

A View of IAQ as the Century Closes

The First Century of Air Conditioning

This is the twelfth and final article in a special series that commemorates a century of innovation in the HVAC&R arts and sciences.

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In the October issue of *ASHRAE Journal*, John E. Janssen provides a history of research and standards development aimed at improving indoor air quality. That article reveals that such activities are at least as old as civilization. Now at the brink of a new millenium, it is a good time to take stock as to where we are and what may lie ahead in our quest for better air and in our understanding the influence air quality has upon the complete indoor environment.

A Glance Backward

During the last decade, the demand for better indoor air quality has gradually led to improvements in the design provisions for ventilation, reduction of building contaminant sources, and the management of buildings, especially of their HVAC systems.

ANSI/ASHRAE Standard 62-1989, *Ventilation for Acceptable Indoor Air Quality* was not written in code language. This did not deter many jurisdictions from adopting it by reference into their mechanical building codes. Several model code organizations did seek assistance from ASHRAE to update their ventilation requirements. ASHRAE's response resulted in increases in outdoor air ventilation rates required by many codes that were consistent with the provisions of the standard. Minimum ventilation rates increased from 5 cfm (2.5 L/s) to 15 cfm (7.5 L/s) per person.

Many jurisdictions did not adopt the provisions of Standard 62-1989 as contained in the model codes until the mid-1990s (and some have chosen not to do so at all). Nevertheless, the standard has been accepted as the "standard of care" in most legal proceedings involving IAQ issues.

A number of puzzling provisions of the standard have been clarified by interpretations prepared by Standing Standard Project Committee 62 (SSPC 62), which succeeded the committee that produced Standard 62-1989.

Indoor air quality affects both comfort and health. Its effects are often misjudged, because the perception of air quality is strongly influenced by other environmental factors. Temperature and humidity have been found to significantly affect such



This copper manikin was used in the 1960s to measure the warmth provided by clothing.

perceptions. The research of Berglund and Cain¹ in 1989 that was performed under ASHRAE Research Project 462,² demonstrated that perceptions of indoor thermal conditions and air quality are closely linked. Complaints from more than 15% of building occupants of stuffy air quality are likely if the air temperature is above 75°F (24°C). Relative humidity was found to have less impact on this perception in both studies. It is noteworthy that the upper thermal limits determined by that research are in close agreement with the comfort chart produced by the ASHRAE Research Laboratory in the 1920s.

Poor lighting, noise and psychosocial stress also can produce these environmental stress symptoms that are most often attributed to poor air quality. Symptoms such as headache, fatigue, and sensory irritation that can be related to building occupancy are well known as "sick building syndrome." Recently, this condition has been described as a "situation in which a substantial proportion of occupants of a building experience

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symptoms associated with acute discomfort that are relieved upon leaving the premises.”³ All building-related physical and mental stress conditions are therein recognized as potential causes—not simply a lack of ventilation.

More serious illness also has been attributed to building environments. Legionnaire’s disease, sometimes caused by bacterial contamination propagated in and dispersed into building air by air conditioning, is one example. Multiple Chemical Sensitivity, although not yet a clinically defined illness, is a seriously debilitating condition that has been attributed to chemicals released into the air by building materials, processes or maintenance activities.

Health concerns led to congressional efforts to enact legislation to regulate ventilation rates, system design, maintenance and operations as incorporated in the Indoor Air Act of 1991. Although similar legislation was reintroduced in succeeding years, such proposals have never become law. The Occupational Safety and Health Administration (OSHA) in 1994 proposed rules for the indoor work environment with extensive provisions governing ventilation system design, maintenance and operation as well as smoking activity. This proposal received widespread comment. OSHA has not yet proceeded further.

The realization is growing that an unfavorable building environment can reduce productivity. Though this effect is difficult to quantify, estimates of the cost of lost productivity due to the indoor environment in the United States have been estimated in the ten billions of dollars.⁴

The broadened knowledge base provided by IAQ research and investigative experience coupled with heightened public concern created intense interest in revising Standard 62-1989. In 1992, SSPC 62-1989 was formed with revision of the standard as a primary objective. The committee engaged this task on an accelerated schedule. Not simply an updating of the content of Standard 62-1989, the draft,⁵ approved for public review in the summer of 1996, represented a total rewrite covering 68 pages of text plus 15 appendices, some of which were “normative,” intended as part of the standard. This extensive document, known as 62-1989R, more than doubled the length of Standard 62-1989. Unlike previous ventilation standards, the proposed revision was written in code language as directed by the standards committee to facilitate adoption by model code bodies and code adopting agencies.

ASHRAE 62-1989R: Dead Duck or Phoenix?

During the 90-day public review period, nearly 9,000 comments were received. By June 1997, the project committee was well into the task of addressing these and preparing a second draft proposal. Then, in a surprise action at the close of the ASHRAE annual meeting in June, the Board of Directors placed Standard 62-1989 on “continuous maintenance.” This differed from the policy of “periodic maintenance” under which the revision effort was undertaken. Further development of the proposed revision was terminated. The public review draft was consequently withdrawn. Continuous maintenance, an ANSI-approved process, allows revision by addenda of the various provisions of the current standard. Such addenda are subject to the public review process prior to

ASHRAE approval.

Two other actions materially affect the ventilation standard. The document is to be split into two standards: one to cover commercial, institutional and high-rise residential buildings; the other covers single family and low-rise residential dwellings. Following the recommendation of a Presidential Ad Hoc Committee, the standard provisions also are to be separated into two parts, those intended for adoption as code and those for design practice. These latter provisions may be conformed as an ASHRAE guideline.

Once polished by the review draft comments and after further deliberations by SSPC 62, many key features of 62-1989R are beginning to resurface in the form of addenda to the current standard. How its content will be separated into code and guidance versions is not apparent at the time of this writing. Some of the more significant changes proposed by the revision are worth noting.

- Recognition that dilution ventilation can be accomplished by outdoor, cleaned recirculated or transfer air that is comparatively free of those contaminants produced within the ventilated space. This is not a new idea. It is consistent with ASHRAE’s long-established definition. What is new in the proposed revision are several provisions that assign quantitative value to the diluting effectiveness of these other air paths. Ventilation no longer can be regarded as simply a matter of supplying outdoor air to building spaces.
- Contaminants are produced in an interior space by two basic sources: first, occupants and occupant-related activities and second, other building materials and space-related activities. The former is regarded to be proportional to the number of occupants. Consequently, minimum outdoor air ventilation rates are prescribed based upon the number of occupants. The latter component is assumed to be related to the net floor area of the occupiable space. The rate accordingly is based upon that parameter. These contaminant strengths are presumed, based upon limited research, to be additive and the total outdoor air ventilation rate necessary is the sum of the two component rates.
- The objective of the ventilation rates so determined is to avoid dissatisfaction with the air in the occupied space as expressed by a substantial majority of occupants and to avoid known contaminants at concentrations likely to be harmful. Thus, the basis for the ventilation rates is the response of adapted persons, not visitors (the basis for the rates in Standard 62-1989). An increased rate to satisfy visitors is prescribed. Since a safe concentration of environmental tobacco smoke is unknown, the rates are based upon the absence of tobacco smoke. Guidelines for ventilation design to provide for sensory comfort when smoking is permitted are included in an informative appendix.
- Whether made up of outdoor air or recirculated air rendered equivalent by removal of three micron size particles (as determined by the particulate efficiency of the filtration tested in accordance with ASHRAE Standard 55.2-1999⁶), 15 cfm (7.5 L/s) per person is the minimum supply air rate required. The intent of this provision is to reduce airborne transmission of infectious disease, especially in densely occupied ap-

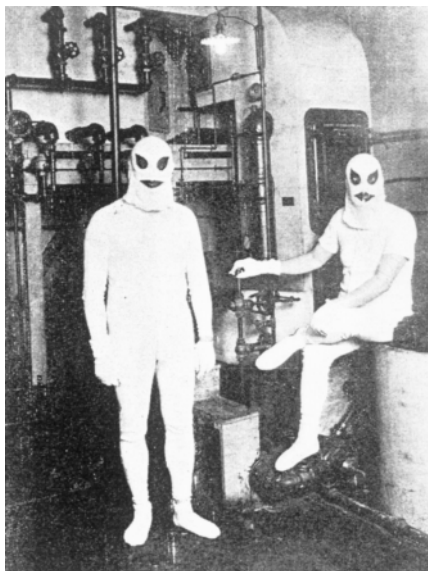
- plications.
- It is directed to construction, operation, and maintenance procedures as well as design.
 - Equipment and systems are to meet specific requirements of design, location and control as they can affect the quality of the indoor air.
 - Extensive documentation pertinent to IAQ performance of the design, operation, and maintenance of the mechanical ventilation is called for. Its purpose is to communicate design intent to both initial and future building owners and operators.

Health, Comfort or Both?

The purpose of the last two ASHRAE ventilation standards was to specify ventilation rates and indoor air quality for both health and comfort (more precisely occupant acceptability). The prior standard, Standard 62-73,⁷ made no reference to indoor air quality at all in title or text. Its purpose was, in part, to specify "...ventilation air quantities for the preservation of the occupants' health, safety, and well-being." Broadly, "well-being" may be interpreted as including comfort, but thermal comfort with respect to the upper limits of temperature and humidity is not found in building code provisions that also purpose "well-being."

Ventilation design for non-industrial settings historically has aimed at providing both health and comfort. Dr. Billings' recommendation for a minimum of 30 cfm (15 L/s) per person adopted by ASHRAE before the turn of the century was initially directed toward reducing the risk of airborne infection, most specifically tuberculosis. This ventilation rate became well accepted, as evidenced by the recommendation of several authorities.⁸

A paper appearing in Volume 1 of the *Transactions of the American Society of Heating and Ventilating Engineers* (ASHVE)⁹ included discussions involving a half dozen design engineers. Ventilation at the rate of 30 cfm (15 L/s)/person was their common practice for school classrooms. The purposes of ventilation were cited as "hygienic" and for occupant "vitality." Comfort per se with respect to ventilation was not mentioned in these sources. In time, a number of states



*By the 1920s, ASHVE research laboratory conducted air-conditioning research. The photo shows cloth body suits that could be saturated and used to test the reaction of the human body to "wet-bulb" conditions. ("Ku Kluxing in Science," *The Aerologist*, January 1927.)*

enacted laws mandating 30 cfm (15 L/s) per person of outdoor air for schools and public buildings.

In 1930, ventilation was defined to include both comfort and health as considerations.¹⁰ Ventilation for comfort primarily was to prevent overheating. However, perception of odors by unadapted persons was one basis for judging the effectiveness of ventilation.

Actually sharp distinctions between health and comfort are not readily identifiable even by medical authorities. Samet¹¹ has provided a helpful classification of the adverse effects of indoor air pollution related to the full range of responses.

1. Clinically evident disease.
2. Increased risk for diseases.
3. Physiological impairment.
4. Symptom responses.
5. Perception of unacceptable indoor air quality.
6. Perception of exposure to indoor air pollutants.

Moreover, he couples "well-being" to "health" as does the World Health Organization's definition of health, and includes all six of the above categories as adverse health effects "in the current concepts of health."

This background of thinking over the past century consistently agrees that ASHRAE's ventilation standard, whatever its title may be, is directed toward the health and well-being (a term that can embrace comfort) of building occupants. Yet debate persists over the issue of whether ASHRAE's ventilation standard should be for health or for comfort.¹²

Looking Ahead

The quantitative relationship of ventilation rates to occupant health and well-being has been difficult to establish scientifically. Examination of the Analytical Procedure of the 62-1989R public review draft (and to a lesser extent the Indoor Air Quality Procedure of the current ASHRAE Standard) explains the problem. Such a procedure, if applied, offers only generalized solutions. Individuals react differently depending upon component pollutants and their concentrations. Although the task is immense, research into the nature and effect of both organic and inorganic contaminants and their control continues throughout the world. Our knowledge gains in the quest for healthier buildings during the closing years of the century include:

- Expanded data relating to building source emissions, such as building materials and improvements in their manufacture.
- Better understanding of the effects of environmental tobacco smoke.
- Improved performance, through design and testing methods, of air filters.
- Advances in microbiology relating to fungal and microbial growth in building and ventilation systems and the effect that such growth and dispersion has upon building occupants.
- Design of air-conditioning system components to minimize microbial growth.
- Growing application of direct digital controls, computerized management of HVAC systems and the capabilities of systems so equipped to accomplish improved ventilation.

As time passes, both research and experience will enable an increasingly solid base for establishing dilution ventilation rates for the diverse uses of buildings. For the foreseeable future, the protocol for setting ventilation rates and other systems criteria will involve, as in the past, the

collective judgment of “an interdisciplinary committee,” comprising engineers, research scientists, industrial representatives and facilities managers.

In part, their collective objectivity will determine its success. Can vested interests, prejudices and parochialism be sufficiently subordinated, and the external political forces trying to influence the committee’s work be resisted to allow impartial objectivity?

As the twentieth century closes, building designers, constructors, managers and occupants; manufacturers, material suppliers, government, and, yes, lawyers all look to ASHRAE for the best available guidance for ventilation system design, construction and operations management. Should it falter in this trust, others not as well equipped technically—most likely the government armed with vast financial resources and political agendas—will become the standard maker.

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