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Future Directions for Ventilation Standards

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INTRODUCTION

The dominant mechanism used to control air quality in buildings is ventilation with outdoor air. Thus the role of ventilation standards, the documents that provide guidance to the engineering and design community, is crucial for the maintenance and improvement of indoor air quality. This discussion paper will examine the present situation from the perspective of one who has participated in the ASHRAE Standard 62 revision process and will explore several options that are available to improve future ventilation standards.

PRESENT SITUATION

The revision process that led to the publication of ASHRAE Standard 62-1989 has been completed (1). An improved standard based on new information and new experience since the publication of Standard 62-1981 resulted from a consensus process involving representatives of many disciplines and a public review of the draft standard. This process and the compromises that are an inherent part of such a activity have been described in other papers and will not be reviewed here (2).

The present scientific basis for the Standard 62, although based on the best available research, is not strong (3). There are important data necessary to establish a solid foundation for the Standard that do not yet exist. In the absence of appropriate data, assumptions have been made that must be tested experimentally and verified. Much more should be known from measurements in actual buildings before the Standard can be justified rigorously on its scientific merits.

The two most important gaps in our knowledge about indoor air quality required for the standards process are health effects related to long-term exposure of low levels of pollutants and source emission rates of sources within the buildings. Information about health effects is used to set limits on the concentrations of pollutants found within buildings; source emission rates must be known if ventilation rates are to be specified to insure that the concentrations limits are not exceeded.

The most difficult are studies of the health effects of long-term exposures to low concentrations of pollutants. In the absence of this information, the experiences of practicing engineers and designers about "what works" has been used to fill gaps in knowledge. Thus Standard 62, as all standards, is a transition document that must be updated as new scientific data become available.

FUTURE STANDARD

In order to describe these gaps more clearly let us spend some time imagining a standard that could be written if unequivocal experimental data about pollutant sources, health effects, and ventilation rates existed.

The purpose of Standard 62-1989 is (and any future standard will be assumed to be) "To specify minimum ventilation rates and indoor air quality that will be acceptable to human occupants and are intended to avoid adverse health effects" (4).

The ideal standard is constructed from knowledge of the health effects of all the pollutants that are found within the building. Once these are known, relative risks of exposures to these pollutants can be determined and acceptable concentration limits can be set. At this point a performance procedure (called the Indoor Air Quality Procedure in Standard 62-1989) could be used. The designer of the building would be free to choose any technology available to achieve the air quality specified by our set of concentration guidelines.

The ideal standard has a prescriptive path as well as a performance path to give the designer a well-understood and explicit procedure to satisfy the standard. For each pollutant found in the building an upper bound on source strength and a lower bound on ventilation rate will assure that the concentration limit for that pollutant is not exceeded. These bounds would be determined using verified indoor air quality models which would accurately simulate pollutant emission and transport, ventilation parameters (e.g., ventilation effectiveness), and occupant exposures.

The importance of limiting the source strength cannot be emphasized too much. Since the goal is to limit pollutant concentrations (the ratio between a source strength and a ventilation rate), source strengths must be less than some value while ventilation rates must be larger than some related value. Field measurements demonstrate that most problems in buildings occur because pollutant source strengths are too large rather than from insufficient ventilation (5), (6), (7).

Setting source strength upper limits and minimum ventilation rates for our ideal standard will be an iterative process. Typical source terms for materials found in buildings of a similar design and recognized concentration limits will be used to produce minimum ventilation rates. A realistic ventilation rate for the building type will then be chosen and maximum source terms adjusted accordingly.

The prescriptive portion of Standard 62-1989, the Ventilation Rate Procedure, largely ignores source strengths. The author views this as its major failing -- one of the primary areas that must be improved in any future revision of the Standard. The concentration guidelines of the Indoor Air Quality Procedure are not part of the Ventilation Rate Procedure. The only source term considered in determining the ventilation rates of Table 2 of Standard 62-1989 is the CO_2 generation rate of the building occupants. This value, coupled with the observation from many studies that CO_2 concentrations larger than 1000 parts per million (ppm) are associated with an increase in occupant complaints in buildings, leads to the minimum ventilation rate of 15 cfm/occupant in the Standard. Standard 62-1989 clearly notes that the CO_2 concentration limit is not, in itself, a physiological limit. Rather it substitutes for many pollutants associated with occupancy that may cause discomfort in the space.

This lack of coupling between the criteria adopted for the performance procedure in Standard 62-1989 (admittedly an incomplete list) and the prescriptive procedure forces the nature of Standard 62-1989 to change from one based on avoiding adverse health effects to one based on acceptability of the air within a space, i.e., from health to comfort. This change means that the purpose of Standard 62-1989, ...avoid adverse health effects..., cannot be achieved directly. Scientific data to establish concentration limits for pollutants in buildings do not exist. Only modest information about source strengths of common pollutants is available.

HOW CAN WE MOVE FROM HERE TO THERE?

Experts differ on the amount of time required to do the research required to produce an ideal standard. Buildings continue to be designed and built; engineers and designers require the best possible guidance from the standards they use. How can the process that will yield the information required be accelerated?

1. Develop concentration limits using indoor air quality experts following World Health Organization (8) procedures. Demonstrating appropriate concentration limits for indoor pollutants is a non-trivial task. Interim guidance is necessary to inform those who will construct the next version of Standard 62 or its equivalent. Interim guidance from international experts such as the group assembled regularly by the WHO is a source of such information. Organizations such as ASHRAE or other standards setting bodies must learn to recognize the value of the recommendations of these groups.

2. Develop a consistent technique for source characterization. A major shortcoming of the present standard is the dearth of information about sources and source strengths. This is not a simple problem. There are a large number of sources present in the indoor air; the pollutants they emit must be measured and evaluated using many different kind of analytical instruments.

Are there alternatives? One intriguing possibility is provided by Ole Fanger and his colleagues (9). He argues that the basic response to pollutants comes from our sense of odor as we enter a space. He and his colleagues have developed a consistent set of units for source strength, pollutant concentration, and has projected a concentration limit for acceptable air quality based upon experience in Danish office buildings. While there are problems with this approach because of its reliance the odor sensation as the fundamental pollutant detector, the approach has a logical consistency and simplicity that is appealing. Those interested in ventilation standards should follow the results from Fanger's laboratory and from others engaged in similar work. Some part of this approach may be an appropriate path to use for an interim standard until the requisite health-based concentration limits are available to give the ideal standard a more rigorous scientific foundation.

3. Couple the prescriptive and performance procedures together (10). Both the ventilation rate procedure, the prescriptive part of standard 62, and the indoor air quality procedure, its performance option, have features that contribute to improving the indoor air quality of a building. Standard 62 is inherently a design standard. For that purpose the prescriptive procedure is more straight-forward and should continue to represent an important part of the standard.

However, the standard should not abandoned once the building is designed. A building should be checked periodically throughout its lifetime. For this purpose the indoor air quality procedure is more appropriate.

Demonstrating that the air quality in a building satisfy accepted standards as the building ages, its use and contents change, should be a regular part of building maintenance.

REFERENCES

1. ASHRAE Standard 62 (1989). *Ventilation for acceptable indoor air quality*, American Society of Heating, Refrigerating, and Air Conditioning Engineers, Atlanta.

2. Janssen, J.E. (1989). Ventilation for acceptable air quality, *ASHRAE Journal* **31(10)**,40-48.

3. Grimsrud, D.T., Teichman, K.Y. (1989). The scientific basis of Standard 62-1989, *ASHRAE Journal* **31 (10)**, 51-54.

4. ASHRAE Standard 62 (1989). *Ventilation for acceptable indoor air quality*, American Society of Heating, Refrigerating, and Air Conditioning Engineers, Atlanta.

5. Nero, A.V., Boegel, M.L., Hollowell, C.D., Ingersoll, J.G., Nazaroff, W.W. (1983). Radon concentrations and infiltration rates measured in conventional and energy-efficient houses, *Health Physics* **45**, 401-406.

6. Traynor, G.W., Apte, M.G., Carruthers, A.R., Dillworth, J.F., Grimsrud, D.T., Gundel, L.A. (1987). Indoor air pollution due to emissions from wood-burning stoves, *Environ. Sci, and Tech.* **21**, 691-697.

7. Turk, B.H., Grimsrud, D.T., Brown, J.T., Geisling-Sobotka, K.L., Harrison, J., Prill, R.J. (1989). Commercial building ventilation rates and particle concentrations, *ASHRAE Transactions* **95 (I)**, 422-433.

8. WHO (1984). World-Health Organization, Report on a WHO meeting, August 21-24, 1984, *Indoor Air Quality Research*, EURO Reports and Studies 103, Regional Office for Europe, Copenhagen, Denmark.

9. Fanger, P.O. (1989). A new comfort equation for indoor air quality, in *Proceedings of IAQ'89, The Human Equation: Health and Comfort*, ASHRAE, Atlanta, pp. 251-254.

10. Teichman, K.Y. (1989). Personal communication.