ASHRAE's proposed ventilation rate procedure cleans up many of 62-1989's faults, but key components remain dependent on judgment rather than science

Points and Perspectives on ASHRAE's Proposed Ventilation Rate Calculation Procedure

By MICHAEL IVANOVICH, Editor

The first public review draft of Addendum 62n[1] is a complete rewrite of the ventilation rate calculation procedure contained in Section 6.1 of ASHRAE Standard 62-1989, *Ventilation for Acceptable Indoor Air Quality*.[2] It was released in June 1999, and the comment period closed August 6, 1999. The addendum, if adopted, would set new minimum outdoor air rates for commercial and institutional spaces and publish new or revised equations and default tables in code-enforceable language.

For design engineers, there is much to like about the addendum's structure as it sets forth a straightforward approach based on equations and tables in code-enforceable language.

Key components of the proposed addendum's content (and structure), however, were based on judgment or have not been validated through research, modeling, or practice. These circumstances are generating debates on whether the addendum should go forward or not based on whether there is sufficient new information in the field of ventilation to substantiate the changes.

To explore these issues and learn more about the new addendum and its implications, HPAC Engineering led a roundtable meeting to discuss the changes and the drivers leading to them. Some of those who participated are on the standard committee behind the addendum, some were past members, and others are researchers, consultants, or building professionals who are in some way involved with ventilation systems design, operations, or maintenance.

This article summarizes key provisions in the addendum, highlights significant differences between it and the current standard, and illuminates key points that are being debated in the industry on ventilation standards.

DIFFERENCES BETWEEN 62n AND 62-1989

Proposed Addendum 62n would replace guidelines within 62-1989 with code-minimum requirements, but it does not alter the standard's purpose, scope, or definition of acceptable indoor air quality (IAQ). (These were changed earlier.) A selling point of the proposed addendum is that 62n would change the ventilation rate calculation procedure by "clarifying vagaries, correcting inaccuracies, strengthening inadequacies, enhancing enforceability, and increasing design flexibility."[3]

It includes minimum ventilation rates for both people-related sources (bio-effluents) and building-related sources that are generated indoors.

The HPAC Engineering roundtable

The HPAC Engineering roundtable on 62n was held on August 31, 1999 at Gas Research Institute, Chicago, Ill. Participating were:

- **George Benda,** chairman and CEO, Chelsea Group Limited
- **Roger Hedrick,** principal engineer, GARD Analytics
- **Michael G. Ivanovich,** editor, HPAC Engineering (moderator)
- **Douglas R. Kosar,** managing director distribution program, Gas Research Institute
- **Dennis Moran,** commodity team leader, Marriott International, Inc.
- **Francis (Bud) J. Offermann III,** PE, CIH, president, Indoor Environmental Engineering
- **Don B. Shirey, III,** program manager, Florida Solar Energy Center
- **Dennis Stanke,** applications engineer, The Trane Company
- **Richard S. Sweetser,** president, Exergy Partners Corp.
- **Bede W. Wellford,** vice president, marketing, Airxchange

[1]*Superscript numerals indicate references listed at end of article.*

These minimum ventilation air rates are added together for a minimum outdoor air rate for each space. This rate is then combined (for most spaces) with ventilation effectiveness factors and system efficiency to determine both a minimum supply air rate for the space and a total outdoor air intake rate for the system. These rates can be measured at the supply diffuser and the air handler, respectively, making design requirements enforceable.

Figure 1 shows the differences in resultant ventilation rates between the current standard and the draft addendum for 33 selected spaces in terms of both the outdoor air intakes and within the breathing zone. The figure allows for easy comparison between the standard and the addendum. Please note that for demonstration purposes assumptions had to be made regarding population density, air change effectiveness, ventilation system efficiency, and other parameters for each space type. The complete spreadsheets (with formulae) and documentation of the assumptions are available at the HPAC Engineering Website at *www.hpac.com* in the November '99 Interactive Feature.

Figure 2 shows graphs that compare outside air rates for different spaces and population densities per specifications in 62-1989 and 62n. Smoking is not permitted in any of the spaces.

When examining Figure 2, keep in mind that the current standard prescribes "breathing zone" rates used to calculate breathing zone ventilation air flow. Prior to the proposed 62n, no version required specific accounting for room air change effectiveness (E_{ac}), so most designers assumed E_{ac} = 1.0, making supply ventilation rates (R_s) equal to breathing zone ventilation rates (R_t). The proposed 62n procedure has default values for E_{ac}, which makes this part of the procedure more practicable. When using Figure 1 to compare 62n space ventilation rates with 62-1989, compare Rs-1989 to Rs-62n not breathing zone rates.

THE ISSUE OF COMPLEXITY

According to panelists and the addendum's foreword, the current version of 62-1989 has components that are often ignored or misapplied. For example, Table 2, in 62-1989, is an easy source for ventilation rates in cfm per person or cfm per sq ft. These are handy numbers to have when trying to determine the cfm per person or cfm per sq ft needed for a design. Although there is language for refining Table 2's values based on specific design conditions, the table values are often taken at face value, and the subsequent refinements for air change effectiveness and ventilation system efficiency are disregarded.

> "I think we all have one common goal here—we want buildings that work."

Another example is the multiple-space equation, which, as one panelist put it, states that "There are no examples in the standard, so designers are not sure what values to plug into the (multiple space) equation's variables... so they ignore the equation." The addendum's foreword also states that the multiple-space equation is seldom used.

Does the proposed Addendum 62n contain simplified procedures that implementers will follow without resorting to shortcuts? Some roundtable panelists thought yes, others no. Some felt that the splitting of the total ventilation rate into people and building components was an unnecessary complication because the precision of the overall calculation was insufficient to justify this level of design scrutiny. The construct for splitting the ventilation rate is discussed later in this article.

Others felt that the equations and default tables provided a clear path to compliance as well as post-construction measurements to enforce building codes adopting the standard. The 62n foreword positions the addendum as being more straightforward by stating that "after the user becomes familiar with the procedures and terms, this revision will be considered simpler . . ." One panelist expressed that "the air change effectiveness and ventilation system efficiency corrections (would) encourage designers to specify better diffusers and get better mixing into the space."

Missing from the addendum, however, is a simple procedure of steps to follow. Instead, there are nested equations, which are algebraic expressions with variables that are calculated using other equations. Although variables are defined along the way, it is sometimes difficult to keep the variables straight; for example, six varieties of ventilation air have separate variables beginning with the letter "V" (V_{ns}, V_{oa}, V_{oat}, V_p, V_b, V_{oau}). After a while, it's hard to keep the Vs straight, and when talking about any particular V in isolation, it's not clear where that particular variety fits into the procedure.

The use of nested equations may be simpler and clearer to design engineers (who eventually become familiar with it and create design software using the equations), but what about contractors and code officials who need to know how to apply the standard in the field? Such practitioners may not have the math background for working out nested equations and understanding abstract concepts requiring six different types of ventilation air to treat a building space. One panelist, who trains contractors on ventilation practices, stated that without simple processes such as one-step lookup tables, they will ignore the standard and "do what their daddy did..." As blunt as this statement is, the truth is that many buildings are in fact built this way.

This begs the questions:

- Who are the users of the ventilation standard?
- How are the standards being used?
- If there are different levels of users of the standard, how should the standard be written to meet the needs of all of its users?

The panelists agreed, however, that it would be imprudent to oversimplify the standard such that it leads to poor practice rather than away from it. As one panelist stated eloquently, "Without compromising the sanctity of the standard or its intellectual rigor, the committee should advance the science of ventilation toward making the standard more practical and clear and, thus, more accessible to all of its users."

FIGURE 1 Comparative outside air (OA) rates for selected occupied spaces.

Type of space	Breathing Zone OA (cfm per person) 62-1989	Breathing Zone OA (cfm per person) 62n	Percent difference	OA Intake Rate (cfm per person) 62-1989	OA Intake Rate (cfm per person) 62n	Percent difference	Error if E_v/E_{ac} not used (%)*
FOOD AND BEVERAGE SERVICE							
Cafeteria, fast food, dining hall	10	7.6	-24%	10	7.6	-24%	0%
HOTELS, MOTELS, RESORTS, DORMITORIES							
Bedrooms	30	30	0%	30	60	100%	50%
Living rooms	30	30	0%	30	60	100%	50%
Lobbies/prefunction	7.5	8.2	9%	7.5	10.25	37%	20%
Meeting rooms	20	6.2	-69%	20	7.75	-61%	20%
OFFICE BUILDINGS							
Office space	20	14.57	-27%	20	18.21	-9%	20%
Reception areas	7.5	9	20%	7.5	11.25	50%	20%
Telecommunication/data entry	20	8	-60%	20	10	-50%	20%
Conference rooms	20	6.2	-69%	20	7.75	-61%	20%
Main entry lobbies	7.5	13	73%	7.5	16.25	117%	20%
RETAIL							
Sales floor (except as below)	20	15	-25%	20	15	-25%	0%
Supermarket	11.25	13.8	23%	11.25	13.8	23%	0%
SPORTS AND AMUSEMENT							
Ice arena (skating area)	50	30	-40%	50	37.5	-25%	20%
Spectator areas	15	7.4	-51%	15	9.25	-38%	20%
THEATERS							
Auditorium seating area	15	5.4	-64%	15	5.4	-64%	0%
Lobby	10	7.4	-26%	10	7.4	-26%	0%
EDUCATIONAL FACILITIES							
Daycare (through age 4)	15	12.6	-16%	15	15.75	5%	20%
Classrooms grades K to 3 (ages 5 to 8)	15	11.6	-23%	15	14.5	-3%	20%
General classrooms (grade 4 plus)	15	8.86	-41%	15	11.07	-26%	20%
Lecture classroom	15	7.54	-50%	15	9.42	-37%	20%
Lecture hall (fixed seats)	15	5.4	-64%	15	6.75	-55%	20%
Art classroom	15	11	-27%	15	13.75	-8%	20%
Science laboratories	20	10	-50%	20	12.5	-38%	20%
Wood/metal shop	20	9.8	-51%	20	12.25	-39%	20%
Media Center	10.5	11.6	10%	10.5	14.5	38%	20%
Music/theater/dance	20	18	-10%	20	22.5	13%	20%
Multi-use Assembly	10.5	7	-33%	10.5	8.75	-17%	20%
HEALTH CARE							
Patient rooms	25	25	0%	25	31.25	25%	20%
Treatment and exam rooms	15	15	0%	15	18.75	25%	20%
Operating and delivery rooms	30	30	0%	30	37.5	25%	20%
Recovery & ICU	15	15	0%	15	18.75	25%	20%
Autopsy	62.5	62.5	0%	62.5	78.13	25%	20%
Physical therapy	15	15	0%	15	18.75	25%	20%

*This is the error, i.e., the percentage that the OA rate at the intake will be below the required rate, if E_v and E_{ac} are ignored.

FIGURE 1. Selected space occupancy types showing outdoor air rates from ASHRAE Standard 62-1989 and proposed Addendum 62n. Courtesy of Roger Hedrick, GARD Analytics, Inc. (rhedrick@gard.com), from work sponsored by the Gas Research Institute.

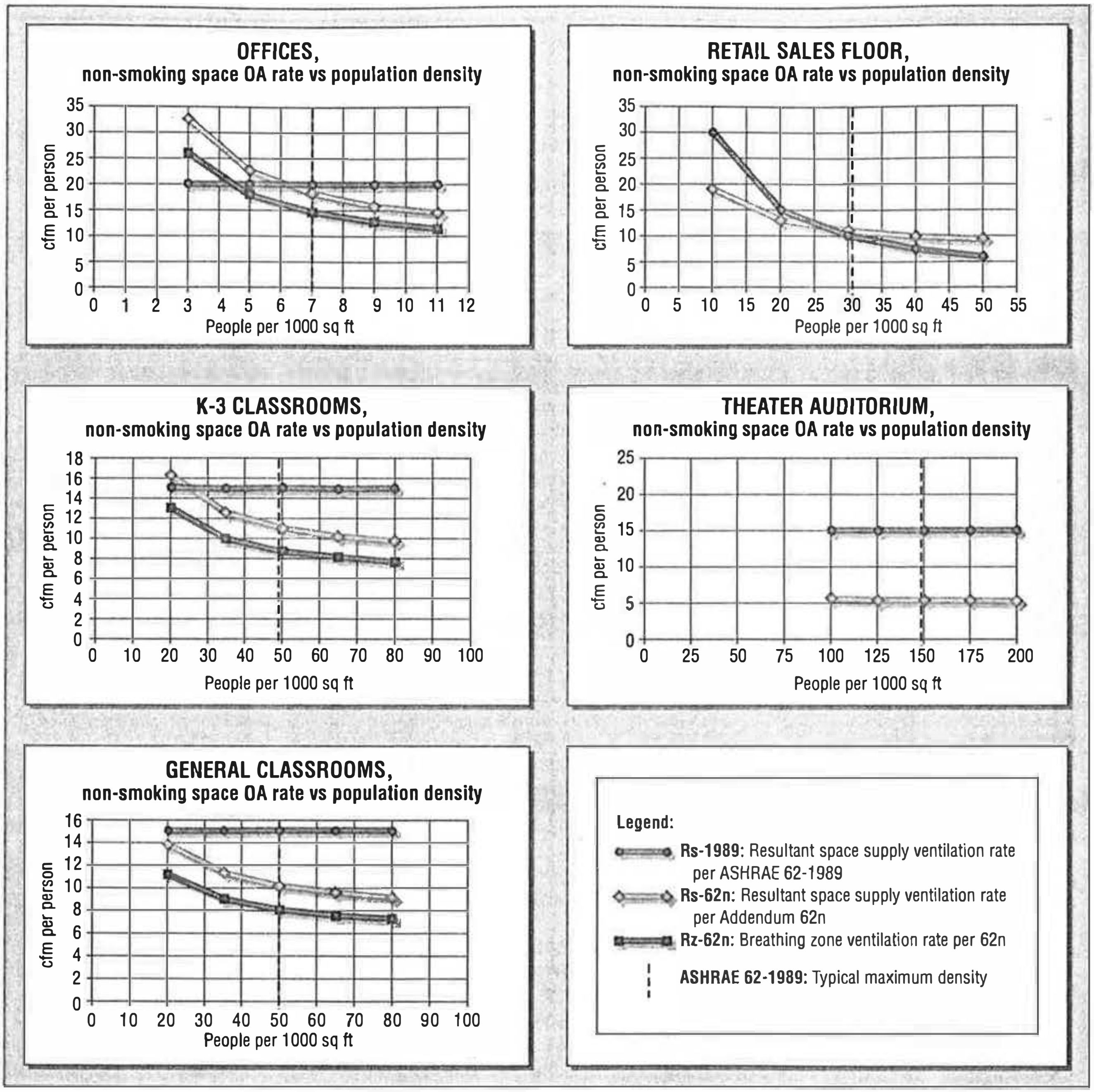

FIGURE 2. Comparisons of outdoor air rates for varying occupancy space types and occupancy ranges. System efficiency effects are not considered. Courtesy of Dennis Stanke, The Trane Company.

THE CONSTRUCT

In looking at the Table 2 in 62-1989 and Table 6.1 in the proposed addendum, one might think that rigorous research was performed to arrive at Table 6.1's ventilation rates for 78 different occupied spaces, that these values came from analyzing data aggregated from actual buildings, or that the rates came from a computer model implementing first-principle equations. This is not the case, however. Based on review of published studies on sick building syndrome in office buildings,[4] a ventilation rate of 20 cfm per person was deduced to be an appropriate rate for office buildings. In conjunction with this, and a desire to separate a "people component" and a "building component" from a building's total ventilation rate, a construct was created that was subsequently applied to establish the remaining 77 occupancy spaces in Table 6.1. To explain this construct and how it was applied, refer to the accompanying sidebar by Bede Wellford, *Airxchange*.

HOT AND HUMID CLIMATES

The panelists discussed the dilemma faced by hot and humid climates where high ventilation rates bring a lot of

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warm, moist air into a building—raising the risk for mold growth and associated IAQ problems. There is also a perception that treating this air with dehumidification equipment or higher capacity air conditioning systems would result in higher first costs and higher operations and maintenance costs.

Panelists responded that the standard committee needs to be aware that "there are alternative, cost-competitive technologies" that work, although they may involve doing things differently than in the past. Another point made during the discussion was that the ventilation committee should not compromise the ventilation necessary for dilution of contaminants based on energy or someone's perception of what costs are acceptable. These matters are within the scope of ASHRAE Standard 90.1, just as thermal comfort issues are addressed in ASHRAE Standard 55.

THE "L" AND "H" WORDS

There was some discussion about the liability and litigation consequences surrounding the health of occupants, IAQ, and the ventilation standard. It was noted that the word "health" has disappeared from the standard's language contained in the title, purpose, and scope (TPS) sections. Some felt that ASHRAE was trying to dodge responsibility by creating a "body odor" standard. Some even argued that the committee did not even accomplish this with the addendum—that densely occupied spaces are going to smell bad to people upon entering them, and some of these people are the occupants who remember, even after they adapt, that the space smells.

The health issue was raised because ventilation rates in many densely populated spaces were reduced dramatically. Cutting the ventilation rate in half for a space containing a source with a constant emission rate could double the concentration of the contaminant in the space. As such, panelists noted, without research supporting their assumption that cutting rates in half is not a health risk, the standard committee could be exposing practitioners to liability risks.

One panelist stated that since the ventilation standard had "health" in its TPS language since the standard first existed (until recently), it had become a "standard of care." Another panelist claimed that it was a "*de facto* health standard" regardless of its intent. Panelists discussed whether removing the word "health" from the TPS language adopted in 1997, and the caveats stated in Addendum 62d, would provide adequate protection from IAQ lawsuits filed by occupants.*

EDUCATION, TRAINING, AND RESEARCH NEEDED

The need for research was expressed so often during the roundtable that discussions were set

**Addendum 62d adds language stating that following the standard does not guarantee acceptable IAQ due to individual sensitivities to contaminants.*

Suggested Research Projects

The following topics were suggested during the HPAC Engineering roundtable as research projects appropriate for ASHRAE to sponsor in support of existing and future ventilation standards:

- ***Disease control***—Link between ventilation and disease control. For example, are environments in schools that are better ventilated healthier, as measured by the absentee rate of students and staff? Under what conditions does ventilation prohibit the spread of disease within a building, and under what conditions does ventilation accelerate or facilitate the spread of disease?
- ***Odors and adaptivity***—Are adapted occupants satisfied, or can they be so turned off to a space upon entry that they cannot acclimate to it or eventually be satisfied within it? What percentage of dissatisfied occupants constitutes a problem building?
- ***Multiple building types***—Quantify the ventilation rate among the spaces defined in Table 6.1 of the addendum where occupants find the indoor air quality acceptable.
- ***Ventilation calculation refinements***—Are Table 6.2 and 6.3 accurate for refining air change effectiveness and ventilation system efficiency, respectively?
- ***Alternatives***—Investigate alternatives to dilution for the control of contaminant sources. Investigate whether these alternatives can address the totality of the indoor contaminants or if they can only work on specific sources one at a time. To be an alternative to dilution, they would have to address the totality.
- ***Field studies***—Examine the real-world implications of standards in the operations and maintenance environment. How can the standard be improved (made more practical) to facilitate easier, less expensive, and more effective O&M?
- ***Infiltration***—Examine the role unplanned air flow plays in building ventilation and the measurement of ventilation rates. A technician could be measuring the outside air intake rates, but the actual dilution rate for the building could be much greater due to infiltration.
- ***Literature review***—Gather and review published and unpublished reports from researchers and practitioners that add to the existing body of literature used when developing the ventilation standard.
- ***Cost-benefit analyses***—Model different ventilation strategies to introduce outside air and achieve humidity and temperature control. Examine the costs and benefits within the context of the life cycle of a building and systems.
- ***High asthma rates***—With asthma rates increasing dramatically over the past few decades, especially among children, could or should Standard 62 address potentially large populations having respiratory afflictions? What is the relationship to school environments and ventilation rates?
- ***Research protocol***—We need to have a research protocol in place before initiating a lot of research projects. The protocol would help layout a research strategy and ensure that the results of different projects are compatible.

aside and panelists were asked to suggest research projects that ASHRAE could sponsor. The result is shown in the accompanying sidebar.

Also, there was general consensus that education and training are needed to advance the state of ventilation practice throughout the industry.

CONCLUSIONS

This article describes some differences between the ventilation rate procedure in the current ventilation standard and the new procedure proposed in Addendum 62n. I encourage readers to buy the addendum, if it is available, from ASHRAE and become familiar with it. I also encourage readers to participate in the second public peer review, which is likely to occur in the first half of the year 2000.

The roundtable discussions were interesting in that they raised philosophical issues that at times seemed as contentious as any of the technical issues. For example:

- Are there any limits to the degree that a standard can be based on judgment? On the other hand, should ventilation judgment be enfolded into consensus standards or should it be passed on to time-pressed practitioners and overburdened code authorities?
- Should the portions of a standard that are based on judgment be distinguished from those that are substantiated by research or other forms of validation? On the other hand, does it matter so long as the drafts of a standard have undergone an extensive public peer review process?
- Should the standard be written so practitioners who are likely to be intimidated by algebraic equations can use it? On the other hand, should practitioners who design and/or build the structures that the public uses be expected to know and apply high school algebra in the design process?

Research will not resolve these types of issues, but it will help. What will help the most are face-to-face forums that get qualified people to debate issues openly. After all, as one panelist stated in the roundtable, "I think we all have one common goal here—we want buildings that work." **HPAC**

The Ventilation Rate Construct in Proposed Addendum 62n

By Bede Wellford, Airxchange

Discussions at the HPAC Engineering roundtable meeting on Addendum 62n identified what may be a significant flaw in the development of the methodology (known as "the construct") used to develop the rates in Table 6.1. In reviewing the sample tables of calculated outdoor air rates shown in Figure 2, it is clear that all dense occupancies (except offices) would experience a reduction in rates, while sparsely occupied spaces sometimes experience drastic increases in rates. Noted during the roundtable was the fact that these changes do not appear to bear any consistent relation to which types of buildings experience problems or the anticipated sources in these occupancies. It was suggested that the observed relationship is more of an artifact of the construct than any known truth about the required ventilation rates.

In an effort to explain this, it is useful to look at how the construct was developed. The following is my understanding from attendance at various SSPC-62 committee and subcommittee meetings:

- The committee decided that they wished to pursue a method, which would account separately for the people-driven and the building-driven components of ventilation.
- The Mendell study[4] was identified as the only valid reference relating ventilation rate to "acceptable indoor air quality." It was understood that this summary of available research only speaks directly to the rates for office buildings.
- The committee also decided that the new construct would be based on satisfying the odor perceptions of 80 percent of adapted occupants as opposed to 80 percent of visitors. (The 80 percent of visitors criterion embedded in 62-1989 resulted in the 15 cfm per person minimum and was the basis for other rates, including offices, which were adjusted using judgment based on the additional indoor contaminant burden expected in the various spaces.) This decision reduced the people-driven component from a minimum of 15 cfm per person to a minimum 5 cfm per person.
- The "successful" office rate of approximately 20 cfm per person from the Mendell study was used as a benchmark and combined with the 5 cfm per person for people to derive the building component for offices of 0.06 cfm per sq ft.
- Finally, the committee used judgment to come up with building ventilation components ranging from 0.06 to 1.0 cfm per sq ft based on how "dirty" various occupancies could be relative to office space. On a line-by-line basis, the occupant ventilation components in Table 6.1 were also adjusted to account for activity levels.

This brief description glosses over many key discussion issues with which the SSPC wrestled, including the theory of additivity; the practicality of specifying some spaces based on occupants rather than only floor area; and the impact of assumptions about occupant density on the results. Nevertheless, it represents the key steps taken in developing the construct.

If we examine each of these steps in turn, we may identify important problems or at least questions regarding the methodology:

- In and of itself, this approach of adding ventilation components together could be considered a step forward. It opens the door to the development of more detailed information about what drives ventilation requirements and could provide a framework for future development of ventilation standards. However, there are questions about the value of applying this framework in a national standard based on a lack of substantiation of the theory and imprecision in both theory and practice.
- There is no question regarding the importance and usefulness of the Mendell study as a benchmark.
- The "adapted occupants" decision is certainly at the heart of the issue. The decision to utilize the lower adapted occupants rate may have been driven by

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concerns for energy conservation, humidity control, or cost. This is speculative, however, because the committee did not state reasons for the change in the foreword. Regardless, the committee seems to have ignored the impact this change will have on visitors (which includes occupants for a brief time each time they enter the space). The question of what percentage of satisfied occupants is required to have a "successful" building is likewise not addressed.

The low rate for people (one-third of the baseline minimum from 62-1989) results in a correspondingly higher building rate. This in turn gives rise to the large and questionable increases in lobbies, reception areas, supermarkets, libraries, etc. Note that these are spaces seldom, if ever, associated with IAQ complaints. On the other hand, classrooms, auditoriums, conference rooms, and meeting rooms would see greatly reduced rates. These are precisely the occupancies, which are most frequently cited as having insufficient dilution ventilation. This appears to be an artifact of the construct, driven by the "adapted occupants" decision.

Conclusion

In our discussions, it was identified that the building component of the construct appears to be too high. If this were true, then using the proposed construct and the Mendell data, the rate for people is too low. Adjusting the construct based on satisfying visitors would bring the various occupancies back into line with experience. At the conclusion of the roundtable, two panelists, including one member of the 62 committee, stated that they had previously been advocates of a higher building component, but the roundtable discussions persuaded them to rethink this position. Prior to a second public review, the committee may wish to reexamine whether people-related rates based on adapted occupants are supported by science or experience.

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