# *VENTILATION CODES*:
# ICC's International Mechanical Code vs. NFPA 5000,
*Analysis and Recommendations*

April 16, 2003

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## INTRODUCTION

The International Code Council (ICC) was established in 1994 as a nonprofit organization dedicated to developing a single set of comprehensive and coordinated national model construction codes. The founders of the ICC are three previously independent model code bodies, who have just recently merged their efforts and organizations. They include: Building Officials and Code Administrators International, Inc. (BOCA), International Conference of Building Officials (ICBO), and Southern Building Code Congress International, Inc. (SBCCI).

The most noticeable absence from this group is IAPMO, the International Association of Plumbing and Mechanical Officials, which historically published the Uniform Building Codes (UBC). The UBC and their Mechanical Code are mostly used in the western part of the U.S. The jurisdictions still using the last update to the UBC will need to find another model code reference as the UBC will no longer be published. In the alternative, the National Fire Protection Association (NFPA) has joined with IAPMO, ASHRAE and the Western Fire Chiefs Association and established an ANSI-accredited comprehensive "consensus"-based set of model codes (C3). Their new building code is called NFPA 5000 and combines with the National Electric Code, NFPA101 Life Safety Code, UPC, UMC, and NFPA 1.

Because NFPA 5000 depends largely on ASHRAE Standard 62 – Ventilation for Acceptable Indoor Air Quality, we will restrict the bulk of our discussion to the current IMC.

The International Code is on a 2-year development / review cycle, with the changes for the 2003 version being approved at the ICC conference in October 1-4, 2002 in Ft. Worth, Texas. It will be some time before jurisdictions consider and approve the newest version, some requiring legislation to do so. Therefore, our discussion will be limited to the IMC2000, which is the most relevant to current building design and operational requirements.

## IMC2000 ANALYSIS AND RECOMMENDATIONS

### *SECTION 401 - GENERAL*

The purpose of this section is defined in paragraph 401, and that is to require that minimum ventilation be provided to a space during occupied periods.

> ***"401.3 When required.*** *Ventilation shall he provided during the periods that the room or space is occupied."*

### *SECTION 403 - MECHANICAL VENTILATION*

When mechanical ventilation is used, specific rates of ventilation based on occupancy and structure type, but construction requirements based directly on net floor area. The section continues into 403.3.1 to specify that the ventilation requirements are allowed to be based on rates "per person" but limited to the actual number of occupants present.

***403.3.1 System operation.*** *"The minimum flow rate of outdoor air that the ventilation system must be capable of supplying during its operation shall be permitted to be based on the rate per person indicated in Table 403.3 and the* ***actual number of occupants present****."*

This very fact **disallows the use of $CO_2$ demand control ventilation** schemes that "approximate" occupancy and indirectly calculates ventilation. $CO_2$ levels have no direct relationship to the actual intake rates required in table 403.3 that need to be provided and controlled.

The following should be familiar to everyone with any exposure to ASHRAE Standard 62. The next section provides for the use of ASHRAE's "multi-space equation" when a single supply system serves more than one zone.

***"403.3.2 Common ventilation system.*** *Where spaces having different ventilation rate requirements are served by a common ventilation system, the ratio of outdoor air to total supply air for the system shall he determined based on the space having the largest outdoor air requirement or shall be determined in accordance with the following formula:*

*(Equation 4-1)* $\boldsymbol{Y = X / (1 + X - Z)}$ *where:*

$Y = V_{ot} / V_{st}$ = *Corrected fraction of outdoor air in system supply.*
$X = V_{on} / V_{st}$ = *Uncorrected fraction of outdoor air in system supply.*
$Z = V_{oc} / V_{sc}$ = *Fraction of outdoor air in critical space. The critical space is that space with the greatest required fraction of outdoor air in the supply to this space.*

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|---|---|---|
| $V_{ot}$ | = | *Corrected total outdoor airflow rate.* |
| $V_{st}$ | = | *Total supply flow rate. i.e., the sum of all supply for all branches of the system* |
| $V_{on}$ | = | *Sum of outdoor airflow rates for all branches on system* |
| $V_{oc}$ | = | *Outdoor airflow rate required in critical spaces.* |
| $V_{sc}$ | = | *Supply flow rate in critical space."* |

The Multi-space Equation is a simplistic way of providing consideration for the needs of the occupants in the "critical" zone, while giving some credit for those spaces that will be over-ventilated by keying the intake rate for the building to the needs of a previously identified "critical" zone. The latest proposal to modify ASHRAE Standard 62 – 2001 includes a new method of determining the intake rates for air handlers supplying multiple zones. It is located in Section 6.1, the Ventilation Rate Procedure. Addendum "n", in its latest Public Review form, includes consideration of several new factors that help make the calculation more effective, even if more complicated for the practitioner.

Other significant sections of Chapter 4 in the IMC include the following paragraphs.

***"403.3.3.1 Variable air volume system control.***
*Variable air volume [VAV] air distribution systems, ……. shall be provided with controls to regulate the flow of outdoor air.* ***Such control system shall be designed to maintain the flow of outdoor air at a rate of not less than that required by Section 403 over the entire range of supply air operating rates."***

***"403.3.4 Balancing.*** *Ventilation systems shall be balanced* ***by an approved method****. Such* ***balancing shall verify that the ventilation system is capable of supplying the airflow rates required by Section 403****."*

When reading these sections on VAV systems and verification, I cannot believe that any means other than direct measurement of outside air intakes will satisfy this requirement, while optimizing the energy used. To attempt a one-time manual balance and set-up would require the user to set the system for the worst-case condition and thereby increase the intake of outside air at unnecessary rates and

***SECTION 405 - SYSTEMS CONTROL***

> ***"405.1 General.*** *Mechanical ventilation systems shall be provided with manual or automatic controls that will operate such systems whenever the spaces are occupied.* ***Air-conditioning systems that supply required ventilation air shall be provided with controls designed to automatically maintain the required outdoor air supply rate during occupancy."***

To provide effective and efficient control of dynamically changing systems, it is not reasonable to expect static or indirect control methods to provide acceptable results. When the requirements of this section mandates controls that will "automatically maintain the required…rate" of ventilation air, I can only interpret that to mean a dynamic control mechanism.

The only problem I found in the structure and content of the section is the limitation of ventilation requirements during occupied periods, without consideration of the need to dilute building-generated contaminants – independent of occupancy. There is effectively no base ventilation rate requirement or provision for pre-occupancy purge.

## NFPA 5000 - 2003

Were the International Mechanical Code takes only the *Ventilation Rate Procedure* directly from ASHRAE Standard 62-1999, the latest proposal for the NFPA ventilation code refers directly to the current version of ASHRAE Standard 62 for 7 specific structure types – in its entirety – (Section 49.2.2.1, page 355). A number of jurisdictions still subscribe to the UBC / UMC which governs their ventilation requirements until they adopt a new basis for their code.

Although theoretically less limiting, certain provisions of ASHRAE Standard 62 – 2001 are just as stringent as the IMC for VAV system designs.

> ***"5.3 Ventilation System Controls.*** *Mechanical ventilation systems shall include either manual or automatic controls that enable the fan system to operate whenever the spaces served are occupied. The system shall be designed to* ***maintain the minimum outdoor airflow as required by section 6 under any load condition****. Note: VAV systems with fixed outdoor air damper positions must comply with this requirement at minimum supply air flow."*

Readers should note that "section 6" of the Standard describes both the Ventilation Rate and Air Quality Procedures. Therefore, regardless of the method chosen for compliance, the designer and user must "maintain the minimum rates" determined by either procedure "under any load condition".

Also, remember if you chose a method which reduces the intake rates below the values shown in Table 2, one must be very concerned about the error rates in controlling much smaller intake volumes and be mindful of the impact of those errors on building pressurization requirements.

A comprehensive discussion of ASHRAE 62-2001 and all current addenda is contained in the White Paper entitled, "ASHRAE STANDARD 62, Ventilation for Acceptable Indoor Air Quality - Analysis and Recommendations" dated December 5, 2002. It is posted for viewing or retrieval at www.automatedbuildings.com.

## CONCLUSIONS

The word “maintain” is unambiguous and does not mean “get close to” or “average” the required rate. In fact, VAV requirements (403.3.3) provide that the control systems will maintain the required ventilation at a rate “not less than” that in the tables. Therefore, **any indirect method of control** (fixed intake damper, adiabatic mixing, supply-return calculation, return fan speed-slaving, $CO_2$, etc.) **will not be capable of insuring that the rates never drop below the minimums specified** in the table.

The IMC 2000 prescribes ventilation rates for acceptable indoor air quality. It should be clear to the design professional that the dynamic nature of mechanical ventilation requires dynamic control. Because the code and ASHRAE 62 are both “rate based” documentary requirements, continuous airflow measurement should be a central component of any effective control strategy to assure compliance.