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Addendum 62n

breathes new life into ASHRAE Standard 62

PRECIS

Addendum 62n revises the entire Ventilation Rate Procedure, including prescribed rates and design calculations. Compliance:

- **requires use of new people- and building-related rates for each zone ("additivity")**
- **mandates a new design procedure to find minimum intake of outdoor airflow**
- **permits use of conditions averaged over three time-constants for intermittent occupancy**
- **Allows dynamic reset during operation to match intake airflow to the present ventilation need**

from the editor …
Ventilation requirements in building codes have been patterned after ANSI/ASHRAE Standard 62, "Ventilation for Acceptable Indoor Air Quality," since its initial publication in 1973. Subsequent republications lowered the prescribed ventilation rates (1981) in response to the international energy crisis, and then raised them again (1989) to address growing concern about indoor air quality and its effects on health.

Since 1997 when the revision process for Standard 62 was converted to continuous maintenance, a number of separately reviewed and approved addenda clarified and updated the requirements in the 1989, 1999, and 2001 versions. Until Addendum 62n, however, none of these revisions revisited the ventilation rates at the heart of Standard 62. Addendum 62n revitalizes the premier standard for ventilation system design by giving it a much-needed "heart transplant."

In this EN, author Dennis Stanke (staff applications engineer for Trane and vice chair of ASHRAE SSPC 62.1) examines "62n" and its implications for ventilation system design.

The significance of "62n"

In accordance with the continuous maintenance procedures that update many high-profile ASHRAE standards, Standard 62–2001, *Ventilation for Acceptable Indoor Air Quality,* was recently modified by an important new addendum (approved and published online at www.ashrae.org).

Addendum 62n updates the ventilation rates that were first prescribed by the 1989 version of the standard, and which now serve as the basis of numerous building codes and building designs. With its approval, "62n" marks the culmination of more than a decade of active debate within the ASHRAE community. It should be a welcome sight to many design engineers because the 1989 rates prescribed for several categories of building occupancy have been a source of contention since they first aired for public review in 1986.

The new ventilation rates better account for *additivity* (inset, p. 2), which in the context of ventilation, means that odors from different sources tend to heighten the overall perception of odor. Building occupants and their activities generate odorous pollutants, as do building contents; therefore, the ventilation requirements of "62n" consist of:

> … a people component (to dilute contaminants from people and their activities) and an area component (to dilute contaminants from non-occupant-related sources that are more related to floor area than the number of people).[1]

This approach to diluting indoor contaminants eliminates the inherent penalty for high-density zones that resulted when ventilation requirements were prescribed solely on airflow per person.

Addendum 62n also:

- … revises the procedure for calculating *zone* ventilation airflow to more accurately represent the performance of different types of ventilation systems by accounting for the effects of supply-air temperature versus breathing-zone temperature and for placement of discharge diffusers relative to return grilles.
- … updates and clarifies the procedure for calculating *system* intake airflow for different types of ventilation systems. (Incorrectly calculating intake airflow often results in underventilation—especially in VAV applications at part-load conditions.)
- … identifies control strategies that reduce (or increase) intake flow so that ventilation capacity matches a variable ventilation "load." These options can save considerable preconditioning energy and therefore may be required by ASHRAE Standard 90.1.

Let's take a closer look at each of these changes. *(Note: The equations and variables referenced throughout this discussion are summarized in the inset on p. 7.)*

[1] From the "Foreword" to ANSI/ASHRAE Addendum *n* to ANSI/ASHRAE Standard 62–2001 (Atlanta: ASHRAE, Inc.), published in 2003.

New ventilation rates

Exhibit 1 shows the minimum breathing-zone ventilation rates for several occupancy categories, comparing the requirements from Addendum 62n with those of ASHRAE Standard 62–1989 (which remained the same in the 1999 and 2001 editions). The most significant changes apply to densely occupied spaces, such as auditoriums, conference rooms, and lecture classrooms. What's less apparent from the table is the shift in focus from satisfying *visitors* (people initially exposed to odors in a space) to satisfying *occupants* (people already adapted to the odors in that space). This shift, coupled with additivity, results in slightly lower ventilation rates for many categories of occupancy.

It's worth noting that Table 6.1 of "62n" now expresses the ventilation rates as minimum requirements. It also adds new occupancy categories (e.g., art classrooms, mall common areas, health-club aerobics rooms), excludes others (e.g., kitchens, commercial laundries, enclosed parking garages), and alters the defaults for occupant density. Accompanying notes clarify the table's content and application; among them, these general qualifications are particularly significant:

- The assumption underlying the rates in Table 6.1 is that *all other requirements in Standard 62 are met*—drain pans drain, humidity is limited, filters are used, and so on.
- The table's default values for occupant density should only be used if the actual density is unknown.
- Table 6.1 rates only pertain to *no-smoking areas.*[2]

[2] ANSI/ASHRAE Addendum 62*o*, published online at www.ashrae.org, removes prescriptive ventilation rates for smoking-permitted areas and, instead, simply requires an unspecified increase in ventilation.

Exhibit 1. Comparison of ventilation rates[a]

	ASHRAE Standard 62–1989, Table 2		Addendum 62n, Table 6.1[b]			
Occupancy category	People, R_p cfm/person	or Area, R_a cfm/ft²	People, R_p cfm/person	+ Area, R_a cfm/ft²	Default occupancy qty/1000 ft²	Default combined OA rate, V_{bz} cfm/person
Office	20	—	5.0	0.06	5	17
Classroom (ages 5–8)	15	—	10.0	0.12	25	15
Lecture classroom	15	—	7.5	0.06	65	8
Retail sales	—	0.3[c]	7.5	0.12	15	16
Auditorium	15	—	5.0	0.06	150	5
Conference room	20	—	5.0	0.06	50	6

[a] Addendum 62n presents minimum breathing-zone ventilation rates in Table 6.1, which replaces Table 2 in the 2001 edition (as well as the 1999 and 1989 editions) of ASHRAE Standard 62. Our comparison is based on the 1989 standard to emphasize the age of the prescribed rates.

[b] The effective (default combined) outdoor-air rate per person is based on "typical" occupant density (default occupancy). We included the default values to simplify comparison with the 1989 ventilation rates.

[c] For ventilation zones classified as "retail sales," the 1989 standard required an effective outdoor-air rate of 20 cfm per person if occupant density is assumed to be 15 people per 1000 ft².

- Correcting for air density is acceptable but not required.

Note that Addendum 62n, Table 6.4, also prescribes minimum exhaust rates for 19 occupancy categories in which strong contaminant sources are present (e.g., art classrooms, commercial kitchens, locker rooms). Eight of these categories carry minimum requirements for both exhaust *and* ventilation: exhaust airflow to flush some of the contaminants from the zone and transport them out of the building, and ventilation airflow to dilute the contaminants remaining in the zone. For example, a 1000 ft² art classroom with a design occupancy of 20 people requires at least 380 cfm of breathing-zone outdoor airflow ($V_{bz} = 10 \cdot 20 + 0.18 \cdot 1000$) for ventilation and 700 cfm of exhaust airflow ($0.70 \cdot 1000$).

Making sense of "additivity"

ASHRAE Standard 62 specifies minimum ventilation rates that are intended to provide *acceptable indoor air quality*—indoor air that's free of harmful concentrations of known contaminants and that satisfies at least 80% of the occupants. Occupant satisfaction is determined by odor intensity, which results from the strengths of contaminant sources and the ventilation rate.

Contaminant sources either originate from occupants and their activities or from the building and its furnishings. If both sources are present and both (for example) produce perceivable odors, then the ventilation rate required for adequate dilution is the sum of the rates needed to handle each source separately.

Accounting for the "additive" effect of contaminant sources really isn't new. Earlier versions of the standard did so behind the scenes; dilution rates for building-related contaminants were added to the per-person dilution rate and the resulting composite was published for each occupancy category. For example, the standard previously required 20 cfm per person for offices: 15 cfm to dilute people-related odors and an additional 5 cfm to dilute building-related odors.

Using Equation 6-1 of Addendum 62n (inset, p. 7), design engineers now can explicitly account for occupant density using two ventilation rate requirements: one rate *per occupant* (cfm/person) and the other *per unit of occupiable floor area* (cfm/ft²). To determine the required ventilation, simply multiply the per-person rate by the number of people in the space and the per-unit rate by the floor area; then add the resulting airflows together. ●

Makeup air to replace the air that's exhausted from the zone/building may be any combination of outdoor air and transfer air from other zones.

New calculation for zone-level ventilation

"62n" outlines a three-step calculation for determining how much outdoor air must reach the zone diffusers, regardless of ventilation-system type. The new procedure will help assure correct and consistent application of the prescribed breathing-zone ventilation rates.

To demonstrate this procedure, we'll consider a "typical" office space that's divided into seven distinct ventilation zones (Exhibit 2).

❶ Find the minimum outdoor-airflow requirement, V_{bz}, for each breathing zone.

The *breathing zone* is that region of the ventilation zone at least 2 feet from the walls and between imaginary planes at 3 inches and 72 inches above the floor. Until Addendum 62n, this region was called the *occupied zone*.

To find V_{bz}, it's first necessary to:

- Identify each ventilation zone.[3]
- Determine the design population (P_z) and zone floor area (A_z) for each ventilation zone.
- Look up the minimum outdoor-air rates (R_p in cfm/person and R_a in cfm/ft² from Table 6.1) to dilute contaminants from people- and building-related sources.

To illustrate, assume that we want to ventilate an office space that comprises 4000 ft² of occupiable area and is occupied by 20 people during normal usage (Exhibit 3). According to Table 6.1, the prescribed minimum outdoor-air rates for the occupancy category "office space" are 5 cfm/person (R_p) and 0.06 cfm/ft² (R_a). Solving Equation 6-1 …

$$V_{bz} = 5\ cfm/p \cdot 20\,p + 0.06\ cfm/ft^2 \cdot 4000\,ft^2$$
$$= 100\ cfm + 240\ cfm = 340\ cfm$$

… we find that at least 340 cfm of outdoor air must be delivered to the breathing zone within this space.

[3] In the context of ventilation-system design, a "zone" consists of one or more occupiable spaces that share a similar occupancy type, population density, air-distribution effectiveness, and primary airflow. The spaces within a ventilation zone may or may not lie within the same thermal control zone.

Notice that Exhibit 3 introduces two variables, not specifically mentioned in "62n," that divide breathing-zone airflow V_{bz} into its constituents: V_{bzp} to dilute people-related contaminants and V_{bza} to dilute building-related contaminants. These variables will come in handy later on when we calculate occupant diversity.

❷ Account for air-distribution effectiveness, E_z, of the zone.

This step addresses the possibility that some of the air that's supplied through the diffusers won't reach the breathing zone due to placement of the diffusers and return grilles. For example, supply air from an overhead diffuser may short-circuit to a poorly placed return grille; or, warm supply air may never enter the breathing zone but merely float above it before entering a return grille. Air-distribution effectiveness, E_z, is the ratio of airflow that *actually* enters the breathing zone to the airflow that's delivered to the ventilation-zone diffusers.

Exhibit 4 (p. 4) shows four of the ten air-distribution configurations and E_z values listed in Table 6.2 of "62n." Most supply-and-return configurations result in an E_z of 1.0, but achieving this degree of effectiveness with overhead delivery of warm supply air may require extra design measures, such as a higher diffuser velocity or a lower supply-air temperature.

Exhibit 2. Typical office space divided into ventilation zones

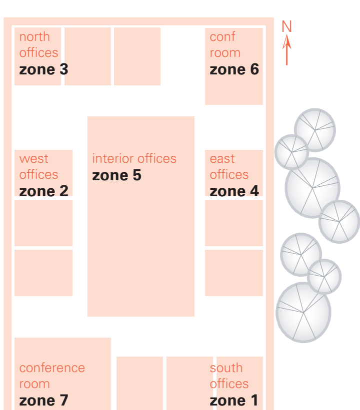


Exhibit 3. Zone-level ventilation calculations for example office space[a]

Ventilation zone	R_p cfm/p	• P_z qty	= V_{bzp} cfm	R_a cfm/ft²	• A_z ft²	= V_{bza} cfm	V_{bz} cfm	/ E_z fraction	= V_{oz} cfm
1 South offices	5	20	100	0.06	4000	240	340	1.0	340
2 West offices	5	20	100	0.06	4000	240	340	1.0	340
3 North offices	5	20	100	0.06	4000	240	340	[b]0.9	378
4 East offices	5	20	100	0.06	4000	240	340	1.0	340
5 Interior offices	5	100	500	0.06	20000	1200	1700	1.0	1700
6 North conference rm	5	20	100	0.06	2000	120	220	[b]0.9	244
7 South conference rm	5	30	150	0.06	2000	120	270	[b]0.9	300
System total	—	230 (ΣP_z)	1150 (ΣV_{bzp})	—	—	2400 (ΣV_{bza})	— ❶	— ❷	3642 ❸

[a] See Exhibit 2 (left) for a plan view of the office space for this example. Variables are defined in the inset on p. 7.

[b] We used a lower (more conservative) E_z value than specified in Table 6.2, assuming that the proximity of the supply diffuser and return grille would cause some short-circuiting.

Exhibit 4. Zone air-distribution effectiveness[a]

E_z value[b]	Air-distribution configuration
1.0	• Ceiling supply of cool air • Ceiling or floor return
0.8	• Ceiling supply of warm air ≥ t_{space} + 15°F (8°C) • Ceiling return
1.0	• Ceiling supply of warm air < t_{space} + 15°F (8°C) and mixing within 4.5 ft (1.4 m) of floor • Ceiling return
1.0	• Floor supply of cool air, with mixing at least 4.5 ft (1.4 m) above floor[c] • Ceiling return

[a] Excerpt paraphrased from Table 6.2 of Addendum *n* to ANSI/ASHRAE Standard 62–2001.

[b] If determined in accordance with ASHRAE Standard 129, air-change effectiveness can be used in lieu of the values in this table. *Exception: Systems with unidirectional flow.*

[c] Typical of most underfloor air-distribution systems.

Note: As the E_z defaults in Exhibit 4 indicate, floor-mounted mixing diffusers usually perform no better than overhead diffusers when delivering cool air.

❸ Find the required zone-level outdoor airflow, V_{oz}, at design.

If the system serving our example office delivers cool air through overhead diffusers and has overhead return grilles, then Table 6.2 indicates a default of 1.0 for zone air-distribution effectiveness. Solving Equation 6-2 tells us that the supply air delivered to the diffusers at the office space must contain at least 340 cfm of outdoor air:

$$V_{oz} = V_{bz} / E_z = 340\ cfm / 1.0 = 340\ cfm$$

Steps 1 through 3 must be repeated for each zone that the ventilation system serves. Armed with that information, we then can determine how much outdoor air the system must bring into the building.

New calculation for outdoor-air intake

Addendum 62n defines three configurations for ventilation systems: *single-zone, 100% outdoor air,* and *multiple-zone recirculating*. The method for calculating outdoor-air intake flow V_{ot} differs for each configuration, but each method builds on the three-step calculation for zone-ventilation airflow.

Single-zone systems. In a single-zone system, such as a packaged-terminal air conditioner or a classroom unit ventilator, one air handler serves the ventilation needs of one zone. All of the outdoor air that enters the system passes through the diffusers that supply air to the space, so single-zone-system ventilation efficiency E_v always equals 1.0.

The last step, ❹, is simply setting the required outdoor-air intake flow V_{ot} equal to the required zone outdoor airflow V_{oz} (Equation 6-3). Returning to our example, if a single-zone rooftop unit serves the south offices, then V_{ot} = V_{oz} = 340 cfm.

100% outdoor-air systems. In a 100% (or "dedicated") outdoor-air system, a single air handler serves the dilution requirements of one or more ventilation zones by delivering the appropriate outdoor airflow—without any recirculated air—to each zone. Terminal units (fan–coils, water-source heat pumps, even chilled/heated ceiling panels) handle the thermal loads within each zone.

Like the air handler in a single-zone system, all outdoor air entering this unit passes through the ventilation-zone diffusers. Therefore, system ventilation efficiency E_v for 100% outdoor-air systems always equals 1.0.

In this case, the final design step, ❹, is to sum the outdoor-airflow values for the zones (Equation 6-4). Solving Equation 6-4 for the seven ventilation zones in our example results in outdoor-air intake flow of 3642 cfm:

$$V_{ot} = \Sigma V_{oz} = 3642\ cfm$$

Multiple-zone recirculating systems. When one air handler supplies a mixture of outdoor air and recirculated return air to more than one ventilation zone, it's considered a *multiple-zone recirculating (MZR) system*. The most common example is a VAV system.

An MZR system delivers the same mixture of primary air (outdoor and recirculated return air) to each ventilation zone. Properly ventilating the "critical" zone (the one that requires the highest fraction of outdoor air) will overventilate the others. In this case, system ventilation efficiency is less than 1.0 because some "unused" outdoor air leaves the building in the relief and/or exhaust air stream without diluting indoor contaminants.

System ventilation efficiency E_v is determined either using Equation 6-5 and default values from Table 6.3 of the addendum, or using the calculation procedure described in Appendix G. Having found E_v, outdoor-air intake flow V_{ot} is determined by solving Equations 6-6, 6-7, and 6-8.

Let's examine both methods of determining ventilation efficiency and intake flow for an MZR system.

Alternative 1: Default E_v. Basing the determination of outdoor-air intake flow on Table 6.3 defaults involves a four-step process (summarized in Exhibit 5), which builds on the three-step calculation for zone ventilation airflow (p. 3).

❹ Find zone primary outdoor-air fraction Z_p for each ventilation zone.

The fraction of outdoor air that's required in the primary air, Z_p, is the ratio of zone outdoor airflow (at the diffusers) to the primary airflow that's supplied to the zone. In a VAV system, Z_p for each ventilation zone is largest

Exhibit 5. Alternative 1 system-level ventilation calculations, based on default E_v, for example office space[a]

	Ventilation zone	Cooling load cfm/ft²	V_{pz} cfm	Minimum primary air[b] setting	V_{pzm} cfm	Z_p ratio	E_v interpolated fraction	P_s head count	D ratio	V_{ou} cfm	V_{ot} interpolated cfm
1	South offices	1.10	4400	0.35	1540	0.22	—	—	—	—	—
2	West offices	1.00	4000	0.30	1200	0.28	—	—	—	—	—
3	North offices	0.80	3200	0.27	864	0.44	—	—	—	—	—
4	East offices	0.90	3600	0.30	1080	0.32	—	—	—	—	—
5	Interior offices	0.80	16000	0.30	4800	0.35	—	—	—	—	—
6	North conference rm	1.20	2400	0.25	600	0.41	—	—	—	—	—
7	South conference rm	1.60	3200	0.25	800	0.38	—	—	—	—	—
	System total	—	36800 (ΣV_{pz})	—	—	0.44 ❹	0.71 ❺	200	0.87	3400 ❻	4790 ❼

[a] For a plan view of the office space represented in this example, see Exhibit 2 (p. 3). Variables are defined in the inset on p. 7.

[b] Ratio of the minimum primary airflow setting, V_{pzm}, to the primary airflow at design conditions, V_{pz}.

when zone primary airflow V_{pz} is smallest. So, use the *minimum* expected primary airflow, V_{pzm}, to find the outdoor-air fraction by solving Equation 6-5 for each zone. For Zone 1:

$$Z_p = V_{oz} / V_{pzm} = 340 \text{ cfm} / 1540 \text{ cfm} = 0.22$$

Note: For this example, we assumed the design cooling load (in cfm/ft²) and minimum primary airflow fraction for each ventilation zone. It was then possible to calculate each zone's design-cooling primary airflow V_{pz}, minimum primary airflow V_{pzm}, and primary outdoor-air fraction Z_p.

Exhibit 6. E_v defaults from Table 6.3[a]

Maximum Z_p[b]	System ventilation efficiency, E_v
≤ 0.25	0.9
≤ 0.35	0.8
≤ 0.45	0.7
≤ 0.55	0.6
> 0.55	Use Appendix G

[a] From Addendum *n* to ANSI/ASHRAE Standard 62–2001, Table 6.3.

[b] Largest *zone primary outdoor airflow fraction,* calculated using Equation 6-5, among all of the ventilation zones that the system serves.

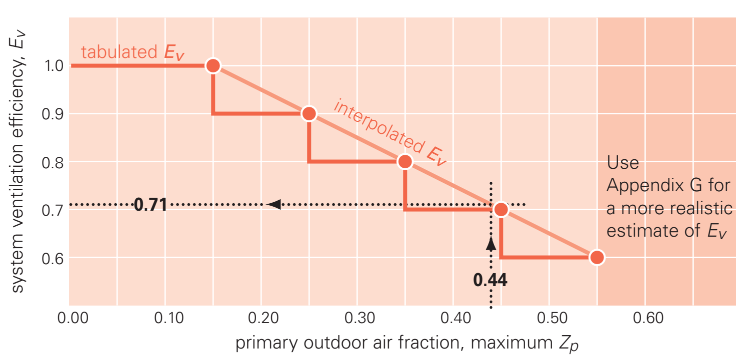
❺ Determine system ventilation efficiency E_v from Table 6.3.

Compare the primary outdoor-air fractions for the zones that the ventilation system serves. Use the largest value (maximum Z_p) to look up the corresponding default efficiency in Table 6.3 (Exhibit 6) or interpolate between the table's default E_v values. Plotting these defaults on a graph can simplify interpolation.

The north offices in our example, Zone 3, have the highest primary ventilation fraction. Using that value—Z_p = 0.44—we interpolated a system ventilation efficiency, E_v, of 0.71 from the Table 6.3 defaults (Exhibit 7).

Note: Interpolating always results in a system ventilation efficiency that equals or exceeds the tabulated E_v.

Exhibit 7. Graphic representation of E_v defaults from Table 6.3 of Addendum 62n



❻ Find the uncorrected value for outdoor-air intake, V_{ou}.

Generally, all zones in an MZR system are not occupied simultaneously at their peak populations. Equation 6-7 of "62n" quantifies the distribution of population as *occupant diversity, D*. Occupant diversity for ventilation calculations is similar to load diversity for cooling load calculations. Mathematically, it's the ratio of the expected peak system population (such as the exit population) to the sum of the peak populations in the zones.

Assuming an exit-population head count of 200 for our example, we found the sum of the zone peak populations (ΣP_z = 230) and solved Equation 6-7 for occupant diversity, D = 200/230 = 0.87.

Solving Equation 6-6 compensates for occupant diversity by adjusting the total per-person ventilation airflow for the system to find the uncorrected outdoor-air intake, V_{ou}. In this case, $V_{ou} = 0.87 \cdot 1150 + 2400 = 3400$ cfm.

7 Find outdoor-air intake flow V_{ot}.

Using Equation 6-8, adjust the uncorrected outdoor-air intake, V_{ou}, to account for the ventilation inefficiency, E_v, inherent in all MZR systems. In our example, $V_{ot} = 3400/0.71 \approx 4790$ cfm.

Note: Table 6.3 was designed to yield conservatively low values for "default" ventilation system efficiency as compared to the "actual" values calculated with Appendix G. Conservatively low defaults for E_v are likely for systems that need a high fraction of outdoor air (schools) and for systems with two supply paths (series fan-powered and dual-duct VAV). But for systems with very low outdoor-air fractions (some office buildings), the Table 6.3 default may be higher than the "actual" system ventilation efficiency found using the appendix.

Alternative 2: Calculated E_v. Finding intake flow using Appendix G to calculate system ventilation efficiency (rather than basing it on a Table 6.3 default) also builds on the three-step calculation for zone-level ventilation. Exhibit 8 summarizes the results of this process for our example.

4 Find discharge outdoor-air fraction Z_d of the critical zone.

This may necessitate calculating Z_d for each ventilation zone unless you know (through design experience) which zone requires the richest mix of outdoor air. Appendix G uses *discharge outdoor-air fraction* Z_d instead of primary outdoor-air fraction Z_p to account for the multiple recirculation paths in dual-duct and fan-powered VAV systems.

In single-supply systems, outdoor air only enters the zone from the central air handler, so in our example, zone primary air fraction Z_p (Equation 6-5) equals zone discharge air fraction Z_d, which is used in the appendix, $Z_p = Z_d$.

5 Find uncorrected outdoor-air intake flow V_{ou}.

Solve Equation 6-7 to determine occupant diversity D; then apply that value in Equation 6-6 to correct the *total* breathing-zone airflow for the peak *system* (rather than peak *zone*) population.

In our example, the sum of the peak zone populations is 230 (Exhibit 3, p. 3) and we assumed an exit-population head count of 200. So, occupant diversity $D = 200/230 = 0.87$ and uncorrected intake flow $V_{ou} = 0.87 \cdot 1150 + 2400 = 3400$ cfm.

6 Find system primary airflow V_{ps}.

Appendix G implies that system primary airflow is the sum of the peak zone airflows; that usually isn't the case. A more practical definition for V_{ps} would include a load diversity factor: $V_{ps} = LDF \cdot \sum V_{pz}$, where $LDF = V_{ps\ block} / V_{ps\ peak}$. In other words, for the sake of designing the ventilation system, V_{ps} actually is $V_{ps\ block}$.

$$V_{ps\ block} = 0.60 \cdot 36800 \approx 22100\ cfm$$

Although the load diversity factor of 0.60 that was used in this example may be unrealistically low, it was selected to simplify the calculations.

7 Find the uncorrected average outdoor-air intake fraction, X_s, for the system.

$$X_s = V_{ou}/V_{ps} = 3400\ cfm/22100\ cfm \approx 0.15$$

8 Find *zone* ventilation efficiency E_{vz} … then *system* ventilation efficiency E_v.

$$E_{vz} = 1 + X_s - Z_d \quad \text{[Equation G-1]}$$
$$E_v = minimum\ E_{vz} \quad \text{[Equation G-3]}$$

Exhibit 8. Alternative 2 system-level ventilation calculations, based on calculated E_v, for example office space[a]

Ventilation zone	Cooling load cfm/ft²	V_{pz} cfm	Minimum primary air setting	V_{pzm} cfm	Z_d ratio	P_s head count	D ratio	V_{ou} cfm	V_{ps} cfm	X_s ratio	E_{vz} ratio	V_{ot} cfm
1 South offices	1.10	4400	0.35	1540	0.22	—	—	—	—	—	0.93	—
2 West offices	1.00	4000	0.30	1200	0.28	—	—	—	—	—	0.87	—
3 North offices	0.80	3200	0.27	864	0.44	—	—	—	—	—	0.72	—
4 East offices	0.90	3600	0.30	1080	0.32	—	—	—	—	—	0.84	—
5 Interior offices	0.80	16000	0.30	4800	0.35	—	—	—	—	—	0.80	—
6 North conference room	1.20	2400	0.25	600	0.41	—	—	—	—	—	0.75	—
7 South conference room	1.60	3200	0.25	800	0.38	—	—	—	—	—	0.78	—
System total	0.60 (LDF)	36800 (ΣV_{pz})	—	—	4	200	0.87	3400 5	22100 6	0.15 7	0.72 8	4720 9

[a] See Exhibit 2 (p. 3) for a plan view of the office space for this example. Variables are defined in the inset on p. 7.

The critical ventilation zone (the ventilation zone with the lowest ventilation efficiency, E_{vz}) requires discharge air with the richest mix of outdoor air, so it significantly affects system ventilation efficiency.

9 Find outdoor-air intake flow, V_{ot}.

For the "typical" office space in our example, using the Appendix G procedure results in a design V_{ot} requirement of 4720 cfm (that is, 3400/0.72; see Exhibit 8) … slightly less than the outdoor-air intake flow of 4790 cfm found using the default E_v from Table 6.3.

Averaging ventilation requirements for design

The ventilation system must deliver the required outdoor airflow to the breathing zones whenever the zones are occupied. However, if peak occupancy won't last long, or if ventilation airflow varies or is interrupted for short periods, the design of the ventilation system can be based on average conditions over time rather than on peak conditions. Equation 6-9 of Addendum 62n defines how to calculate the averaging time period: $T = 3 \cdot v / V_{bz}$.

Earlier versions of Standard 62 allowed intermittently occupied zones to be ventilated for the average population. Now, population averaging may be considered for *any* zone. Equation 6-9's "averaging time" variable helps avoid underventilation in high-density spaces.

For zones with a fluctuating number of occupants, zone population P_z may be defined as the average population over a finite time, T, rather than as peak occupancy. Solving Equation 6-9 may result in an averaging time period of 6 hours for a 1000 ft² office space but only 2 hours for a theater lobby with a 30 ft ceiling.

What's important to remember is that averaging for the sake of design calculations is *not* the same as resetting intake airflow for part-load conditions:

- Averaging a variable population results in lower intake flow and smaller-capacity equipment.
- Resetting ventilation to match present conditions (described later) will reduce *operating* capacity but not design capacity.
- Averaging variable or intermittent intake airflow results in higher intake airflow and (usually) larger-capacity equipment.

What about part-load operation?

Dynamically resetting intake airflow so that ventilation capacity matches a less-than-design ventilation load can prevent overventilation and save

Equations and variables from Addendum 62n

[6-1] $V_{bz} = R_p P_z + R_a A_z$

[6-2] $V_{oz} = V_{bz} / E_z$

[6-3] $V_{ot} = V_{oz}$ single-zone systems

[6-4] $V_{ot} = \Sigma V_{oz}$ 100% outdoor-air systems

[6-5] $Z_p = V_{oz} / V_{pz}$

[6-6] $V_{ou} = D \Sigma_{all\ zones} R_p P_z + \Sigma_{all\ zones} R_a A_z$
$= D \Sigma_{all\ zones} V_{bzp} + \Sigma_{all\ zones} V_{bza}$

[6-7] $D = P_s / \Sigma_{all\ zones} P_z$

[6-8] $V_{ot} = V_{ou} / E_v$ MZR systems

[6-9a] $T = 3v / V_{bz}$ IP version

[6-9b] $T = 50v / V_{bz}$ SI version

where,

$\boldsymbol{A_z}$ is *zone floor area,* the net occupiable floor area of the zone, in ft² (m²)

$\boldsymbol{D}$ is *occupant diversity,* the ratio of system population to the sum of zone populations

$\boldsymbol{E_v}$ is *ventilation efficiency* of the *system*

$\boldsymbol{E_{vz}}$ is *zone ventilation efficiency,* how effectively the system distributes outdoor-air intake flow to the diffusers for a specific ventilation zone; E_v = minimum E_{vz}

$\boldsymbol{E_z}$ is *air-distribution effectiveness* within the *zone*

$\boldsymbol{P_s}$ is *system population,* the maximum simultaneous number of occupants in the area served by the ventilation system (See caveats in Addendum 62n–Appendix G)

$\boldsymbol{P_z}$ is *zone population,* the largest expected number of people to occupy the ventilation zone during typical usage (See caveats in Addendum 62n–Section 6.2.1.1)

$\boldsymbol{R_a}$ is *area outdoor-air rate,* the required airflow per unit area of the ventilation zone determined from Addendum 62n–Table 6.1, in cfm/ft² (L/s•m²)

Rp is *people outdoor-air rate,* the required airflow per person determined from Addendum 62n–Table 6.1, in cfm/person (L/s•person)

$\boldsymbol{T}$ is *averaging time period,* in minutes

$\boldsymbol{v}$ is ventilation-zone volume, in ft³ (m³)

$\boldsymbol{V_{bz}}$ is *breathing-zone outdoor airflow,* the outdoor airflow required in the breathing zone of the occupiable space(s) of the ventilation zone, in cfm (L/s)

$\boldsymbol{V_{bza}}$ is the "unit area" component of *breathing-zone outdoor airflow* to dilute building- and furnishing-related contaminants, in cfm (L/s)

$\boldsymbol{V_{bzp}}$ is the "people" component of *breathing-zone outdoor airflow* to dilute contaminants related to people and their activities, in cfm (L/s)

$\boldsymbol{V_{ot}}$ is *outdoor-air intake flow,* adjusted for occupant diversity and corrected for ventilation efficiency, in cfm (L/s)

$\boldsymbol{V_{ou}}$ is the *uncorrected outdoor-air intake flow,* in cfm (L/s)

$\boldsymbol{V_{oz}}$ is *zone outdoor airflow,* the outdoor airflow that must be provided to the zone by the supply-air-distribution system at design conditions, in cfm (L/s)

$\boldsymbol{V_{pz}}$ is *zone primary airflow,* the primary airflow that the air handler delivers to the ventilation zone; includes both outdoor air and recirculated return air

$\boldsymbol{X_s}$ is the *average outdoor-air fraction,* the fraction of outdoor-air intake flow V_{ou} in system primary airflow V_{ps} at the air handler

$\boldsymbol{Z_d}$ is the outdoor-air fraction that's required in air discharged into the zone, based on the minimum discharge airflow … in a single-duct system, $Z_d = Z_p$

$\boldsymbol{Z_p}$ is zone primary outdoor-air fraction, the fraction of outdoor air in the primary airflow delivered to the ventilation zone … for VAV systems, Z_p is based on the minimum expected primary airflow, V_{pzm} ●

outdoor-air-conditioning energy. But by lowering the design ventilation rates for high-density zones, Addendum 62n makes this control strategy less valuable. Despite that irony, "62n" explicitly allows three methods of dynamic reset for ventilation airflow:

- variations in occupancy,
- changes in system ventilation efficiency, and/or …
- higher-than-design fraction of outdoor air in zone primary airflow.

Reset based on population. If the ventilation system serves a zone with varying population, then the people-related portion of breathing-zone outdoor airflow, V_{bzp}, also varies. Including controls that estimate real-time population or ventilation rate per person—and then adjusting intake airflow accordingly—will help assure that the system delivers the minimum requirement while minimizing preconditioning energy. Carbon dioxide is commonly used for population-based reset because people produce this easily monitored gas.

Note: Although Addendum 62n specifically allows demand-controlled ventilation based on carbon dioxide concentrations, it does not specify methods for implementing this nor any other dynamic reset strategy.

Reset based on ventilation efficiency. If ventilation efficiency E_v of a multiple-zone system varies with time, then the required intake airflow also will vary in accordance with the ventilation calculations for multiple-zone recirculating systems. In VAV systems (which vary each zone's primary airflow in response to the thermal load), E_v almost always increases as the system primary airflow decreases. That's because less unused outdoor air leaves the system at part load than at design.

Typically, applications with automated DDC–VAV control measure the primary airflow at each VAV box, which means that zone outdoor-air fraction Z_d can be calculated at any time. That information makes it possible to recalculate E_v and determine the outdoor-air intake flow, V_{ot}, that's presently needed.

Reset based on outdoor-air fraction. When a multiple-zone recirculating system enters the economizer cooling mode, intake airflow exceeds the minimum requirement. As a result, the primary air that's delivered to the ventilation-critical zone contains a richer-than-necessary mix of outdoor air.

An automated DDC–VAV control system can reduce overventilation and save reheat energy by measuring intake airflow, calculating the fraction of outdoor air (both first-pass intake air and unused recirculated air) in the primary air stream, and then lowering the minimum primary-airflow setpoint at some of the VAV boxes.

"At the end of the day …"

The "heart transplant" provided by Addendum 62n gives the ventilation standard a new "lease on life." By lowering the outdoor-air rates to avoid overventilation and improving calculation procedures to increase consistency among designers, Addendum 62n should reduce the cost of operating the ventilation system *and* improve indoor air quality. ●

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