure that allows the designer to use whatever amount of outdoor air he finds necessary to keep specified contaminant concentrations below recommended limits. This procedure was included to permit innovative energy saving solutions to the ventilation problem. The ´81 version provides guidance for the use of filters to reduce outdoor air requirements and addresses the case of transient occupancy. These features of the ´81 standard which were included to make the standard more flexible and more realistic have been the source of misunderstanding and criticism.

Comparison of the Standards

Acceptable Ventilation Air

Both standards define the acceptability of outdoor air used for ventilation. The 1981 figures are the National Ambient Air Quality Standards. Small differences between the 1973 and 1981 publications are shown in Table 1[1,2]. Both standards state that outdoor air should meet the conditions listed or be treated to comply.

Table 1. Acceptable Ventilation Air.

CONTAMINANT	ANNUAL AVERAGE		SHORT-TERM LEVEL			
	1973	1981	1973		1981	
	Mg/M^3	Mg/M^3	Mg/M^3	TIME	Mg/M^3	TIME
CARBON MONOXIDE	20,000	-	30,000	8 HRS.	40,000	1 HR.
LEAD	-	1.5 FOR 3 MO.	-		-	
NITROGEN DIOXIDE	200	100	-		-	
OXIDANTS (OZONE)	100		500	1 HR.	235	1 HR.
PARTICULATES	60	75	150	24 HRS.	260	24 HRS.
SULFUR DIOXIDE	80	80	400	24 HRS.	365	24 HRS.
HYDROCARBONS	1800	-	4000	3 HRS.		

Guidance is provided for determining local outdoor air acceptability. Both standards recognize further that other contaminants may be of concern. Standard 62-73 says, "3.3 AIR shall be considered unacceptable for ventilation use in accordance with this standard if it contains any contaminant in a concentration greater than one tenth the Threshold Limit Value (TLV) currently accepted by the American Conference of Governmental Industrial Hygienists". Standard 62-73 goes on to specify procedures for sampling and analysis. Standard 62-1981, on the other hand, presents a table of "Additional Ambient Air Quality Guidelines"for common contaminants for which no EPA ambient air quality standards exist and presents data selected from current practices in various states, provinces, and other countries. The designer is also cautioned to be alert for other contaminants.

The additional guidelines were included in Standard 62-1981 to aid the designer in unusual cases. The response of engineers has been opposite from the intention, however. Since there was no listing of additional contaminants in Standard 62-73, they went largely ignored. Listing the potential hazzards in the 1981 standard suddenly made everyone believe that these all had to be measured. Measurement procedures were unfamiliar to most ventilation system designers and they felt threatened.

Minimum Outdoor Air Requirements

The primary indoor air contaminant requiring dilution is carbon dioxide exhaled by the occupants of a space. Appendix D of Standard 62-1981 presents the rationale for the minimum outdoor air dilution rate based on the CO_2 level. It is shown that an air flow rate of only about 0.11 L/S (0.24 cfm) per person of outdoor air is needed to provide oxygen. However, 2.27 L/S (4.82 cfm) per person of outdoor air is needed to dilute the carbon dioxide exhaled to maintain a steady state CO_2 concentration of 0.25% (2500 ppm). Men can function (with some side effects) in nuclear submarines at 1% CO_2. Studies in bomb shelters showed that 0.5% CO_2 was permissible. The 0.25% CO_2 level is considerably higher than the Nordic and Japanese standards and is being reconsidered in the present review. Odor may be the overriding concern at this low ventilation rate.

Table 2. Outdoor Air Requirements for Various Steady State Indoor CO_2 Levels (Sedentary Adult Activity Assumed)

% CO_2 Limit	Outdoor Air Flow Rate L/S	CFM
0.5	1.25	2.25
0.4	1.43	2.86
0.3	1.96	3.92
0.25	2.50	5.00
0.2	3.12	6.23
0.1	7.55	15.10

Table 2 provides the basis for the Ventilation Rate Procedure of Standard 62-1981. The basic rate of 2.5 L/S which yields a steady state CO_2 level of 0.25% was chosen. This is consistent with the minimum outdoor air flow rate specified in Standard 62-73. It is also consistent with the calculations of Tredgold[3] made in 1836.

The Smoking Issue

The minimum flow rates in the '73 standard are very similar to the non-smoking flow rates in the '81 version. The 1973 standard identified smoking specifically only in auditoriums and specified twice the outdoor air when smoking was permitted. In other cases where smoking is common, e.g. bars, the minimum outdoor flow rates specified in Standard 62-73 were only slightly less than the recommended rates. Thus, Standard 62-73 tacitly assumed that the recommended columns would be used where smoking was allowed.

Table 3. Outdoor Air Requirements.

APPLICATION	OCCUPANCY OCCUP. PER 100M² OR PER 1000 FT²	MINIMUM L/S• PERSON (CFM)	RECOMMENDED L/S• PERSON (CFM)	OCCUPANCY OCCUP. PER 100M² OR 1000 FT²	SMOKING L/S• PERSON (CFM)	NONSMOKING L/S• PERSON (CFM)
GENERAL OFFICE	10	7 (15)	7-12 (15-25)	7	10 (20)	2.5 (5)
AUDITORIUMS	150	2.5 (NS) (5)	2.5-5 (NS) (5-10)	150	17.5 (35)	3.5 (7)
HOTEL LIVING ROOMS	20	5 (10)	7.5-10 (15-20)	20	25* (50)	12.5* (25)
HOTEL BEDROOMS	5	3.5 (7)	5-7.5 (10-15)	5	15* (30)	7.5* (15)
BARS	150	15 (30)	20-25 (40-50)	100	25 (50)	5 (10)
RESIDENTIAL LIVING AREAS	5	2.5 (5)	3.5-5 (7-10)		5* (10)	5* (10)
INDUSTRIAL FACILITIES (OCCUPANTS ONLY)	-	3.5-17.5 (7-35)	5-22.5 (10-45)	-	17.5 (35)	10 (20)

*AIRFLOW PER ROOM INSTEAD OF PER OCCUPANT

In general office spaces and bars, for example, the recommended column and the smoking column, as shown in Table 3 are similar. A ventilation system designer usually determines the occupant density per unit area floor space and multiples this by the flow requirement per occupant to get a flow rate per unit floor area. Outdoor air requirements for general office spaces and for bars are compared in Table 4.

Table 4. Outdoor Air Required for Smoking.

Application	Standard 62-73 L/S x m²	Standard 62-73 (cfm/ft²)	Standard 62-1981 L/S x m²	Standard 62-1981 (cfm/ft²
General Office	1.2	(0.25)	0.7	(0.14)
Bars	37.5	(7.50)	25.0	(5.00)

The greater occupant density along with an assumed increase in smoking in bars greatly increases the outdoor air requirements. Table 4 was calculated using the recommended column from Standard 62-73. Minimum flow rates would have been 40% less. Thus, Standard 62-1981 gives outdoor air requirments for smoking which are generally between the minimum and recommended values in Standard 62-73. This varies by application.

The rationale for the specified ventilation rates for control of tobacco smoke is based on the control of particulates. Each cigarette produces about 31.9 mg of total suspended particulates[4]. The National Ambient Air Quality Standard specifies a limit of 0.26 mg/m^3 for total suspended particulates. Approximately 30% of the population in the USA smokes at an average of 2 cigarettes per hour. A simple mass balance shows that about 20.5 L/S (41 cfm) per person (both smokers and non-smokers) is needed to dilute particulates. The flow rates recommended in Table 3 of Standard 62-1981 were adjusted down from this basic rate because the duration of exposure is substantially less than 24 hours. Smoking in areas such as bars approaches the assumed rate. There is also a finite settling rate that removes some of the particulates.

Appendix E of Standard 62-1981 also shows how filters can greatly reduce the amount of outdoor air needed. The total circulation rate must be increased, however. This may present a problem in variable ventilation systems.

Variable Occupancy

Standard 62-1981 introduced a provision for variable occupancy not considered in the ′73 standard. If the contaminants are generated primarily by the occupants, e.g. CO_2, moisture, odors and tobacco smoke, a building tends to be cleared of contaminants at night if it is unoccupied. It is feasible, therefore, to delay the start of the ventilation system in the morning until the occupants have entered the building and contaminant levels have risen. Standard 62-1981 provides a graph for determining the permissible ventilation lag time. A permissible delay of one hour in the start up of the ventilation system is not uncommon.

If contaminants are generated by the space itself, however, start up of the ventilation system must lead the occupancy period. Outgassing of formaldehyde, organics and such, that is independent of occupant activities require the system to be started in advance of occupancy in order to bring contaminant levels down to an acceptable range. Standard 62-1981 also includes a graph for estimating the lead time required. Lead times of the order of one hour may be common.

Air Quality Option

"Section 6.2 Indoor Air Quality Procedure" of Standard 62-1981 is an alternative procedure not included in Standard 62-73. This alternate air quality procedure was provided to permit and encourage innovative, energy conserving solutions to the problem of building ventilation. The procedure, allows the designer to use any amount of outdoor air he wants to use if he can show that specified contaminants are kept below recommended limits. Table 5 recommends limits for only 5 contaminants, but it specifies procedure for establishing acceptable concentration levels for 15 other potential contaminants and advises the designer to consider contaminants listed in Table 2 of the standard. Thus, there is a considerable burden on the engineer if he uses the Air Quality Procedure.

Unfortunately the procedure has been misunderstood and misinterpreted. The formaldehyde limit of 120 $\mu g/m^3$ (0.1 ppm) was based on evidence which shows that sensitive people begin to experience irritation of the eyes and mucous membranes at about this level. Formaldehyde is known to cause cancer in laboratory animals at some higher concentrations, but the risk to humans is unknown. Standard 62 is concerned with ventilation for comfort as well as prevention of health risk. Thus, the recommended formaldehyde limit is a comfort criterion rather than a health risk criterion.

Standard 62-1981 plainly states that the Air Quality Procedure is an alternate procedure. If the ventilation rate procedure is followed, it is assumed (ipso facto) that the indoor air quality will be acceptable. Residential systems, however, do not use mechanical ventilation but depended instead on passive infiltration. Newly manufactured homes use many wood products bonded with urea formaldehyde resins which emit formaldehyde vapors. Fabric finishes on draperies, carpeting, and particle board used in furniture add to the formaldehyde load. The manufactured housing industry feared that they would be blamed for the entire formaldehyde problem even though their construction materials were only part of the formaldehyde source. Since building inspectors had no good way to measure infiltration, but they could measure formaldehyde concentration, this could become the controlling factor even though the standard did not intend it to be. This has been the core of the argument over formaldehyde.

Current Status of Standard 62-1981

An ASHRAE Standards Project Committee began a review of Standard 62-1981 in January of 1983. Work by Dr. William Cain and his associates at the John B. Pierce Foundation, Yale University, suggests that the minimum outdoor air flow rate of only 2.5 L/S person (5 cfm/person) will satisfy only about 50% of the visitors to a space from the standpoint of odor. Cain estimates that it will be necessary to increase the outdoor air flow rate from 2.5 L/S person to 7.5 L/S in order to reach 80% acceptance by visitors. Occupants rapidly become adapted and cease to notice odors. This raises a question of whether we should ventilate for visitors or adapted occupants. One approach being considered is to define two classes of spaces.

The smoking issue is also under study. Recent work by Repace[5] at EPA has produced a correlation between risk and outdoor air flow rate. This shows that 10 L/S (20 cfm) of outdoor air reduces health risk to a point of dimishing returns. Although a somewhat lower risk factor for involuntary risk from tobacco smoke would be desirable, a large increase in outdoor air flow rate would be needed for a significant reduction in risk. Thus, the recommendations for tobacco smoke control are not expected to change greatly.

A change in format, similar to the Nordic Standard, for presenting the recommended air flow rates is under consideration. The proposal is to use a building block approach. A basic ventilation rate for a space, independent of occupants, would be specified to control humidity, odors, etc. The requirements for metabolic needs, odor control, tobacco smoke control, etc. would be added to the basic building ventilation rate. Allowances could be made for expected ventilation efficiency with various distribution systems and applications. Allowances would be made also for known internal contaminant sources such as office copying machines.

This approach would allow the designer to use whichever factors fit his particular application, and design the ventilation to fit his particular needs.

The question of ventilation efficiency is also under study. It is known that room air mixing if often imperfect. Usually outdoor air is inducted, mixed with recirculated air and is delivered to the space through ceiling diffusers. Some of this air may bypass the occupied level of the room and pass directly to the return system where a part of this return air may be exhausted. A ventilation efficiency model is under study[6]. Some limited data suggests that 50% ventilation efficiency may not be uncommon[7], Variable Air Volume Systems appear to be particularly susceptible to the bypassing described here. The ventilation standard must address this problem.

Biological contaminants must be considered also. Air conditioning coils, drain pans and cooling towers can provide a place for growth of Leagonella bacteria if maintenance is poor. Mold spoors can grow in damp areas and may be circulated by a ventilation system. It is expected that some precautionary language will be added to the revised standard to cover biological contaminants.

Conclusions

Everyone abhors constraining regulations, but some are inevitable if society is to be adequately protected. The objective of the ventilation standard is to define a set of conditions which a designer can use to design a building ventilation system that will achieve an optimum balance among energy requirements, health, safety and comfort. Standard 62-1981 represented a step forward, but it needs explanation and clarification to be properly understood and accepted.

References

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