Standard 62-2001 Addendum 62*n*

Ventilation for Changeover-Bypass VAV Systems

By Dennis Stanke, Member ASHRAE

ANSI/ASHRAE Standard 62-2001, *Ventilation for Acceptable Indoor Air Quality*,[1] prescribes ventilation rates for commercial and institutional buildings. Historically, Standard 62 required both zone- and system-level calculations for the design of multiple-zone ventilation systems, such as single-path constant volume and VAV systems. Unfortunately, without clear calculation procedures, system-level calculations frequently were misinterpreted or ignored by designers. As a result, many multiple-zone systems were underventilated.

In an effort to avoid underventilation and increase calculation consistency among designers, Addendum 62*n*[2] updates prescribed ventilation rates and the calculation procedure for zone ventilation airflow and for system intake airflow for different ventilation systems. A previous article[3] introduced Addendum 62*n* rates and described the design of single-zone and 100%-outdoor-air ventilation systems. This article discusses the "62*n*-compliant" design of a very specific multiple-zone ventilation system: changeover-bypass VAV, also called "variable volume and temperature" (VVT).

A changeover-bypass VAV system (*Figure 1*) uses a constant-volume air handler (often a packaged rooftop unit or split DX system) to ventilate and cool or heat a large area within a building. The area served comprises many "comfort zones" or "HVAC zones," defined by ANSI/ASHRAE/IESNA Standard 90.1[4] as areas "with heating and cooling requirements that are sufficiently similar so that desired conditions can be maintained throughout using a single sensor." Each comfort zone has its own thermostatically controlled VAV damper and ideally, all comfort zones associated with an air handler have similar thermal loads (that is, all zones need some level of heating or some level of cooling, like interior spaces or southern perimeter spaces).

In practice, however, many systems include comfort zones with dissimilar loads; some zones need heating at the same time that other zones need cooling. In either case, each comfort zone usually is considered as a "ventilation zone," defined by Addendum 62*n* as an area with "similar occupancy category, occupant density, zone air distribution effectiveness, and zone primary airflow per unit area."

Although Addendum 62*n* shows ventilation rates in both IP and SI units, this paper uses IP, except in selected specific calculations. This is because 62*n* uses rational conversions, not mathematical.

About the Author

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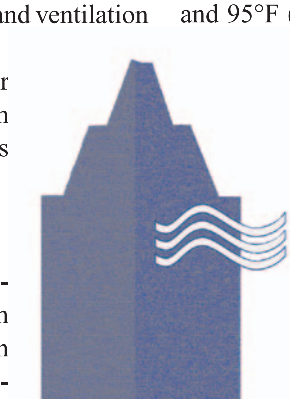
The changeover-bypass VAV system includes a central bypass damper that modulates open as the zone VAV dampers modulate closed. The air handler delivers approximately constant primary airflow, while each comfort zone receives a variable air volume to match its thermal load.

Air-handler mode (heating or cooling) is usually based on zone-by-zone polling to determine the number of zones calling for heating or cooling, for instance, and the "strength" of the calls. Air-handler capacity may be controlled by the largest load, or by simply maintaining primary air temperature at a heating or cooling setpoint. As the zone dampers close and zone airflow drops, the bypass damper opens to maintain a constant differential pressure between the primary duct and the return plenum, and consequently, relatively constant airflow through the fan and coils. This results in relatively constant outdoor-air intake flow (ignoring wind effects).

Note: Depending on building construction and the operation of relief (exhaust) fans and/or dampers, mixed-air pressure may actually rise relative to outdoor pressure as the bypass damper opens. If the minimum outdoor-air-damper position is fixed, it should be set to ensure at least minimum *outdoor-air intake flow* with the bypass damper at both extremes (open to maximum and fully closed).

A single duct delivers air for thermal comfort and ventilation to all comfort zones.

When the system is occupied, the outdoor air damper at the air handler opens to provide minimum *outdoor-air intake flow*. This outdoor airflow helps determine design cooling and heating capacity.



Designing to Comply with Addendum 62*n*

Changeover-bypass VAV systems can be designed (and operated) to comply with Addendum 62*n*,* thereby ensuring proper ventilation in each zone. To comply, the system must deliver sufficient *outdoor-air intake flow* at the air handler as well as sufficient outdoor air to the *breathing zone* within each ventilation zone. These flows, which are inextricably linked, must be determined for design cooling *and* design heating conditions. Because this is a multiple-zone recirculating system, wherein the air handler supplies a mixture of outdoor air and recirculated return air to more than one ventilation zone, Equations 6.5 through 6.8 of Addendum 62*n* must be used.

In the following paragraphs, we consider two approaches to ventilation system design for an area within an example office building (*Figure 2*). In the first approach, we work from the zones to the air handler, selecting minimum *zone primary airflow* settings and then calculating the *outdoor-air intake flow* needed for proper ventilation of all zones. In the second approach, we work from the air handler to the zones, selecting the *outdoor-air intake flow* and then calculating the required settings for minimum *zone primary airflow*.

Based on thermal loads, our example building area is divided into eight comfort zones, each with its own thermostat and VAV damper. We consider each of these comfort zones as a separate ventilation zone.

The following zone-level calculations must be performed, regardless of which approach to system design is used (*Figure 3*):

1. Look up the minimum *people outdoor air rate* (R_p) and the minimum *area outdoor air rate* (R_a) in Addendum 62*n*, Table 6.1, for each zone. Using peak *zone population* (P_z) and *zone floor area* (A_z), find the design *breathing-zone outdoor airflow* using Equation 6-1 ($V_{bz} = R_p \times P_z + R_a \times A_z$). (We could have used average zone population for P_z, but then we probably could not have taken credit for *occupant diversity*. See Step 6.) For example, the south offices in our example building require

$$V_{bz} = 5 \times 20 + 0.06 \times 2000 = 100 + 120 = 220 \text{ cfm.}$$

2. For each zone, look up *zone air-distribution effectiveness* (E_z) based on the air-distribution configuration and the default values in Table 6.2 (see excerpt in *Figure 4*).

In our example, all offices use overhead diffusers and ceiling returns, and receive 58°F (14°C) primary air during cooling and 95°F (35°C) during heating. Effectiveness changes from 1.0 when cooling to 0.8 when heating, demonstrating how operating mode can affect zone ventilation performance.

3. Find *zone outdoor airflow* using *Equation 6-2* ($V_{oz} = V_{bz}/E_z$) for both cooling and heating operation.

For our example south offices, $V_{oz} = 220/1.0 = 220$ cfm during cooling, and $V_{oz} = 220/0.8 = 275$ cfm during heating. Therefore, the system must be designed to deliver at least $V_{oz} = 275$ cfm, either continuously or on average, to ensure adequate ventilation in both modes. (During operation, the example VAV dampers may be allowed to close to deliver less than 275 cfm when the primary air temperature doesn't match the zone thermal requirements, provided system controls are designed to ensure that average minimum primary airflow is at least 275 cfm. See "Design for Short-Term Conditions.")

Addendum 62*n* doesn't explicitly require calculation of V_{oz} at both cooling and heating design, but it is implicit in the requirements for system ventilation efficiency and in the "variable load conditions" section, which states that required ventilation rate must be delivered under all load conditions.

Each ventilation zone in our example is assigned to one of two air handlers, forming two multiple-zone ventilation systems (*Figure 2*). The "interior" system includes all interior zones and the north zones, which are largely adjacent to a conditioned warehouse space; these zones usually need some level of cooling, regardless of outdoor conditions. The "perimeter" system includes zones that need some level of cooling in warm weather and some level of heating in cold weather.

* Along with many other Web-published addenda, Addendum 62*n* will be incorporated into an updated version of Standard 62-2001 and published as ASHRAE Standard 62.1-2004 later this year.

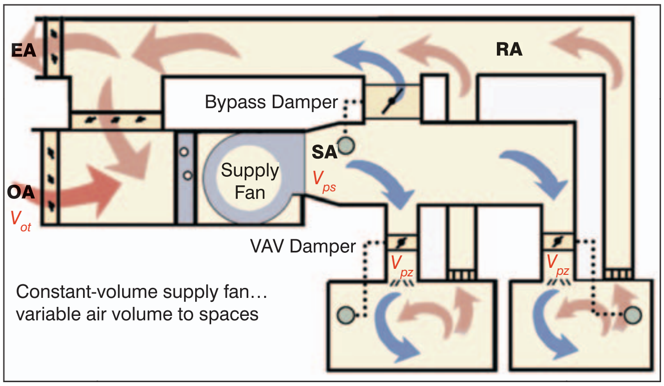


Figure 1: Changeover-bypass system.

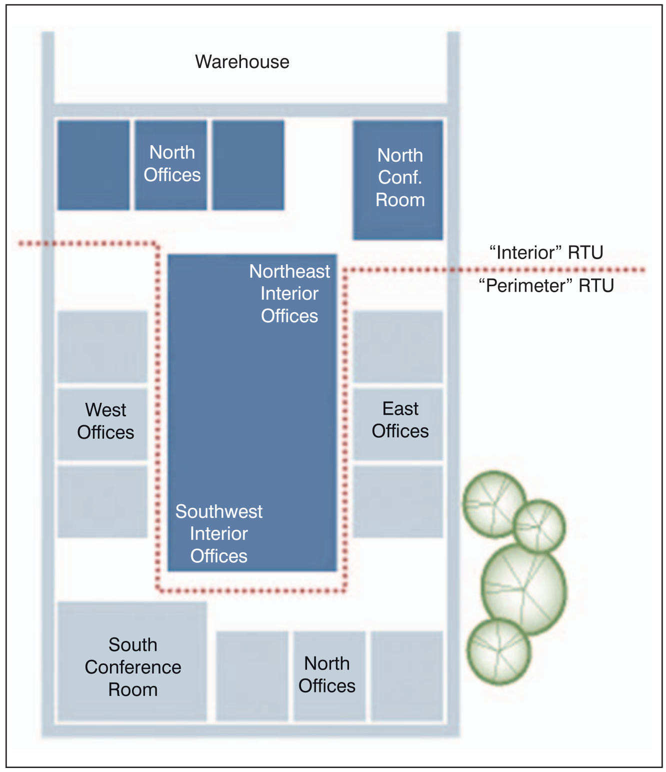


Figure 2: Changeover-bypass office building.

The following procedures describe the two approaches to ventilation system design mentioned previously. Each approach can result in systems that comply with Addendum 62*n*.

Design Procedure 1:
Choose Minimum Zone Settings, Find Intake Airflow

Using this approach, we first select minimum settings for *zone primary airflow* and then determine the minimum *outdoor-air intake flow* at the air handler.

We assume continuous primary airflow (non-zero minimums) to illustrate the calculations. In some cases (as in our example perimeter system), continuous primary airflow can quickly overcool or overheat some zones, making them uncomfortable or causing frequent system changeover (heating to cooling or vice versa). While continuous primary airflow works well for ventilation, it may not provide acceptable comfort and/or energy use. Lower or even intermittent primary airflow (zero minimums) can be used to design changeover-bypass systems—but only if operation results in an average primary airflow that equals or exceeds the minimum chosen for continuous primary airflow. Averaging is discussed in more detail later (see "Design for Short-Term Conditions").

The ventilation rate procedure in Addendum 62*n* prescribes the steps for calculating both zone-level ventilation airflows (described earlier) and system-level intake airflow.

Before we examine these steps, though, we must take care of some preliminary calculations and settings. First, based on design cooling load and primary air temperature, determine design *zone primary airflow* (V_{pz}) for each zone. We use cooling airflow because it's usually much

					Cooling			Heating	
Procedural Step					*1*	*2*	*3*	*2*	*3*
Variable	R_p	P_z	R_a	A_z	V_{bz}	E_z	V_{oz}	E_z	V_{oz}
Ventilation Zone	*cfm/p*	*p*	*cfm/sf*	*sf*	*cfm*		*cfm*		*cfm*
South Offices	5	20	0.06	2,000	220	1.0	220	0.8	275
West Offices	5	20	0.06	2,000	220	1.0	220	0.8	275
South Conference Room	5	30	0.06	3,000	330	1.0	330	0.8	413
East Offices	5	20	0.06	2,000	220	1.0	220	0.8	275
Southwest Interior Offices	5	50	0.06	10,000	850	1.0	850	0.8	1,060
Northeast Interior Offices	5	50	0.06	10,000	850	1.0	850	0.8	1,060
North Offices	5	16	0.06	2,000	200	1.0	200	0.8	250
North Conference Room	5	20	0.06	2,000	220	1.0	220	0.8	275

***Figure 3:** Zone ventilation calculations, which must be performed regardless of chosen approach.*

higher than heating airflow. (This example ignores zone-to-zone load diversity for simplicity, but as in other VAV systems, primary airflow at the changeover-bypass air handler often is less than the sum of the peak zone airflows.)

Next, establish a minimum primary airflow setting ($V_{pz\text{-}min}$) for each zone. In this case, we set the zone minimums to 30% of design airflow. We know that Standard 90.1 allows reheat (if we need it) with 30% minimum settings, and although we might prefer lower settings, 30% minimums allow us to use default values for system ventilation efficiency (see Step 5). (With lower minimum settings, Standard 62 may have required us to calculate E_v, rather than use default values.) Depending on the VAV damper controls, it may be possible to set two minimums—one for cooling and another for heating—but we considered only the simple case of a single minimum setting for each zone.

For design, we assumed that these are *average* values for minimum primary airflow. For operation, the system controls must enforce these average minimums. Zero minimums are acceptable only if the system controls are designed to deliver, on average, the design minimum primary flow. (See "Design for Short-Term Conditions.")

The following system-level steps (*Figure 5*) build on the zone-level steps covered previously, so we begin with Step 4.

4. Using the highest zone outdoor airflow ($V_{oz\text{-}clg}$ or $V_{oz\text{-}htg}$) and the lowest primary airflow ($V_{pz} = V_{pz\text{-}min}$), find the minimum *primary outdoor-air fraction* for each zone using Equation 6-5 ($Z_p = V_{oz}/V_{pz}$). For example, for our south offices, $Z_p = 275/540 = 0.51$.

Addendum 62*n* doesn't explicitly differentiate between heating-mode and cooling-mode Z_p values, but Table 6.3 (next step) implies that the highest V_{oz} must be used because we must find the "largest value of Z_p … among all the zones served by the system." *Note:* To avoid a design that requires 100% intake airflow, minimum (or average) V_{pz} settings must exceed *zone* *outdoor airflow* (V_{oz}). As a result, some systems may require duct reheat or zone heat to avoid overcooling at low load; depending on thermal zoning, systems without local heat may be less comfortable and may "change over" more frequently.

5. Look up *system ventilation efficiency* (E_v) in Table 6.3 (*Figure 6*). Use the largest *primary outdoor-air fraction* ("max Z_p") because it represents the critical zone—the zone that needs the highest percentage of outdoor air in its primary airstream.

For our example, "max Z_p" occurs in the south offices (Z_p = 0.51) and the north offices (Z_p = 0.52). Interpolating in Table 6.3, we find that minimum *system ventilation efficiency* E_v = 0.64 and 0.63 for each system, respectively. Alternatively (or if "max Z_p" exceeds 0.55), we could determine Ev using the equations in Addendum 62*n*, Appendix G,** but most changeover-bypass system designers likely prefer the simpler default-table approach.

Note: Lower minimum settings, though perhaps preferred for zone operation, would result in "max Z_p" greater than 0.55 and require use of the equations rather than the default values from Table 6.3; reduced E_v values and increased *outdoor-air intake flow* would result.

6. Find *occupant diversity* for the system using Equation 6-7 ($D = P_s / \Sigma P_z$). Use a reasonable estimate for the expected *system population* (P_s), along with the sum-of-peak *zone population* (P_z). In this example, we assumed that the conference rooms would only be populated by people from the nearby office spaces. So, system occupant diversity is D = 60/90 = 0.67 for the perimeter system, and D = 100/136 = 0.74 for the interior system.

7. Find the *uncorrected outdoor-air intake* flow for the system using Equation 6-6 $\left(V_{ou} = D \times \Sigma(R_p \times P_z) + \Sigma(R_a \times A_z)\right)$. For our perimeter system, V_{ou} = 0.67 × 450 + 540 = 840 cfm; for the interior system, V_{ou} = 0.74 × 680 + 1,440 = 1,950 cfm.

8. Finally, find the design (minimum) *outdoor-air intake flow* using *Equation 6-8* ($V_{ot} = V_{ou}/E_v$). In our example, the perimeter system needs V_{ot} = 840/0.64 = 1,310 cfm (about 14% outdoor air), while the interior system needs V_{ot} = 1950/0.63 = 3,100 cfm (about 18% outdoor air). As is always the case in multiple-zone recirculating systems, high zone minimum settings lead to low intake airflow requirements.

This design approach (zone-to-system) results in a relatively low outdoor airflow percentage, but it requires high minimum settings for zone primary airflow. This may mean reheat in many zones or frequent heating/cooling changeover.

** In some cases, calculated E_v values may be lower than default values, but Appendix G calculations are left to future articles.

Design Procedure 2: Choose Intake Minimum, Find Zone Minimum Settings

Using this second approach, we select the minimum *outdoor-air intake flow* at the air handler and then determine the required minimum *zone-primary-airflow* setting for each space. In this case, we start with more intake airflow than we found using the first approach. As we will see, more intake airflow results in lower zone minimum settings (or averages). Lower minimums mean less overcooling and/or overheating and less frequent changeover, which in turn may mean increased occupant comfort and lower energy use.

Air Distribution Configuration	E_z
Ceiling Supply of Cool Air	1.0
Ceiling Supply of Warm Air and Floor Return	1.0
Ceiling Supply of Warm Air at Least 8°C (15°F) Above Space Temp. and Ceiling Return	0.8
Ceiling Supply of Warm Air less than 8°C (15°F) above Space Temperature and Ceiling Return, Provided That the 0.8 m/s (150 fpm) Supply Air Jet Reaches to Within 1.4 m (4.5 ft) of Floor Level	1.0

Figure 4: Zone air-distribution effectiveness for several ventilation-zone configurations. Not all Table 6.2 configurations are listed.

Although you won't find the following calculation steps (*Figure 7*) detailed there, this approach is based on the principles of Addendum 62*n*. The calculations build on the zone-level calculations (*Figure 3*) covered earlier, so we start with Step 4:

4. Establish the design (minimum) *outdoor-air intake flow* (V_{ot}) within the constraints of the air handler (such as primary airflow per ton of cooling capacity or unit heating capacity).

We assume that each packaged unit in our example can handle 30% outdoor air, so V_{ot} = 9,100 × 0.30 = 2,730 cfm for the perimeter unit and V_{ot} = 17,400 × 0.30 = 5,220 cfm for the interior unit. Again, we ignore load diversity in this example by assuming that primary airflow is simply the sum of the peak zone airflows.

5. Find *occupant diversity* using Equation 6-7 ($D = P_s / \Sigma P_z$). For the perimeter and interior systems, respectively, D = 60/90 = 0.67 and D = 100/136 = 0.74.

6. Find the occupant portion of breathing-zone outdoor airflow ($R_p \times P_z$) for each zone using the *people outdoor-air rate* (R_p) from Addendum 62*n*, Table 6.1, and the design *zone population* (P_z).

7. Using the *area outdoor-air rate* (R_a) from Table 6.1 and *zone floor area* (A_z), find the building portion of breathing-zone outdoor airflow ($R_a \times A_z$) for each zone.

8. Find the *uncorrected outdoor-air intake flow* for each system using Equation 6-6 $\left(V_{ou} = D \times \Sigma(R_p \times P_z) + \Sigma(R_a \times A_z)\right)$. In our example, the perimeter system needs V_{ou} = 0.67 × 450 + 540 = 840 cfm, while the interior system needs V_{ou} = 0.74 × 680 + 1,440 = 1940 cfm.

9. Using *Equation 6-8* ($E_v = V_{ou} / V_{ot}$) and the V_{ou} and V_{ot} values already established, find the lowest allowable *system ventilation efficiency* for proper ventilation. For the perimeter system, lowest allowable E_v = 840/2730 = 0.31, and for the interior system lowest allowable E_v = 1,940/5,220 = 0.37.

10. Use Table 6.3 (*Figure 6*) to find the maximum *primary outdoor-air fraction* ("max Z_p") for any zone based on the lowest allowable *system ventilation efficiency*. Our minimum E_v values are "off the chart," but because we found the lowest *allowable* E_v for each system, we can use any value above 0.31 or 0.37, respectively, to find "max Z_p." For simplicity (that is, to stay in the default table), we used the lowest E_v value in Table 6.3, E_v = 0.60, for both systems; that value corresponds to "max Z_p" ≤ 0.55. In other words, no zone can require a *primary outdoor air fraction* (Z_p) greater than 0.55.

11. Given V_{oz} (*Figure 3*) and using *Equation 6-5* ($V_{pz} = V_{oz}/Z_p$), find each zone's minimum setting for *zone primary airflow*.

	Cooling Design (SAT = 58°F)		Min. Setting		From Fig. 3						
Procedural Step						4	5	6	7	8	Outdoor
Ventilation Zone	Clg Load	V_{pz}	Min. Primary	V_{pz}-min	V_{oz}	Z_p	E_v	D	V_{ou}	V_{ot}	Air Intake
	cfm/sf	cfm	%	cfm	cfm		(Tbl. 6.3)		cfm	cfm	%
South Offices	0.9	1,800	30	540	275	0.51*	—	—	—	—	—
West Offices	1.0	2,000	30	600	275	0.46	—	—	—	—	—
South Conference Room	1.1	3,300	30	990	413	0.42	—	—	—	—	—
East Offices	1.0	2,000	30	600	275	0.46	—	—	—	—	—
Perimeter System	—	9,100	—	—	—	—	0.64	0.67	840	1,310	14%
Southwest Interior Offices	0.7	7,000	30	2,100	1,060	0.50	—	—	—	—	—
Northeast Interior Offices	0.7	7,000	30	2,100	1,060	0.50	—	—	—	—	—
North Offices	0.8	1,600	30	450	250	0.52*	—	—	—	—	—
North Conference Room	0.9	1,800	30	540	275	0.51	—	—	—	—	—
Interior System	—	17,400	—	—	—	—	0.63	0.74	1,950	3,100	18%

* Ventilation-critical zone.

Figure 5: System ventilation calculations for Design Procedure 1 (fixed minimum zone settings).

For the south offices in our example, minimum V_{pz} = 275/0.55 = 500 cfm.

This design approach yields somewhat lower minimum settings (or averages) for zone primary airflow than the first procedure. Raising *outdoor-air intake flow* allows lower minimum primary airflow settings and therefore, less reheat or local heat (if reheat is used) and less frequent changeover, which may increase comfort and reduce energy use.

Many changeover-bypass system designers are likely to use the default table to find "max Z_p" because it's relatively simple, even though it yields conservative results; that's why we used it in our example. But, the equations in Appendix G can result in a much lower "max Z_p" value when using a high intake-airflow value, so minimum *zone primary airflow* settings can be much lower (almost one half in some zones) with only a little more work. Designers may want to consider using the equations to comply with the standard, rather than the default table; calculations are not as simple, but results are more accurate and less conservative.

Maximum Z_p*	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

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

Figure 6: $\mathbf{E_v}$ ***defaults from Addendum* n *to ANSI/ASHRAE Standard 62-2001, Table 6.3.***

Design for Short-Term Conditions

Regardless of the design approach used, Addendum 62*n* recognizes that it may be reasonable to base design airflow values on average conditions over a finite period, rather than peak conditions. Addendum 62*n* list three "acceptable design adjustments":

• It specifically allows use of an average *zone population* (P_z) in *Equation 6-1* for calculation of the design *breathing-zone outdoor airflow* (V_{bz}). (This seems to preclude the use of *occupant diversity* (*D*) at the system level, to avoid "double credit" at both zone and system population; we didn't use average zone population in our examples.)

• It allows interruptions in delivered *breathing-zone outdoor airflow* (V_{bz})—provided that the average airflow over *averaging time period T* equals or exceeds the minimum V_{bz} value found using Equation 6-1. (This "short-term condition" design option may be key for changeover-bypass systems with minimum primary airflow settings of "zero," but calculating average V_{bz} requires detailed knowledge of system control operation, which varies greatly by manufacturer and designer. Due to this variation in system operation, detailed averaging calculations are beyond the scope of this article.)

• It allows interruption of *outdoor-air intake flow* (V_{ot}), provided that the average intake airflow equals or exceeds the value found using Equations 6-5 through 6-8.

Changeover-bypass VAV systems with very low or zero-minimum settings for *zone primary airflow* tend to interrupt zone ventilation for short periods, making them candidates for design based on primary airflow averaging.

Before we average anything, we need an averaging time. For a given ventilation zone, Equation 6-9 ($T = 3v/V_{bz}$) from Addendum 62*n* defines required averaging time as the ratio of three space volumes to the "continuous" breathing-zone outdoor airflow. This equates to three space–time constants. In response to a step change in airflow, space conditions approach steady-state values after three time constants, so this seems to be a reasonable averaging time. Assuming a 10 ft ceiling,

Setting Zone Minimums

For Design Procedure 1, our "rule of thumb" set the minimum value for *zone primary airflow* (V_{pz}) at about twice the minimum *zone outdoor airflow* (V_{oz}) needed for ventilation. This results in a *zone-air-distribution effectiveness* (Z_p) of about 50%, so we can use Table 6.3 default values rather than Appendix G calculated values. *Lower* minimum settings (like zero) could be selected, provided system controls are designed to deliver at least V_{oz} on average.

Minimum settings also may be limited by diffuser selection and location. When the damper is open, minimum primary airflow should result in a diffuser velocity that will ensure good air distribution in the space (without diffuser "dumping") when cooling, and good air mixing in the space (without stratification) when heating.

If electric reheat is used, minimum primary airflow may be based on the minimum airflow needed for safe heater operation.

Standard 90.1 requirements also may impact minimum primary airflow settings. To comply using primary air reheat, the volume of air reheated must be no more than the highest of:

- The minimum volume required for ventilation (V_{oz}).
- An airflow rate of 0.4 cfm/ft².
- An airflow equal to 30% of design peak airflow (V_{pz}).
- An airflow of 300 cfm, for small zones.
- Any higher rate that reduces overall energy use by reducing intake airflow (V_{ot}), even though it increases local reheat energy.

In our example zones, all minimum primary airflow settings are 30% of peak design airflow and all are lower than 0.4 cfm/ft², so reheat would be allowed in any of the zones.

our south office, for example, has an averaging time of $T = 3 \times 2{,}000 \times 10/220 = 270$ minutes in cooling mode and $T = 3 \times 2{,}000 \times 10/275 = 220$ minutes in heating mode.

Depending on load, any zone in a changeover-bypass VAV system may require either heating or cooling at any time. For a given zone, heating or cooling mode either matches the system mode or opposes it. An "opposing" zone will be more comfortable with very low primary airflow. A "matching" zone must have enough airflow to ensure that, averaged over time T, the zone receives at least the minimum required *breathing-zone outdoor airflow*. A matching zone must be overventilated to compensate for those times when it becomes an opposing zone.†

A system could be designed to integrate primary airflow over the averaging time (T) for each zone, allowing zero "opposing" minimums and resetting the "matching" minimums as high as necessary to ensure that the required continuous *breathing-zone outdoor airflow* is provided on average.

In any case, Addendum 62*n* specifically allows designs based on averaging for short-term conditions, but leaves implementation details to the designer.

Operational Considerations

The preceding design procedures result in proper matching of minimum zone airflow settings with minimum intake airflow settings, allowing proper equipment selection. But Addendum 62*n* addresses ventilation system operation as well as system design. It allows the system controls to reset both minimum *zone primary airflow* and/or *outdoor-air intake flow*, matching current ventilation capacity to current ventilation require-

† We didn't consider the "zero-minimum" case in the preceding design calculations because actual design depends on the control operation specified for a system.

Procedural Step	4	5	6	7	8	9	10	From Fig. 3	11	Minimum V_{pz} Setting*	
Ventilation Zone	V_{ot} (At 30%)	D	V_{bz} (Occ.)	V_{bz} (Area)	V_{ou}	Min E_v	Max Z_p	V_{oz}	V_{pz} (Min.)	Procedure 1	Procedure 2
	cfm		cfm	cfm	cfm			cfm	cfm	%	%
South Offices	—	—	100	120	—	—	0.55	275	500	30	28
West Offices	—	—	100	120	—	—	0.55	275	500	30	25
South Conference Room	—	—	150	180	—	—	0.55	413	750	30	23
East Offices	—	—	100	120	—	—	0.55	275	500	30	25
Perimeter System	2,730	0.67	450	540	840	0.31	0.55	—	—	—	—
Southwest Interior Offices	—	—	250	600	—	—	0.55	1,060	1,930	30	28
Northeast Interior Offices	—	—	250	600	—	—	0.55	1,060	1,930	30	28
North Offices	—	—	80	120	—	—	0.55	250	450	30	28
North Conference Room	—	—	100	120	—	—	0.55	275	500	30	28
Interior System	5,220	0.74	680	1,440	1,880	0.37	0.550	—	—	—	—

* To aid comparison, minimum primary airflow settings (V_{pz}) are shown as percentages of design primary airflow.

Figure 7: System ventilation calculations for Design Procedure 2 (fixed minimum intake setting).

ments. As we saw when we considered short-term conditions, control design can be crucial for both the energy-conscious, comfortable operation of changeover-bypass systems and for proper design.

The "dynamic reset" section of Addendum 62*n* allows the use of system controls that "… reset the design *outdoor air intake flow* (V_{ot}) and/or space or zone airflow as operating conditions change." It lists three specific operating conditions, allowing a system-level reset control strategy that:

• Uses CO_2- or schedule-based, demand-controlled ventilation (DCV) to reset zone-level V_{oz} and system-level V_{ot} in response to zone population changes. Several DCV approaches indirectly can determine or estimate the actual airflow per person and reset either V_{pz} or V_{ot} (or both) in response to the current requirement.

• Uses zone airflow to find the currently required intake airflow (V_{ot}) based on recalculation of *system ventilation efficiency* (E_v)—a dynamic version of Design Procedure 1. This includes resetting V_{ot} as *zone air-distribution effectiveness* (E_z) varies due to heating/cooling operation.

• Lowers the minimum *zone primary airflow* during economizer operation, when V_{ot} exceeds the minimum required intake—a dynamic version of Design Procedure 2.

Addendum 62*n allows* these dynamic reset approaches. It gives no implementation details, but the requirement is clear: Any system control approach that responds to varying conditions must be capable of providing the required breathing-zone ventilation airflow whenever the zones served by the system are occupied. Dynamic reset approaches and results can differ widely. Regrettably, they are outside the scope of this article.

Summary

Addendum 62*n* calculation procedures can be applied to changeover-bypass systems with both zero and non-zero minimum settings for zone primary airflow. Design calculations can proceed from the zone minimums to find the air-handler intake flow, or from intake flow to find the zone minimums. As we've shown, the default table for system ventilation efficiency can be used (and is likely to be common practice—simple design for simple systems).

As with other VAV systems, dynamic reset approaches are allowed by Addendum 62*n*, but operational controls for changeover–bypass systems are beyond our present scope.

References

1. ANSI/ASHRAE Standard 62-2001, *Ventilation for Acceptable Indoor Air Quality*.

2. ANSI/ASHRAE Addendum *n* to ANSI/ASHRAE Standard 62-2001.

3. Stanke, D. 2004. "Addendum 62*n*: single-zone dedicated-OA systems" *ASHRAE Journal* 46(10):12–21.

4. ANSI/ASHRAE/IESNA Standard 90.1-2001, *Energy Standard for Buildings Except Low-Rise Residential Buildings*.