4.3 Ventilation Requirements

§120.1

All of the ventilation requirements are mandatory measures. Some measures require acceptance testing, which is addressed in Section 4.3.11.

Within a building, all enclosed spaces that are normally used by humans must be continuously ventilated during occupied hours with outdoor air, using either natural or mechanical ventilation. An exception is provided to for refrigerated warehouses or other buildings or spaces that are not normally used for human occupancy or work.

The Energy Standards allow for ventilation to use transfer air as long as it doesn't have any "unusual sources of indoor air contaminants" and "the outdoor air that is supplied to all spaces combined, is sufficient to meet the requirements for each space individually. Good practice dictates that sources of contaminants be isolated and controlled with local exhaust. The designation and treatment of such spaces is subject to the designer's discretion. Spaces needing special consideration include:

- Commercial and coin-operated dry cleaners.
- Bars and cocktail lounges.
- Smoking lounges and other designated smoking areas.
- Beauty and barbershops.
- Auto repair workshops.
- Print shops, graphic arts studios and other spaces where solvents are used in a process.
- Copy rooms, laser printer rooms or other rooms where it is expected that equipment may generate heavy concentrations of ozone or other contaminants.
- Blueprint machines.

"Spaces normally used by humans" refers to spaces where people can be reasonably expected to remain for an extended period of time. Spaces where occupancy will be brief and intermittent, and that do not have any unusual sources of air contaminants, do not need to be directly ventilated. For example:

- A closet does not need to be ventilated, provided it is not normally occupied.
- A storeroom that is only infrequently or briefly occupied does not require ventilation. However, a storeroom that can be expected to be occupied for extended periods for clean-up or inventory must be ventilated, preferably with systems controlled by a local switch so that the ventilation system operates only when the space is occupied.

"Continuously ventilated during occupied hours" implies that the design ventilation must be provided throughout the entire occupied period. This means that VAV systems must provide the code-required ventilation over their full range of operating supply airflow. Some means of dynamically controlling the minimum ventilation air must be provided.

4.3.1 Natural Ventilation

§120.1(b)1

Natural outdoor ventilation may be provided for spaces where all normally occupied areas of the space are within a specific distance from an operable wall or roof opening through which outdoor air can flow. This distance is 20 ft. for most spaces and 25 ft. for hotel/motel guestrooms and high-rise residential spaces. The sum of the operable open areas must total at least 5 percent of the floor area of each space that is naturally ventilated. The openings must also be readily accessible to the occupants of the space at all times.

Airflow through the openings must come directly from the outdoors; air may not flow through any intermediate spaces such as other occupied spaces, unconditioned spaces, corridors, or atriums. Also, high windows, operable skylights, and other operable openings need to have a control mechanism accessible from the floor.

Example 4-7

Question

What is the window area required to ventilate a 30 ft. x 32 ft. classroom?

Answer

In order for all points to be within 20 ft. of an opening, windows must be distributed and run at least along two of the opposite walls. The area of the openings must be:

(32 ft. x 30 ft.) x 5 percent = 48 ft²

The actual window area must be at least 96 ft² if only half the window can be open at a time.

Calculations must be based on free area, taking into account framing and bug screens; the actual window area is approximately 100 ft² without bug screens and 110 ft² with bug screens.

Example 4-8

Question

Naturally ventilated classrooms are located on either side of a doubly-loaded corridor and transoms are provided between the classrooms and corridor. Can the corridor be naturally ventilated through the classrooms?

Answer

No. The corridor cannot be naturally ventilated through the classrooms and transom openings. The Energy Standards require that naturally ventilated spaces have direct access to properly-sized openings to the outdoors. The corridor would require mechanical ventilation using either supply or exhaust fans.

4.3.2 Mechanical Ventilation

§120.1(b)2 and (d)

Mechanical outdoor ventilation must be provided for all spaces normally occupied that are not naturally ventilated. The Energy Standards require that a space conditioning system provide outdoor air equal to or exceeding the ventilation rates required for each of the spaces that it serves. At the space, the required ventilation can be provided either directly through supply air or indirectly through transfer of air from the plenum or an adjacent space. The required minimum ventilation airflow at the space can be provided by an equal quantity of supply or transfer air. At the air-handling unit, the minimum outside air must be the sum of the ventilation requirements of each of the spaces that it serves. The designer may specify higher outside air ventilation rates based on the owner's preference or specific ventilation needs associated with the space. However, specifying more ventilation air than the minimum allowable ventilation rates increases energy consumption and electrical peak demand and increases the costs of operating the HVAC equipment. Thus the designer should have a compelling reason to specify higher design minimum outside air rates than the calculated minimum outside air requirements in the Energy Standards.

The minimum OSA provided is required to be within 10 percent of the calculated minimum for both VAV and constant volume units.

In summary:

1. Ventilation compliance at the space is satisfied by providing supply and/or transfer air.
2. Ventilation compliance at the unit is satisfied by providing, at minimum, the outdoor air that represents the sum of the ventilation requirements at each space that it serves.

For each space requiring mechanical ventilation the ventilation rates must be the greater of either:

1. The conditioned floor area of the space, multiplied by the applicable minimum ventilation rate from (Table 4-12). This provides dilution for the building-borne contaminants like off-gassing of paints and carpets, or
2. 15 cfm per person, multiplied by the expected number of occupants. For spaces with fixed seating (such as a theater or auditorium), the expected number of occupants is the number of fixed seats. For spaces without fixed seating, the expected number of occupants is assumed to be no less than one-

half that determined for egress purposes in the California Building Code (CBC). The Energy Standards specify the minimum outdoor ventilation rate to which the system must be designed. If desired, the designer may, with documentation, elect to provide more ventilation air. For example, the design outdoor ventilation rate may be determined using the procedures described in ASHRAE 62, provided the resulting outdoor air quantities are no less than required by the Energy Standards.

Table 4-12: Minimum Ventilation Rates

Type of Use	CFM per ft² of Conditioned Floor Area
Auto repair workshops	1.50
Barber shops	0.40
Bars, cocktail lounges, and casinos	0.20
Beauty shops	0.40
Coin-operated dry cleaning	0.30
Commercial dry cleaning	0.45
High-rise residential	Ventilation Rates Specified by the CBC and CMC
Hotel guest rooms (less than 500 ft²)	30 cfm/guest room
Hotel guest rooms (500 ft² or greater)	0.15
Retail stores	0.20
All Others	0.15

Energy Standards Table 120.1-A

Table 4-13 shows the typical maximum occupant loads for various building uses (upon which minimum ventilation calculations are based). This provides dilution for the occupant-borne contaminants (or bioeffluents) like body odor and germs.

Table 4-14 summarizes the combination of these two rates for typical spaces.

As previously stated, each space-conditioning system must provide outdoor ventilation air as follows.

1. For a space-conditioning system serving a single space, the required system outdoor airflow is equal to the design outdoor ventilation rate of the space.
2. For a space-conditioning system serving multiple spaces, the required outdoor air quantity delivered by the space-conditioning system must not be less than the sum of the required outdoor ventilation rate to each space. The Energy Standards do not require that each space actually receive its calculated outdoor air quantity. Instead, the actual supply to any given space may be any combination of recirculated air, outdoor air, or air transferred directly from other spaces, provided:
    a. The total amount of outdoor air delivered by the space-conditioning system(s) to all spaces is at least as large as the sum of the space design quantities.
    b. Each space always receives supply airflow, including recirculated air and/or transfer air, no less than the calculated outdoor ventilation rate.
    c. When using transfer air, none of the spaces from which air is transferred has any unusual sources of contaminants.

Table 4-13: CBC Maximum Floor Area Allowances Per Occupant

Function of Space	Occupant Load Factor
Accessory storage areas, mechanical equipment room	300 gross
Agricultural building	300 gross
Aircraft hangers	500 gross
Airport terminal	
Baggage claim	20 gross
Baggage handling	300 gross
Concourse	100 gross
Waiting areas	15 gross
Assembly	
Gaming floors (keno, slots, etc.)	11 gross
Exhibit Gallery and Museum	30 net
Assembly with fixed seats	See Section 1004.4
Assembly without fixed seats	

Concentrated (chairs only – not fixed)	7 net
Standing space	5 net
Non-concentrated (tables and chairs)	15 net
Bowling centers and all other spaces	7 net
Bowling lanes (including 15 feet of approach)	5 person per lane
Business areas	100 gross
Courtrooms – other than fixed seating areas	40 net
Day care	35 net
Dormitories	50 gross
Educational	
Classroom area	20 net
Shops and other vocational room areas	50 net
Exercise rooms	50 gross
H-5 Fabrication and manufacturing areas	200 gross
Industrial areas	100 gross
Institutional areas	
Inpatient treatment areas	240 gross
Outpatient areas	100 gross
Sleeping areas	120 gross
Kitchens, commercial	200 gross
Library	
Reading rooms	50 net
Stack area	100 gross
Locker Rooms	50 gross
Mercantile	
Area on other floors	60 gross
Basement and grade floor areas	30 gross
Storage, stock, shipping areas	300 gross
Parking garages	200 gross
Residential	200 gross
Skating rinks, swimming pools	
Rink and pool	50 gross
Decks	15 gross
Stages and platforms	15 net

Source: Table 1004.1.2 of the California Building Code

Where:

Floor Area, Gross -The floor area within the inside perimeter of the exterior walls of the building under consideration, exclusive of vent shafts and courts, without deduction for corridors, stairways, closets, the thickness of interior walls, columns or other features. The floor area of a building, or portion thereof, not provided with surrounding exterior walls shall be the usable area under the horizontal projection of the roof or floor above. The gross floor area shall not include shafts with no openings or interior courts.

Floor Area, Net -The actual occupied area not including unoccupied accessory areas such as corridors, stairways, toilet rooms, mechanical rooms and closets.

Table 4-14: Required Minimum Ventilation Rate per Occupancy

Occupancy		Use	CBC Occupancy Load (ft²/occ)	CBC Occupancy Load (occ/1000 ft²)[A]	CBC Based Ventilation (cfm/ft²)[B]	Ventilation from Table 12((cfm/ft²)
1)	Aircraft Hangars		500	2	0.02	0.15
2)	Auction Rooms		See Section 1004.4			0.15
3)	Assembly Areas (Concentrated Use)					
		Auditoriums	See Section 1004.4			0.15
		Bowling Lane	5 persons			0.15

			per lane			
		Bowling Center[5] (all other spaces)	7	142.86	1.07	0.15
		Churches & Chapels (Religious Worship)	7	142.86	1.07	0.15
		Dance Floors	5	200	1.50	0.15
		Lobbies	15	66.67	0.50	0.15
		Lodge Rooms	7	142.86	1.07	0.15
		Reviewing Stands	15	66.67	0.50	0.15
		Stadiums	See Section 1004.4			0.15
		Theaters - All	See Section 1004.4			0.15
		Waiting Areas	15	66.67	0.50	0.15
4)	Assembly Areas (Non-concentrated Use)					
		Conference & Meeting Rooms[1]	15	66.67	0.50	0.15
		Dining Rooms/Areas	15	66.67	0.50	0.15
		Drinking Establishments[2]	15	66.67	0.50	0.20
		Exhibit/Display Areas	15	66.67	0.50	0.15
		Gymnasiums/Sports Arenas	15	66.67	0.50	0.15
		Lounges	15	66.67	0.50	0.20
		Stages and Platform	15	66.67	0.50	0.15
		Gaming, Keno, Slot Machine and Live Games Areas	11	90.91	0.68	0.20
5)	Auto Repair Workshops		100	10	0.08	1.50
6)	Barber & Beauty Shops		100	10	0.08	0.40
7)	Children's Homes & Homes for Aged		120	8.33	0.06	0.15
8)	Classrooms		20	50	0.38	0.15
9)	Courtrooms		40	25	0.19	0.15
10)	Dormitories		50	20	0.15	0.15
11)	Dry Cleaning (Coin-Operated)		100	10	0.08	0.30
12)	Dry Cleaning (Commercial)		100	10	0.08	0.45
13)	Exercise Rooms		50	20	0.15	0.15
14)	Garage, Parking		200	5	0.04	0.15
15)	Healthcare Facilities:	Sleeping Rooms	120	8.33	0.06	0.15
		Treatment Rooms	240	4.17	0.03	0.15
16)	Hotels & Apartments	Hotel Function Area	7	142.86	1.07	0.15
		Hotel Lobby	100	10	0.08	0.15
		Hotel Guest Room (<500 ft^2)3	200	5	0.04	n.a.3
		Hotel Guest Room (≥500 ft^2)	200	5	0.04	0.15
		High-rise Residential4	200	5	0.04	n.a.4

17)	Kitchen (Commercial)		200	5	0.04	0.15
18)	Library	Reading Rooms	50	20	0.15	0.15
		Stack Areas	100	10	0.08	0.15
19)	Locker Rooms		50	20	0.15	0.15
20)	Manufacturing		200	5	0.04	0.15
21)	Mechanical Equipment Room		300	3.33	0.03	0.15
22)	Nurseries for Children - Day Care		35	28.57	0.21	0.15
23)	Offices:	Office	100	10	0.08	0.15
		Bank/Finan-cial Institution	100	10	0.08	0.15
		Medical & Clinical Care	100	10	0.08	0.15
24)	Retail:	Sales, Wholesale Showrooms	30	33.33	0.25	0.20
		Basement and Ground Floor	30	33.33	0.25	0.20
		Upper Floors	60	16.67	0.13	0.20
		Grocery	30	33.33	0.25	0.20
		Malls, Arcades, & Atria	30	33.33	0.25	0.20
25)	School Shops & Vocational Rooms		50	20	0.15	0.15
26)	Skating Rinks	Skate Area	50	20	0.15	0.15
		On Deck	15	66.67	0.50	0.15
27)	Swimming Pools	Pool Area	50	20	0.15	0.15
		On Deck	15	66.67	0.50	0.15
28)	Transportation Function Area		30	33.33	0.25	0.15
29)	Warehouses, Industrial & Commercial Storage /Stockrooms		500	2	0.02	0.15
30)	All Others -- Including Unknown, Corridors, Restrooms, & Support Areas Commercial & Industrial Work		100	10	0.08	0.15

Footnotes	Equations
Includes Convention & Civic Meeting Areas. Bars, Cocktail & Smoking Lounges, Casinos. including 15 feet of approach. Guestrooms less than 500 ft² use 30 cfm/guestroom. High-rise Residential - for habitable areas not ventilated with Natural Ventilation, cfm=(0.06 cfm/ft² + 5 cfm/occ). Default occupancy for dwelling units shall be two persons for studio and one-bedroom units, with one additional person for each additional bedroom. Bowling centers, allow 5 persons for each lane	A. CBC Occupancy Load Equation: $Number\ of\ occupants/1000$ B. CBC Based Ventilation Equation: $cfm/ft^2 = 15\ cfm \times \frac{(Occu}{}$

Example 4-9

Question

Ventilation for a two-room building:

Consider a building with two spaces, each having an area of 1,000 ft^2. One space is used for general administrative functions, and the other is used for classroom training. It is estimated that the office will contain 7 people, and the classroom will contain 50 (fixed seating). What are the required outdoor ventilation rates?

Answer

1. For the office area, the design outdoor ventilation air is the larger of:

   7 people x 15 cfm/person = 105 cfm; or

   1,000 ft^2 x 0.15 cfm/ft^2 = 150 cfm

   For this space, the design ventilation rate is 150 cfm.

2. For the classroom, the design outdoor ventilation air is the larger of:

   50 people x 15 cfm/person = 750 cfm; or

   1,000 ft^2 x 0.15 cfm/ft^2 = 150 cfm

   For this space the design ventilation rate is 750 cfm.

Assume the total supply air necessary to satisfy cooling loads is 1,000 cfm for the office and 1,500 cfm for the classroom. If each space is served by a separate system, then the required outdoor ventilation rate of each system is 150 cfm and 750 cfm, respectively. This corresponds to a 15 percent outside air (OA) fraction in the office HVAC unit, and 50 percent in the classroom unit.

If both spaces are served by a central system, then the total supply will be (1,000 + 1,500) cfm = 2500 cfm. The required outdoor ventilation rate is (150 + 750) = 900 cfm total. The actual outdoor air ventilation rate for each space is:

Office OA = 900 cfm x (1,000 cfm / 2,500 cfm) = 360 cfm

Classroom OA = 900 cfm x (1,500 cfm / 2,500 cfm) = 540 cfm

While this simplistic analysis suggests that the actual OA cfm to the classroom is less than design (540 cfm vs. 750 cfm), the analysis does not take credit for the dilution effect of the air recirculated from the office. The office is over-ventilated (360 cfm vs. 150 cfm) so the concentration of pollutants in the office return air is low enough that it can be used, along with the 540 cfm of outdoor air, to dilute pollutants in the classroom. The Energy Standards allow this design provided that the system always delivers at least 750 cfm to the classroom (including transfer or recirculated air), and that any transfer air is free of unusual contaminants.

4.3.3 Direct Air Transfer

The Energy Standards allow air to be directly transferred from other spaces in order to meet a part of the ventilation supply to a space, provided the total outdoor quantity required by all spaces served by the building's ventilation system is supplied by the mechanical systems. This method can be used for any space, but is particularly applicable to conference rooms, toilet rooms, and other rooms that have high ventilation requirements. Transfer air must be free from any unusual contaminants, and should not be taken directly from rooms where such sources of contaminants are anticipated. It is typically taken from the return plenum or directly from an adjacent space.

Air may be transferred using any method that ensures a positive airflow. Examples include: dedicated transfer fans, exhaust fans, and fan-powered VAV boxes. A system having a ducted return may be balanced so that air naturally transfers into the space. Exhaust fans serving the space may discharge directly outdoors, or into a return plenum. Transfer systems should be designed to minimize recirculation of transfer air back into the space; duct work should be arranged to separate the transfer air intake and return points.

When each space in a two-space building is served by a separate constant volume system, the calculation and application of ventilation rate is straightforward, and each space will always receive its design outdoor air quantity. However, a central system serving both spaces does not deliver the design outdoor air quantity to each space. Instead, one space receives more than its allotted share, and the other less. This is because the training room has a higher design outdoor ventilation rate and/or a lower cooling load relative to the other space.

4.3.4 Distribution of Outdoor Air to Zonal Units

§120.1(d)

When a return plenum is used to distribute outside air to a zonal heating or cooling unit, the outside air supply must be connected either:

1. Within 5 ft. of the unit; or
2. Within 15 ft. of the unit, with the air directed substantially toward the unit, and with a discharge velocity of at least 500 ft. per minute.

Water source heat pumps and fan coils are the most common application of this configuration. The unit fans should be controlled to run continuously during occupancy in order for the ventilation air to be circulated to the occupied space.

A central space-conditioning system(s) augmented by a few zonal units for spot conditioning may use transfer air from spaces served by the central system. A direct source of outdoor air is not required for each zonal unit. Similarly, transfer air may be used in buildings having central interior space-conditioning systems with outdoor air, and zonal units on the perimeter (without outdoor air).

While not required, the Energy Standards recommend that sources of unusual contaminants be controlled through the use of containment systems that capture the contaminants and discharge them directly outdoors. Such systems may include exhaust hoods, fume hoods, small space exhausts and differential pressure control between spaces. The designer is advised to consult ASHRAE standards or other publications for guidance in this subject.

4.3.5 Ventilation System Operation and Controls

§120.1(c)

4.3.5.1 Outdoor Ventilation Air and VAV Systems

Except for systems employing Energy Commission-certified demand controlled ventilation (DCV) devices or space occupancy sensors, the Energy Standards require that the minimum rate of outdoor air calculated per §120.1(b)2 be provided to each space *at all times* when the space is normally occupied §120.1(c)1. For spaces served by variable air volume (VAV) systems, this means that the minimum supply setting of each VAV box should be no less than the design outdoor ventilation rate calculated for the space, unless transfer air is used. If transfer air is used, the minimum box position, plus the transfer air, must meet the minimum ventilation rate. If transfer air is not used, the box must be controlled so that the minimum required airflow is maintained at all times (unless demand controlled ventilation or occupant sensor are employed).

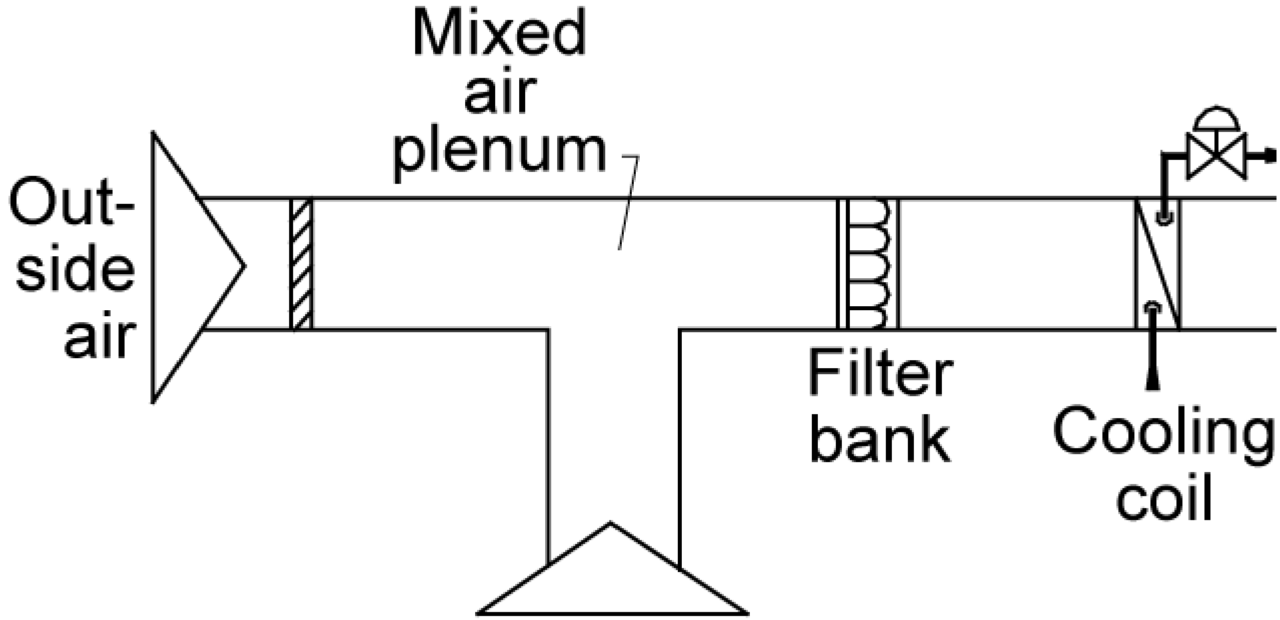
The design outdoor ventilation rate at the system level must always be maintained when the space is occupied, even when the fan has modulated to its minimum capacity §120.1(c)1. Section 4.3.11 describes mandated acceptance test requirements for outside air ventilation in VAV air handling systems. In these tests, the minimum outside air in VAV systems will be measured both at full flow and with all boxes at minimum position.

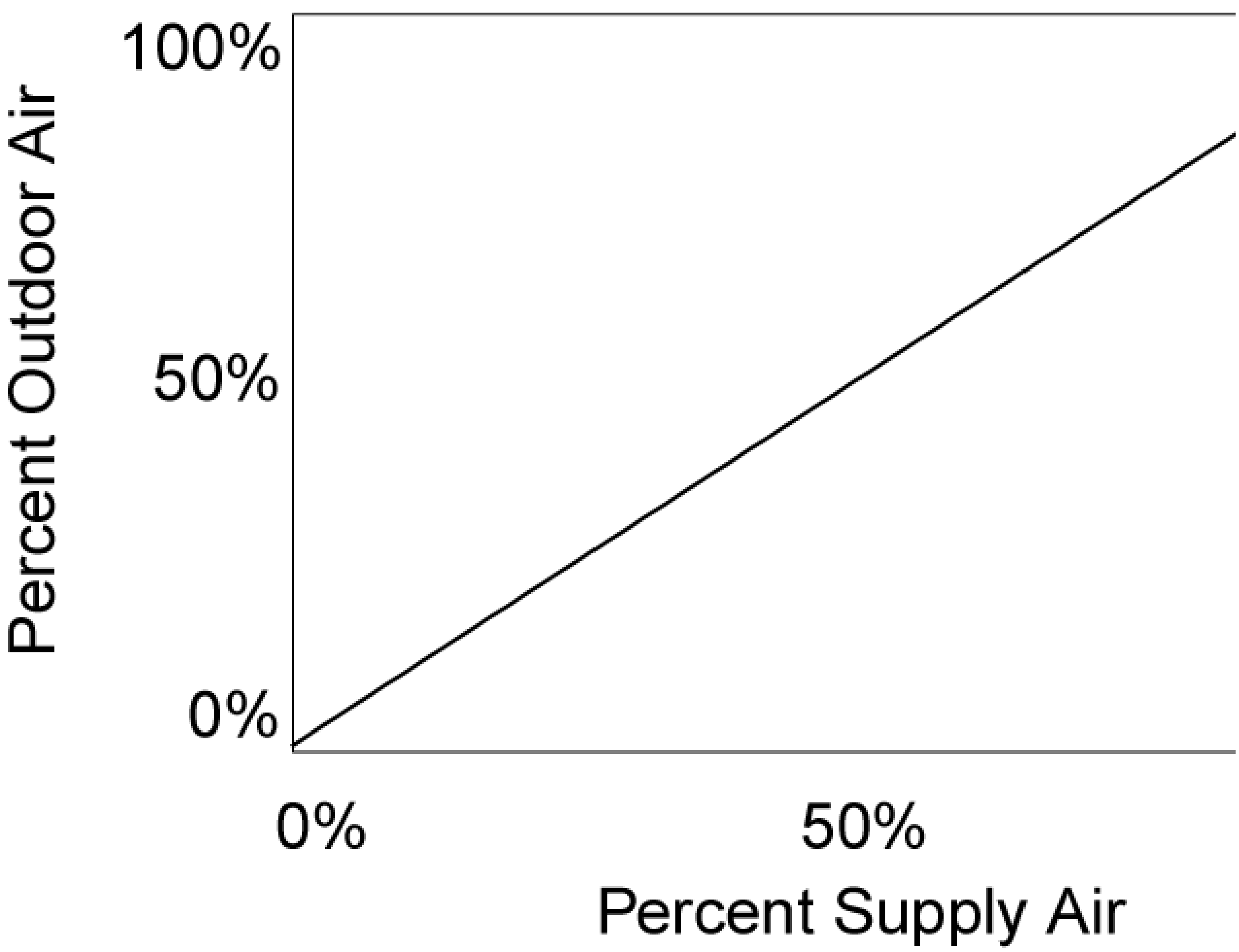
Figure 4-2 shows a typical VAV system. In standard practice, the testing and balancing (TAB) contractor sets the minimum position setting for the outdoor air damper during construction. It is set under the conditions of design airflow for the system, and remains in the same position throughout the full range of system operation. Does this meet code? The answer is no. As the system airflow drops, so will the pressure in the mixed air plenum. A fixed position on the minimum outdoor air damper will produce a varying outdoor airflow. As depicted in Figure 4-2, this effect will be approximately linear (in other words, outdoor air airflow will drop directly in proportion to the supply airflow).

The following paragraphs present several methods used to dynamically control the minimum outdoor air in VAV systems, which are described in detail below.

Regardless of how the minimum ventilation is controlled, care should be taken to reduce the amount of outdoor air provided when the system is operating during the weekend or after hours with only a fraction of the zones active. §120.2(g) requires provision of “isolation zones” of 25,000 ft² or less. This can be provided by having the VAV boxes return to fully closed when their associated zone is in unoccupied mode. When a space or group of spaces is returned to occupied mode (e.g. through off-hour scheduling or a janitor’s override), only the boxes serving those zones need to be active. During this partial occupancy the ventilation air can be reduced to the requirements of those zones that are active. If all zones are of the same occupancy type (e.g. private offices), simply assign a floor area to each isolation zone and prorate the minimum ventilation area by the ratio of the sum of the floor areas presently active divided by the sum of all the floor areas served by the HVAC system.

Figure 4-2: VAV Reheat System with a Fixed Minimum Outdoor Air Damper Setpoint





A. Fixed Minimum Damper Setpoint

This method does not comply with the Energy Standards; the airflow at a fixed minimum damper position will vary with the pressure in the mixed air plenum. It is explicitly prohibited in 120.1(e)2.

B. Dual Minimum Setpoint Design

This method complies with the Energy Standards. An inexpensive enhancement to the fixed damper setpoint design is the dual minimum setpoint design, commonly used on some packaged AC units. The minimum damper position is set proportionally based on fan speed or airflow between a setpoint determined when the fan is at full speed (or airflow) and minimum speed (or airflow). This method complies with the letter of the Energy Standards but is not accurate over the entire range of airflow rates and when there are wind or stack effect pressure fluctuations. But with DDC, this design has very low costs.

C. Energy Balance Method

The energy balance method uses temperature sensors in the outside, as well as return and mixed air plenums to determine the percentage of outdoor air in the supply air stream. The outdoor airflow is then calculated using the equations shown in Figure 4-3. This method requires an airflow monitoring station on the supply fan.

While technically feasible, it may be difficult to meet the outside air acceptance requirements with this approach because:

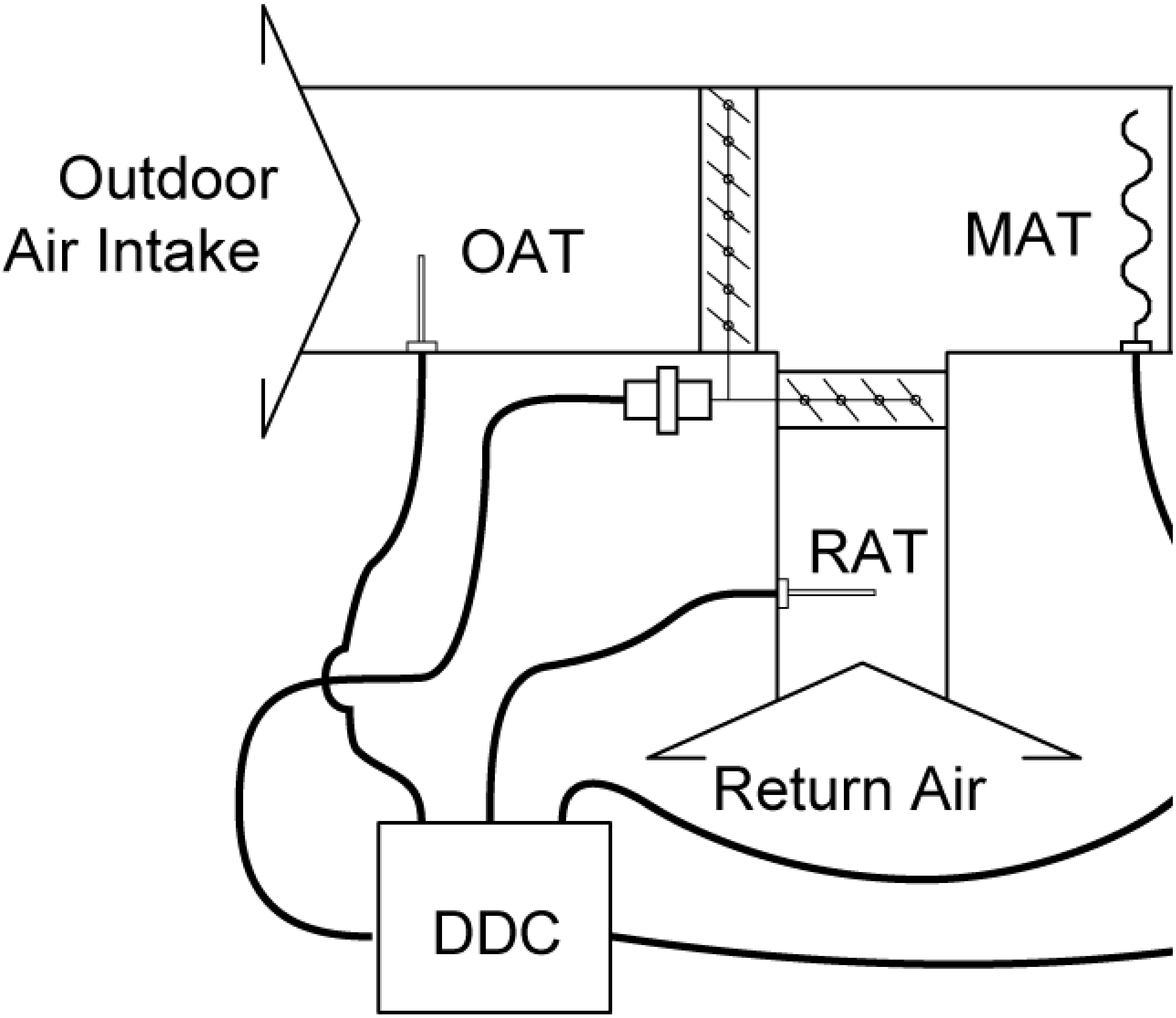
1. It is difficult to accurately measure the mixed air temperature, which is critical to the success of this strategy. Even with an averaging type bulb, most mixing plenums have some stratification or horizontal separation between the outside and mixed airstreams.

2. Even with the best installation, high accuracy sensors, and field calibration of the sensors, the equation for percent outdoor air will become inaccurate as the return air temperature approaches the outdoor air temperature. When they are equal, this equation predicts an infinite percentage outdoor air.

3. The accuracy of the airflow monitoring station is likely to be low at low supply airflows.

4. The denominator of the calculation amplifies sensor inaccuracy as the return air temperature approaches the outdoor air temperature.

Figure 4-3: Energy Balance Method of Controlling Minimum Outdoor Air



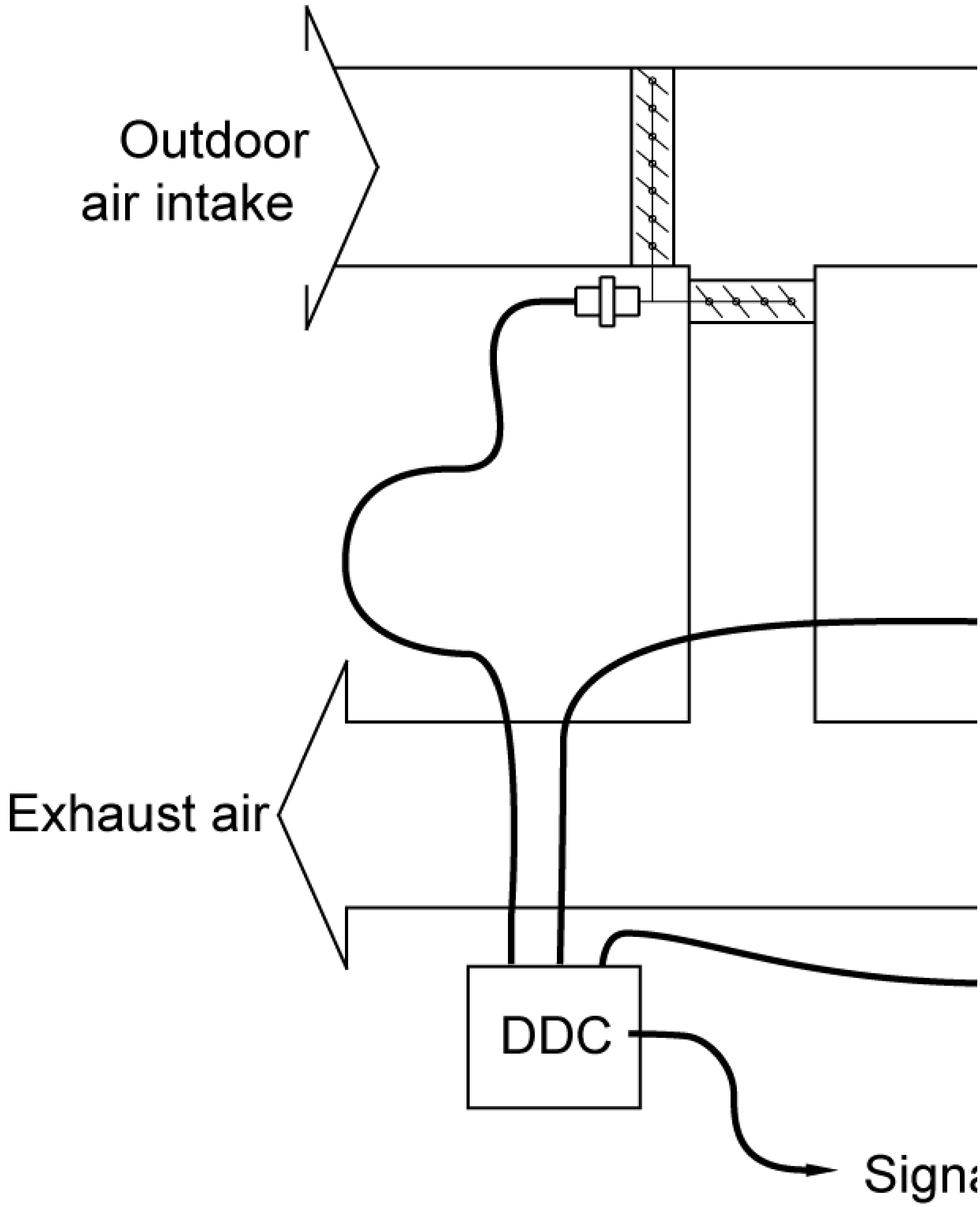
A. Return Fan Tracking

This method is also technically feasible, but will likely not meet the acceptance requirements because the cumulative error of the two airflow measurements can be large, particularly at low supply/return airflow rates. It only works theoretically when the minimum outdoor air rate equals the rate of air required to maintain building pressurization (the difference between supply air and return air rates). Return fan tracking (Figure 4-4) uses airflow monitoring stations on both the supply and return fans. The theory behind this is that the difference between the supply and return fans has to be made up by outdoor air, and controlling the flow of return air forces more ventilation into the building. Several problems occur with this method:

1. The relative accuracy of airflow monitoring stations is poor, particularly at low airflows;
2. The cost of airflow monitoring stations;
3. It will cause building pressurization problems unless the ventilation air is equal to the desired building exfiltration plus the building exhaust.

ASHRAE research has also demonstrated that in some cases this arrangement can cause outdoor air to be drawn into the system through the exhaust dampers due to negative pressures at the return fan discharge.

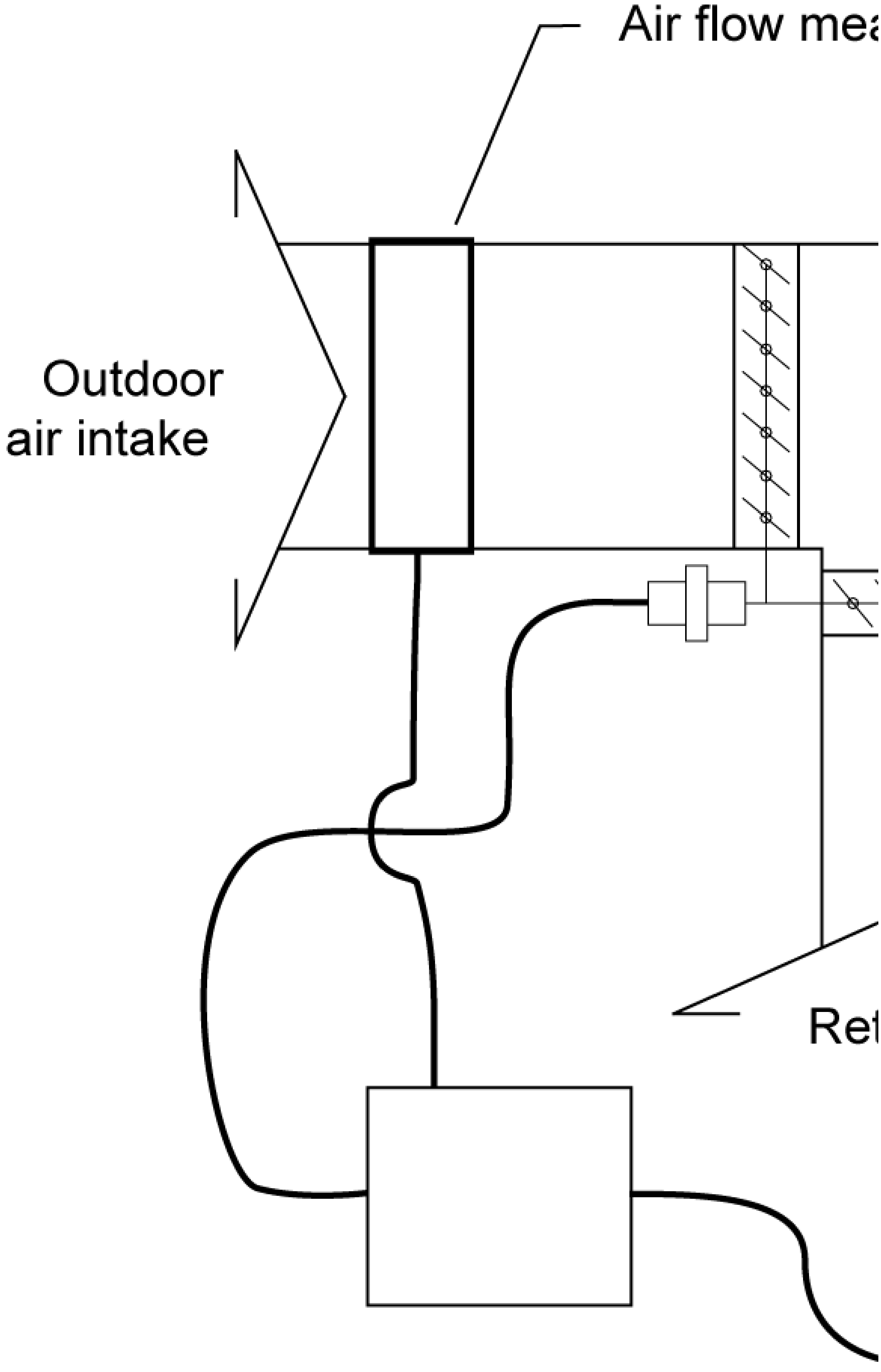
Figure 4-4: Return Fan Tracking



B. Airflow Measurement of the Entire Outdoor Air Inlet

This method is technically feasible but will likely not meet the acceptance requirements depending on the airflow measurement technology. Most airflow sensors will not be accurate to a 5-15 percent turndown (the normal commercial ventilation range). Controlling the outdoor air damper by direct measurement with an airflow monitoring station (Figure 4-5) can be an unreliable method. Its success relies on the turndown accuracy of the airflow monitoring station. Depending on the loads in a building, the ventilation airflow can be between 5 and 15 percent of the design airflow. If the outdoor airflow sensor is sized for the design flow for the airside economizer, this method has to have an airflow monitoring station that can turn down to the minimum ventilation flow (between 5 and 15 percent). Of the different types available, only a hot-wire anemometer array is likely to have this low-flow accuracy while traditional pilot arrays will not. One advantage of this approach is that it provides outdoor airflow readings under all operating conditions, not just when on minimum outdoor air. For highest accuracy, provide a damper and outdoor air sensor for the minimum ventilation air that is separate from the economizer outdoor air intake.

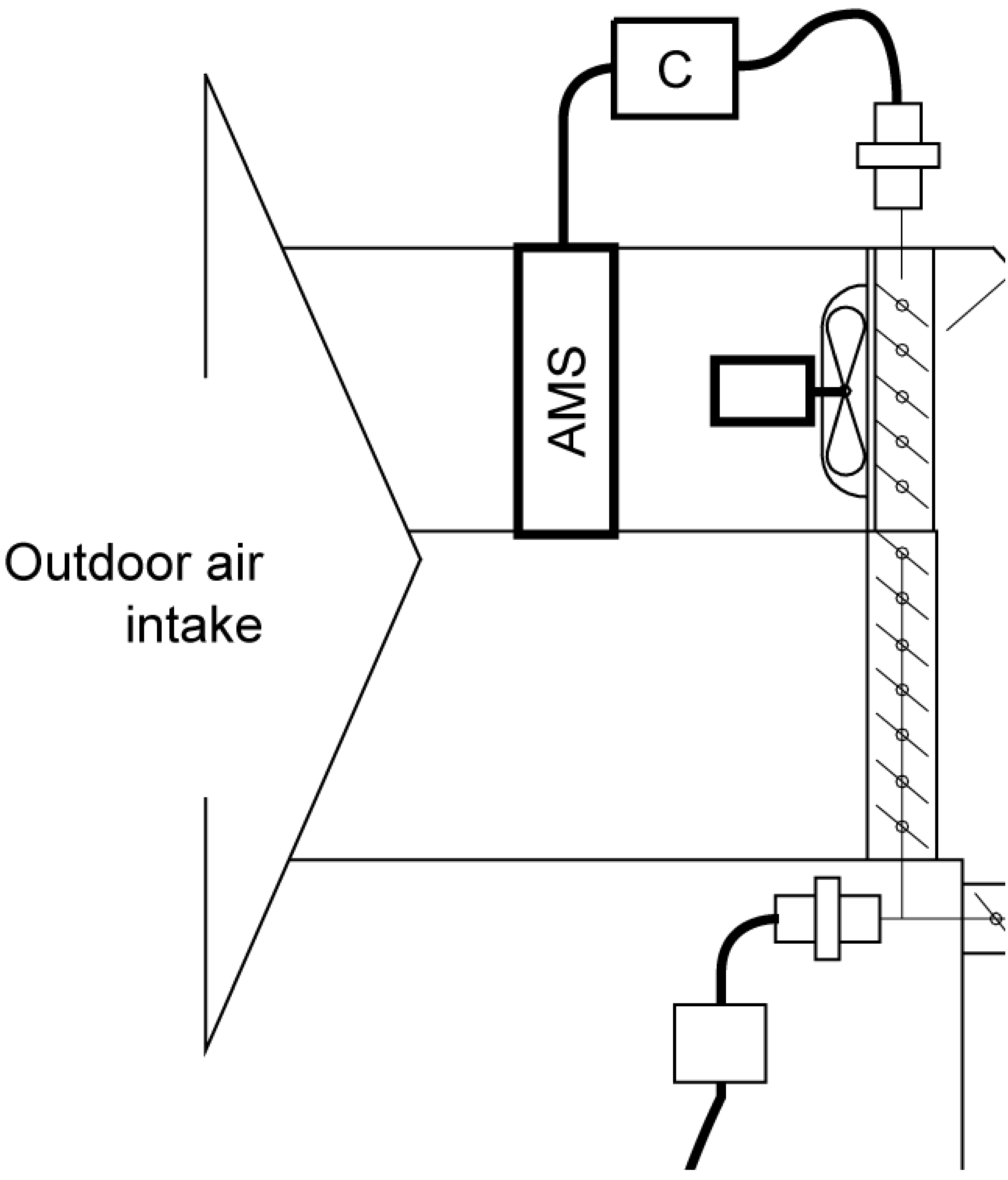
Figure 4-5: Airflow Measurement of 100% Outdoor Air

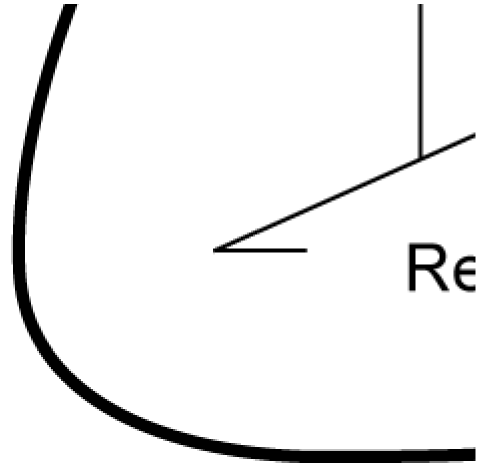

Air flow mea
Outdoor
air intake
Ret

C. Injection Fan Method

This method complies with the Energy Standards, but it is expensive and may require additional space. Note that an airflow sensor and damper are required since fan airflow rate will vary as mixed air plenum pressure varies. The injection fan method (Figure 4-6) uses a separate outdoor air inlet and fan sized for the minimum ventilation airflow. This inlet contains an airflow monitoring station, and a fan with capacity control (e.g., discharge damper; VFD), which is modulated as required to achieve the desired ventilation rate. The discharge damper is recommended since a damper must be provided anyway to shut off the intake when the AHU is off, and also to prevent excess outdoor air intake when the mixed air plenum is very negative under peak conditions. (The fan is operating against a negative differential pressure and thus cannot stop flow just by slowing or stopping the fan.) This method works, but the cost is high and often requires additional space for the injection fan assembly.

Figure 4-6: Injection Fan with Dedicated Minimum Outdoor Air Damper





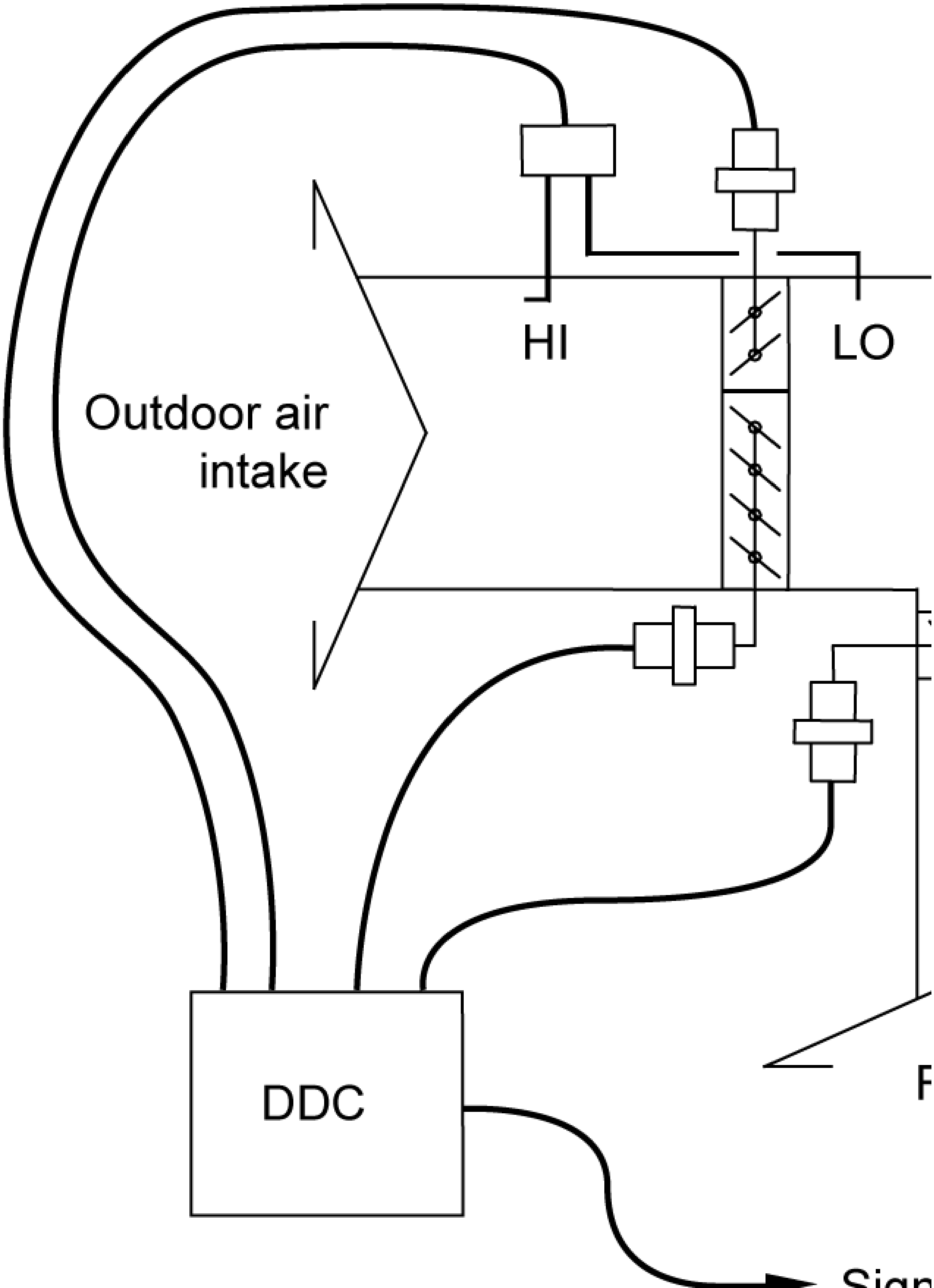
D. Dedicated Minimum Ventilation Damper with Pressure Control

This approach is low cost and takes little space. It can be accurate if the differential setpoint corresponding to the minimum outdoor air rate is properly set in the field. An inexpensive but effective design uses a minimum ventilation damper with differential pressure control (Figure 4-7). In this method, the economizer damper is broken into two pieces: a small two position damper controlled for minimum ventilation air and a larger, modulating, maximum outdoor air damper that is used in economizer mode. A differential pressure transducer is placed across the minimum outdoor air damper. During start-up, the air balancer opens the minimum outside air (OA) damper and return air damper, closes the economizer OA damper, runs the supply fan at design airflow, measures the OA airflow (using a hand-held velometer) and adjusts the minimum OA damper position until the OA airflow equals the design minimum OA airflow. The linkages on the minimum OA damper are then adjusted so that the current position is the “full open” actuator position. At this point the design pressure (DP) across the minimum OA damper is measured. This value becomes the DP setpoint. The principle used here is that airflow is constant across a fixed orifice (the open damper) at fixed DP.

As the supply fan modulates when the economizer is off, the return air damper is controlled to maintain the DP setpoint across the minimum ventilation damper.

The main downside to this method is the complexity of controls and the potential problems determining the DP setpoint in the field. It is often difficult to measure the outdoor air rate due to turbulence and space constraints.

Figure 4-7: Minimum Outdoor Air Damper with Pressure Control


HI
LO
Outdoor air intake
DDC
Sign

Example 4-10

Question

Minimum VAV cfm:

If the minimum required ventilation rate for a space is 150 cfm, what is the minimum allowed airflow for its VAV box when the design percentage of outdoor air in the supply is 20 percent?

Answer

The minimum allowed airflow may be as low as 150 cfm provided that enough outdoor air is supplied to all spaces combined to meet the requirements of §120.1(b)2 for each space individually.

4.3.6 Pre-Occupancy Purge

§120.1(c)2

Since many indoor air pollutants are out-gassed from the building materials and furnishings, the Energy Standards require that buildings having a scheduled operation be purged before occupancy §120.1(c)2. Immediately prior to occupancy, outdoor ventilation must be provided in an amount equal to the lesser of:

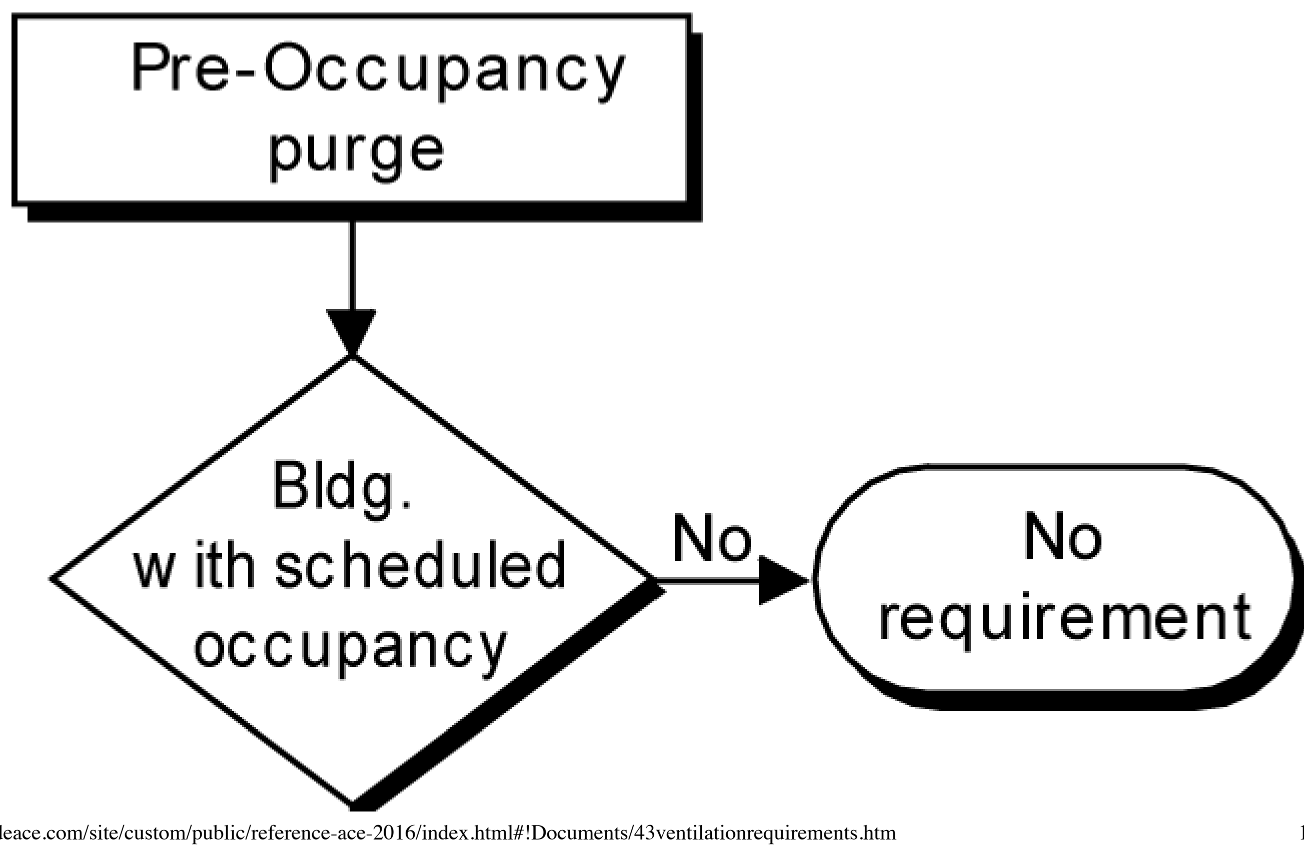
1. The minimum required ventilation rate for 1 hour.
2. 3 complete air changes.

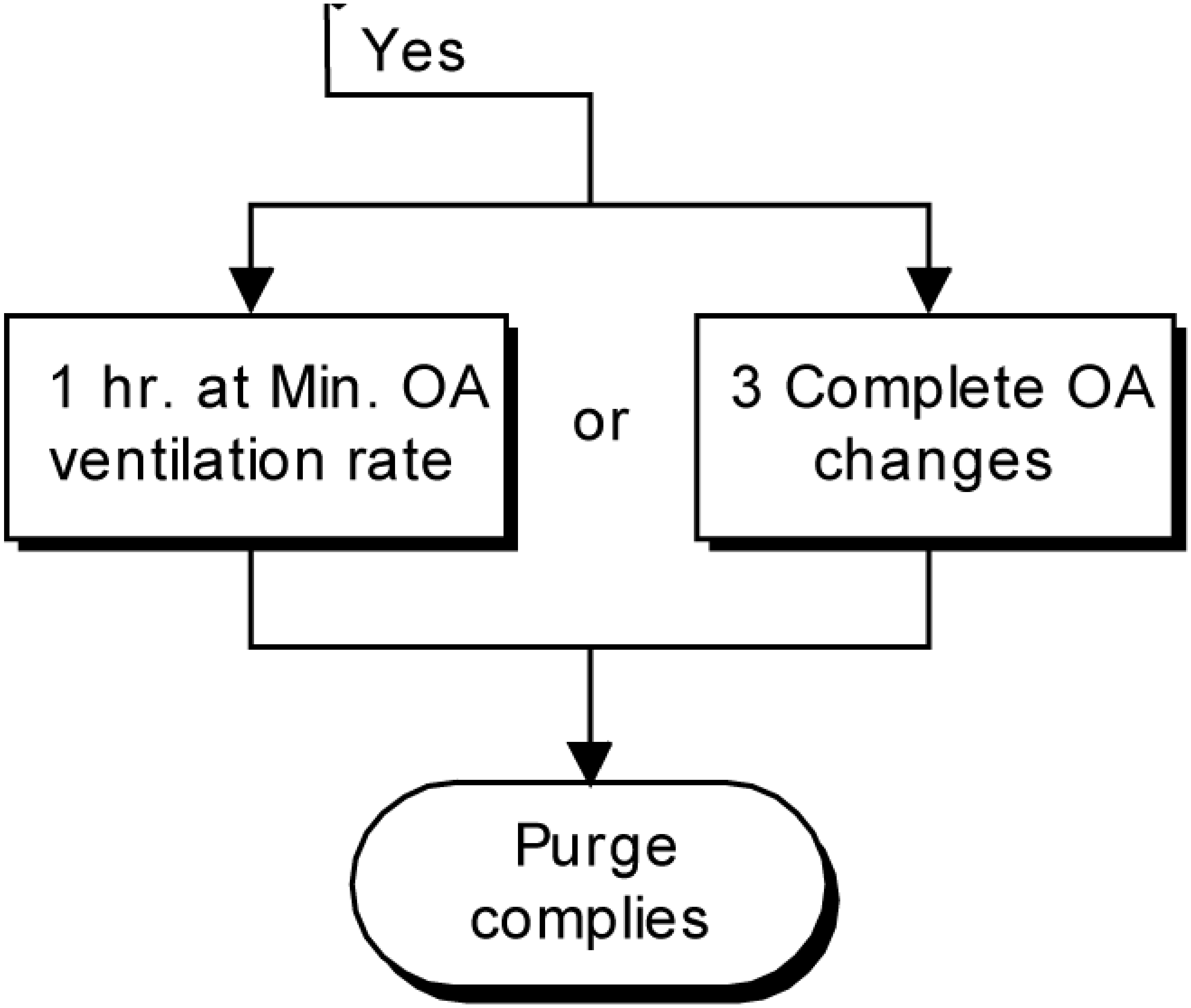
Either criterion can be used to comply with the Energy Standards. Three complete air changes means an amount of ventilation air equal to 3 times the volume of the occupied space. This air may be introduced at any rate provided for and allowed by the system, so that the actual purge period may be less than an hour.

A pre-occupancy purge is not required for buildings or spaces that are not occupied on a scheduled basis, such as storage rooms. Also, a purge is not required for spaces provided with natural ventilation.

Where pre-occupancy purge is required, it does not have to be coincident with morning warm-up (or cool-down). The simplest means to integrate the two controls is to simply schedule the system to be occupied one hour prior to the actual time of anticipated occupancy. This allows the optimal start, warm-up or pull-down routines to bring the spaces up to (or down to) desired temperatures before opening the outdoor air damper for ventilation. This will reduce the required system heating capacity and ensure that the spaces will be at the desired temperatures and fully purged at the start of occupancy.

Figure 4-8: Pre-Occupancy Purge Flowchart





Example 4-11

Question

Purge Period:

What is the length of time required to purge a space 10 ft. high with an outdoor ventilation rate of 1.5 cfm/ft^2?

Answer

For 3 air changes, each ft^2 of space must be provided with:

OA volume = 3 x 10 = 30 cf/ft^2

At a rate of 1.5 cfm/ft^2, the time required is:

Time = 30 cf/ft^2 / 1.5 cfm/ft^2 = 20 minutes

Example 4-12

Question

Purge with Natural Ventilation:

In a building with natural ventilation, do the windows need to be left open all night to accomplish a building purge?

Answer

No. A building purge is required only for buildings with mechanical ventilation systems.

Example 4-13

Question

Purge with Occupancy Timer:

How is a purge accomplished in a building without a regularly scheduled occupancy whose system operation is controlled by an occupancy sensor?

Answer

There is no purge requirement for this building. Note that occupancy sensors and manual timers can only be used to control ventilation systems in buildings that are intermittently occupied without a predictable schedule.

4.3.7 Demand Controlled Ventilation

§120.1(c)3 and 4

Demand controlled ventilation (DCV) systems reduce the amount of ventilation supply air in response to a measured level of carbon dioxide (CO_2) in the breathing zone. The Energy Standards only permit CO_2 sensors for the purpose of meeting this requirement; VOC and so-called “IAQ” sensors are not approved as alternative devices to meet this requirement. The Energy Standards only permit DCV systems to vary the ventilation component that corresponds to occupant bioeffluents (this is basis for the 15 cfm/person portion of the ventilation requirement). The purpose of CO_2 sensors is to track occupancy in a space; however, there are many factors that must be considered when designing a DCV system. There is often a lag time in the detection of occupancy through the build-up of CO_2. This lag time may be increased by any factors that affect mixing, such as short circuiting of supply air or inadequate air circulation, as well as sensor placement and sensor accuracy. Build-up of odors, bioeffluents, and other health concerns may also lag changes in occupancy; therefore, the designers must be careful to specify CO_2 based DCV systems that are designed to provide adequate ventilation to the space by ensuring proper mixing, avoiding short circuiting, and proper placement and calibration of the sensors.

A. The Energy Standards requires the use of DVC systems for spaces with all of the following characteristics:

1. Served by single zone units with any controls or multiple zone systems with Direct Digital Controls (DDC) to the zone level, and
2. Has a design occupancy of 40 ft²/person or smaller (for areas without fixed seating where the design density for egress purposes in the CBC is 40 ft²/person or smaller), and
3. Has an air economizer

B. There are five exceptions to this requirement:

1. The following spaces are permitted to use DCV but are not required to: classrooms, call centers, office spaces served by multiple zone systems that are continuously occupied during normal business hours with occupant density greater than 25 people per 1000 ft² per §120.1(b)2B (Table 4-13 and Table 4-14 above), healthcare facilities and medical buildings, and public areas of social services buildings.

   These spaces are exempted either due to concerns about equipment maintenance practices (schools and public buildings) or concerns about high levels of pathogens (social service buildings, medical buildings, healthcare facilities and to some extent classrooms).

2. Where the space exhaust is greater than the required ventilation rate minus 0.2 cfm/ft².

   This relates to the fact that spaces with high exhaust requirements won’t be able to provide sufficient turndown to justify the cost of the DCV controls. An example of this is a restaurant seating area where the seating area air is used as make-up air for the kitchen hood exhaust.

3. DCV devices are not allowed in the following spaces: Spaces that have processes or operations that generate dusts, fumes, mists, vapors, or gases and are not provided with local exhaust ventilation, such as indoor operation of internal combustion engines or areas designated for unvented food service preparation, or beauty salons.

   This exception recognizes that some spaces may need additional ventilation due to contaminants that are not occupant borne. It addresses spaces like theater stages where theatrical fog may be used or movie theater lobbies where unvented popcorn machines may be emitting odors and vapors into the space in either case justifying the need for higher ventilation rates. DCV devices shall not be installed in spaces included in Exception 3.

4. Spaces with an area of less than 150 ft², or a design occupancy of less than 10 people per §120.1(b)2B (Table 4-13 and Table 4-14 above).

   This recognizes the fact that DCV devices may not be cost effective in small spaces such as a 15 ft x 10 ft conference room or spaces with only a few occupants at design conditions.

5. Spaces less than 1500 ft² that comply with §120.1(c)5 - Occupant Sensor Ventilation Control Devices.

This exception states that an occupant sensor is allowed to reduce the amount of ventilation supply air in a vacant room.

Although not required, the Energy Standards permit design professionals to apply DCV on any intermittently occupied spaces served by either single-zone or multiple-zone equipment. §120.1(b)2 requires a minimum of 15 cfm of outdoor air per person times the expected number of occupants; however, it must be noted that these are minimum ventilation levels and the designers may specify higher ventilation levels if there are health related concerns that warrant higher ventilation rates.

CO_2 based DCV is based on several studies (Berg-Munch et al. 1986, Cain et al. 1983, Fanger 1983 and 1988, Iwashita et al. 1990, Rasmussen et al. 1985) that concluded that about 15 cfm of outdoor air ventilation per person will control human body odor such that roughly 80 percent of unadapted persons (visitors) will find the odor to be at an acceptable level. As activity level increases and bioeffluents increase, the rate of outdoor air required to provide acceptable air quality increases proportionally, resulting in the same differential CO2 concentration.

Note that CO_2 concentration only tracks indoor contaminants that are generated by occupants themselves and, to a lesser extent, their activities. It will not track other pollutants, particularly volatile organic compounds (VOCs) that off-gas from furnishings and building materials. Hence, where permitted or required by the Energy Standards, demand controlled ventilation systems cannot reduce the outdoor air ventilation rate below the floor rate listed in Energy Standards Table 120.1-A (typically 0.15 cfm/ft²) during normally occupied times.

DCV systems save energy if the occupancy varies significantly over time. Hence they are most cost effective when applied to densely occupied spaces like auditoriums, conference rooms, lounges or theaters. Because DCV systems must maintain the floor ventilation rate listed in Energy Standards Table 120.1-A, they will not be applicable to sparsely occupied buildings such as offices where the floor rate always exceeds the minimum rate required by the occupants (See Table 4-14).

C. Where DCV is employed (whether mandated or not) the controls must meet all of the following requirements:

1. Sensors must be provided in each room served by the system that has a design occupancy of 40 ft²/person or less, with no less than one sensor per 10,000 ft² of floor space. When a zone or a space is served by more than one sensor, signal from any sensor indicating that CO_2 is near or at the setpoint within a space, must trigger an increase in ventilation to the space. This requirement ensures that the space is adequately ventilated in case a sensor malfunctions. Design professional should ensure that sensors are placed throughout a large space, so that all areas are monitored by a sensor.

2. The CO_2 sensors must be located in the breathing zone (between 3 and 6 ft. above the floor or at the anticipated height of the occupant's head). Sensors in return air ducts are not allowed since they can result in under-ventilation due to CO_2 measurement error caused by short-circuiting of supply air into return grilles and leakage of outdoor air (or return air from other spaces) into return air ducts.

3. The ventilation must be maintained that will result in a concentration of CO_2 at or below 600 ppm above the ambient level. The ambient levels can either be assumed to be 400 ppm or dynamically measured by a sensor that is installed within four feet of the outdoor air intake. At 400 ppm outside CO_2 concentration, the resulting DCV CO_2 setpoint would be 1000 ppm. (Note that a 600 ppm differential is less than the 700 ppm that corresponds to the 15 cfm/person ventilation rate. This provides a margin of safety against sensor error, and because 1000 ppm CO_2 is a commonly recognized guideline value and referenced in earlier versions of ASHRAE Standard 62.)

4. Regardless of the CO_2 sensor's reading, the system is not required to provide more than the minimum ventilation rate required by §120.1(b). This prevents a faulty sensor reading from causing a system to provide more than the code required ventilation for system without DCV control. This high limit can be implemented in the controls.

5. The system shall always provide a minimum ventilation of the sum of the Energy Standards Table 120.1-A values for all rooms with DCV and §120.1(b)2 (Table 4-13) for all other spaces served by the system. This is a low limit setting that must be implemented in the controls.

6. The CO_2 sensors must be factory-certified to have an accuracy within plus or minus 75 ppm at 600 and 1000 ppm concentration when measured at sea level and 25°C (77°F), factory calibrated or calibrated at start-up, and certified by the manufacturer to require calibration no more frequently than once every 5 years. A number of manufacturers now have “self-calibrating” sensors that either adjust to ambient levels during unoccupied times or adjust to the decrease in sensor bulb output through use of dual sources or dual sensors. For all systems, the manufacturers of sensors must provide a document to installers that their sensors meet these requirements. The installer must make this certification information available to the builder, building inspectors and, if specific sensors are specified on the plans, to plan checkers.

7. When a sensor failure is detected, the system must provide a signal to reset the system to provide the minimum quantity of outside air levels required by §120.1(b)2 to the zone(s) serviced by the sensor at all times that the zone is occupied. This requirement ensures that the space is adequately ventilated in case a sensor malfunctions. A sensor that provides a high CO_2 signal on sensor failure will comply with this requirement.

8. For systems that are equipped with DDC to the zone level, the CO_2 sensor(s) reading for each zone must be displayed continuously, and recorded. The EMCS may be used to display and record the sensors’ readings. The display(s) must be readily available to maintenance staff so they can monitor the systems performance.

4.3.8 Occupant Sensor Ventilation Control Devices

The use of occupant sensor ventilation control devices are mandated for multipurpose rooms less than 1000 ft^2 ; classrooms over 750 ft^2; and conference, convention, auditorium and meeting center rooms greater than 750 ft^2 that do not have processes or operations that generate dusts, fumes, vapors or gasses(by reference to §120.2(e)3). They are also an alternate method of compliance for spaces mandated to have DCV that are less than 1,500 ft^2 (Exception 5 to §120.1(c)3).

There are a few spaces where it appears that both DCV and occupant sensor ventilation controls are mandated (e.g. auditoriums greater than 750 ft^2). Exception 1 to §120.1(c)5 exempts occupant sensor ventilation controls if DCV is implemented as required by §120.1(c)4.

Where occupant sensor ventilation control devices are employed (whether mandated or not) the controls must meet all of the following requirements:

1. Sensors must meet the requirements of §110.9(b)4 and shall have suitable coverage to detect occupants in the entire space.

2. Sensors that are used for lighting can be used for ventilation as well as long as the ventilation system is controlled directly from the occupant sensor and is not subject to lighting overrides.

3. If a terminal unit serves several enclosed spaces, each space shall have its own occupant sensor and all sensors must indicate lack of occupancy before the zone airflow is cut off.

4. The occupant sensor override shall be disabled during preoccupancy purge (i.e. the terminal unit and central ventilation shall be active regardless of occupant status).

5. Supply fans on systems with all zones provided with occupant sensor ventilation control devices can cycle off if all zones are vacant provided that minimum ventilation to all zones is provided as follows:

6. For spaces with a design occupant density greater than or equal to 25 people per 1000 ft^2 (40 square foot or less per person); 25 percent of the rate listed in Table 120.1-A: Minimum Ventilation Rates.

To implement the last provision the supply fan on the unit serving the zones would have to cycle on for at least 15 minutes of every hour with the outside air damper at or above minimum position.

4.3.9 Fan Cycling

§120.1©5E

While §120.1(c)1 requires that ventilation be continuous during normally occupied hours when the space is usually occupied, Exception 2 allows the ventilation to be disrupted for not more than 30 minutes at a time. In this case the ventilation rate during the time the system is ventilating must be increased so the average rate over the hour is equal to the required rate.

It is important to review any related ventilation and fan cycling requirements in Title 8, which is the Division of Occupational Safety and Health (Cal/OSHA) regulations. Section 5142 specifies the operational requirements related to HVAC minimum ventilation. It states:

Operation:

1. The HVAC system shall be maintained and operated to provide at least the quantity of outdoor air required by the State Building Standards Code, Title 24, Part 2, California Administrative Code, in effect at the time the building permit was issued.
2. The HVAC system shall be operated continuously during working hours except:
   a. During scheduled maintenance and emergency repairs;
   b. During periods not exceeding a total of 90 hours per calendar year when a serving electric utility by contractual arrangement requests its customers to decrease electrical power demand; or
   c. During periods for which the employer can demonstrate that the quantity of outdoor air supplied by nonmechanical means meets the outdoor air supply rate required by (a)(1) of this Section. The employer must have available a record of calculations and/or measurements substantiating that the required outdoor air supply rate is satisfied by infiltration and/or by a nonmechanically driven outdoor air supply system.

Title 8 Section 5142(a)(1) refers to Title 24, Part 2 (the California Building Code) for the minimum ventilation requirements. Section 1203 in the California Building Code specifies the ventilation requirements, but simply refers to the California Mechanical Code, which is Title 24, Part 4.

Chapter 4 in the California Mechanical Code specifies the ventilation requirements. Section 402.3 states, “The system shall operate so that all rooms and spaces are continuously provided with the required ventilation rate while occupied.” Section 403.5.1 states, “Ventilation systems shall be designed to be capable of providing the required ventilation rates in the breathing zone whenever the zones served by the system are occupied, including all full and part-load conditions.” The required ventilation rates are thus not required whenever the zones are unoccupied. This section affirms that ventilation fans may be turned off during unoccupied periods. In addition, Section 403.6 states, “The system shall be permitted to be designed to vary the design outdoor air intake flow or the space or zone airflow as operating conditions change.” This provides further validation to fan cycling as operating conditions change between occupied and unoccupied. A vacant zone has no workers present and is thus not subject to working hour’s requirements until the zone is actually occupied by a worker. Finally, Title 24, Part 4, states; “Ventilation air supply requirements for occupancies regulated by the California Energy Commission are found in the California Energy Code.” Thus, it refers to Title 24, Part 6 as the authority on ventilation.

Title 8 Section 5142(a)(2) states, “The HVAC system shall be operated continuously during working hours.” This regulation does not indicate that the airflow, cooling, or heating needs to be continuous. If the HVAC system is designed to maintain average ventilation with a fan cycling algorithm, and is active in that mode, providing average ventilation air as required during working hours, it is considered to be operating continuously per its mode and sequence. During unoccupied periods, the HVAC system is turned off except for setback and it no longer operates continuously. During the occupied period, occupant sensors or CO2 sensors in the space provide continuous monitoring and the sequence is operating, cycling the fan and dampers as needed to maintain the ventilation during the occupied period. The HVAC system is operating with the purpose of providing ventilation, heating, and cooling continuously during the working hours. The heater, air conditioner, fans, and dampers all cycle on and off subject to their system controls to meet the requirements during the working hours.

Exceptions A, B, and C to Title 8 Section 5142(a)(2) all refer to a complete system shutdown where the required ventilation is not maintained.

Example 4-14

Question

Does a single zone air-handling unit serving a 2,000 ft² auditorium with fixed seating for 240 people require demand controlled ventilation?

Answer

Yes if it has an air-side economizer. There are three tests for the requirement.

The first test is whether the design occupancy is 40 ft²/person or less. This space has 2,000 ft²/240 people or 8.3 ft² /person.

The second test is that the unit is single zone

The third is that it has an air-side economizer.

A single CO_2 sensor could be used for this space provided it is certified by the manufacturer to cover 2,000 ft² of space. The sensor must be placed directly in the space.

Example 4-15

Question

If two separate units are used to condition the auditorium in the previous example, is demand controlled ventilation required?

Answer

Yes, if they each meet the three tests.

Example 4-16

Question

The 2,000 ft^2 auditorium in the previous examples appears to require both demand controlled ventilation per Section 4.3.7 and occupant sensor ventilation control devices per Section 4.3.8? Is this the case?

Answer

No, the exception in Section 4.3.8 exempts occupant sensor ventilation controls if implemented as required in Section 4.3.7 Only demand controlled ventilation is required.

Example 4-17

Question

If a central AHU supplies five zones of office space (with a design occupant density of 100 ft²/person and two zones with conference rooms (with a design occupant density of 35 ft²/person) is it required to have demand controlled ventilation and if so, on which zones?

Answer

If the AHU has DDC controls to the zone and an airside economizer it is required to have DCV controls in both of the conference room zones.

The minimum OSA will be set for 0.15 cfm/ft² times the total area of all seven zones (the office and conference room zones) and the maximum required OSA does not need to exceed the sum of 0.15 cfm/ft² for the 5 office zones plus 15 cfm per person for the two conference rooms.

4.3.9.1 Variable Air Volume (VAV) Changeover Systems

Some VAV systems provide conditioned supply air, either heated or cooled, through a single set of ducting. These systems are called VAV changeover systems or, perhaps more commonly, variable volume and temperature (VVT™) systems, named after a control system distributed by Carrier Corp. In the event that heating is needed in some spaces at the same time that cooling is needed in others, the system must alternate between supplying heated and cooled air. When the supply air is heated, for example, the spaces requiring cooling are isolated (cut off) by the VAV dampers and must wait until the system switches back to cooling mode. In the meantime, they are generally not supplied with ventilation air.

Systems of this type may not meet the ventilation requirements if improperly applied. Where changeover systems span multiple orientations the designer must make control provisions to ensure that no zone is shut off for more than 30 minutes at a time and that ventilation rates are increased during the remaining time to compensate. Alternatively, minimum damper position or airflow setpoints can be set for each zone to maintain supply air rates, but this can result in temperature control problems since warm air will be supplied to spaces that require cooling, and vice versa. Changeover systems that are applied to a common building orientation (e.g., all east or all interior) are generally the most successful since zones will usually have similar loads, allowing minimum airflow rates to be maintained without causing temperature control problems.

4.3.10 Adjustment of Ventilation Rate

§120.1(b) specifies the minimum required outdoor ventilation rate, but does not restrict the maximum. However, if the designer elects to have the space-conditioning system operate at a ventilation rate higher than the rate required by the Energy Standards, then the Energy Standards require that the space-conditioning system must be adjustable so that in the future the ventilation rate can be reduced to the amount required by the Energy Standards or the rate required for make-up of exhaust systems that are required for a process, for control of odors, or for the removal of contaminants within the space §120.1(e).

In other words, a system can be designed to supply higher than minimum outside air volumes provided dampers or fan speed can be adjusted to allow no more than the minimum volume if, at a later time, someone decides it is desirable. The Energy Standards preclude a system designed for 100 percent outdoor air, with no provision for any return air, unless the supply air quantity can be adjusted to be equal to the designed minimum outdoor air volume. The intent is to prevent systems from being designed that will permanently over-ventilate spaces.

4.3.11 Acceptance Requirements

§120.5

The Energy Standards have acceptance test requirements for:

1. Ventilation quantities at design airflow for constant volume systems §120.5(a)1 and NA7.5.1.2.
2. Ventilation quantities at design and minimum airflow for VAV systems §120.5(a)1 and NA7.5.1.1.
3. Ventilation system time controls §120.5(a)2 and NA7.5.2.
4. Demand controlled ventilation systems §120.5(a)5 and NA7.5.5.

These test requirements are described in Chapter 13 and the Reference Nonresidential Appendix NA7.5. They are described briefly in the following paragraphs.

Example 4-18

Question

Maintenance of Ventilation System:

In addition to these commissioning requirements for the ventilation system, are there any periodic requirements for inspection?

Answer

The Energy Standards do not contain any such requirements since they apply to the design and commissioning of buildings, not to its later operation. However, Section 5142 of the General Industry Safety Orders, Title 8, California Safety Code: Mechanically Driven Heating, Ventilating and Air Conditioning (HVAC) Systems to Provide Minimum Building Ventilation, states the following:

Inspection and Maintenance

(1) The HVAC system shall be inspected at least annually, and problems found during these inspections shall be corrected within a reasonable time.

(2) Inspections and maintenance of the HVAC systems shall be documented in writing. The employer shall record the name of the individual(s) inspecting and/or maintaining the system, the date of the inspection and/or maintenance, and the specific findings and actions taken. The employer shall ensure that such records are retained for at least five years.

(3) The employer shall make all records required by this section available for examination and copying, within 48 hours of a request, to any authorized representative of the Division (as defined in Section 3207 of Title 8), to any

employee of the employer affected by this section, and to any designated representative of said employee of the employer affected by this Section.

4.3.11.1 Ventilation Airflow

NA7.5.1

Ventilation airflow has to be certified to be measured within 10 percent of the design airflow quantities at two points of operation: full design supply airflow (all systems) and (for VAV systems) at airflow with all VAV boxes at or near minimum position.

If airflow monitoring stations are provided, they can be used for these measurements.

4.3.11.2 Ventilation System Time Controls and Preoccupancy Purge

NA7.5.2

Programming for preoccupancy purge and HVAC schedules are checked and certified as part of the acceptance requirements. The sequences are also required to be identified by specification section paragraph number (or drawing sheet number) in the compliance documents.

4.3.11.3 Demand Controlled Ventilation System

NA7.5.5

Demand controlled ventilation systems are checked for compliance with sensor location, calibration (either factory certificate or field validation) and tested for system response with both a high signal (produced by a certified calibration test gas applied to the sensor) and low signal (by increasing the setpoint above the ambient level). A certificate of acceptance must be provided to the enforcement agency that the demand control ventilation system meets the Acceptance Requirements for Code Compliance. The certificate of acceptance must include certification from the manufacturers of sensor devices that they will meet the requirements of §120.1(c)4F and that they will provide a signal that indicates the CO_2 level in the range required by §120.1(c)4, certification from the controls manufacturer that they respond to the type of signal that the installed sensors supply and that they can be calibrated to the CO_2 levels specified in §120.1(c)4, and that the CO_2 sensors have an accuracy of within plus or minus 75 ppm at 600 and 1,000 ppm concentrations, and require calibration no more frequently than once every 5 years.