CODE NOTES

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

BUILDING TECHNOLOGIES PROGRAM

2012 IECC

Demand Control Ventilation

A demand control ventilation (DCV) system is an integral part of a building's ventilation design. It adjusts outside ventilation air based on the number of occupants and the ventilation demands that those occupants create.

In most commercial occupancies, ventilation is provided to deal with two types of indoor pollution: (1) odors from people, and (2) off-gassing from building components and furniture. When a space is vacant, it has no people pollution so the people-related ventilation rate is not needed. Many types of high-occupancy spaces, such as classrooms, multipurpose rooms, theaters, conference rooms, or lobbies have ventilation designed for a high peak occupancy that rarely occurs. Ventilation can be reduced during the many hours of operation when spaces are vacant or at lower than peak occupancy. When ventilation is reduced, building owners or operators save energy because it is not necessary to heat or cool as much outside air. In colder climates, heating for ventilation air is greater and DCV saves the most energy.

Definitions

Demand control ventilation (DCV): A ventilation system capability that provides for the automatic reduction of outdoor air intake below design rates when the actual occupancy of spaces served by the system is less than design occupancy.

Mechanical ventilation: The active process of supplying air to or removing air from an indoor space by powered equipment.

cfm: Cubic feet per minute, a standard measurement of fan airflow.

Direct digital control (DDC): A control system that uses digital processors to directly control HVAC equipment. Such a system may be specific to the equipment controlled with pre-set programs, or be a separate system that has customizable programs. For multi-zone systems, the DDC system must "report to a central control panel" or bring together information from each zone.

Makeup air: Outdoor air deliberately brought into the building from the outside and supplied to the vicinity of an exhaust hood to replace air, vapor, and contaminants being exhausted. Makeup air is generally filtered and fan-forced, and it may be heated or cooled depending on the requirements of the application. Makeup air may be delivered through outlets integral to the exhaust hood or through outlets in the same room.

Building Energy Codes

Demand Control Ventilation *(Continued)*

Definitions *(Continued)*

Transfer air: Air transferred from one room to another through openings in the room envelope, whether it is transferred intentionally or not. The driving force for transfer air is generally a small pressure differential between the rooms, although one or more fans may be used.

Area outdoor airflow rate: The rate of outdoor airflow in cfm per square foot needed to offset pollution from people in the space. The rate for different occupancies is shown in ventilation standards such as the International Mechanical Code (IMC) or ANSI/ASHRAE Standard 62.1 (sometimes called the "minimum" ventilation rate).

People outdoor airflow rate: The rate of outdoor airflow in cfm per person needed to offset pollution from people in the space. The rate for different occupancies is shown in ventilation standards such as the IMC or ANSI/ASHRAE Standard 62.1.

Full outdoor airflow rate: The rate of outdoor airflow in cfm per square foot needed when the space is fully occupied. The sum of the area and the people outdoor airflow rates. Sometimes called the "maximum" ventilation rate.

Air-side economizer: An air control device with modulating outside air dampers that increases the outside air when cooling is required and outside air will cool the room.

Demand Control Ventilation Systems

Components that control outside air are already required in most systems. These components could include an economizer or air makeup unit with modulating dampers. Other components needed for DCV are control sensors to measure occupancy, and a controller or DDC programming to communicate either directly with the economizer controller or with a central control system.

Occupancy can be measured in one of several ways:

- Space carbon dioxide (CO_2) sensing is the most common method. These systems have a CO_2 sensor in each space or in the return air and adjust the ventilation based on CO_2 concentration. Because people breathe out CO_2, the higher the level, the more people are in the space relative to the ventilation rate. With a CO_2 sensor DCV system, the ventilation rate varies based on the number of people in the space.
- Occupant counting uses turnstiles, ticket sales, video recognition, security swipes, or other methods to obtain an actual or estimated count of occupants in the space. Like systems with CO_2 sensors, the ventilation rate varies based on the number of people in the space.
- Occupancy sensing uses lighting or dedicated occupancy sensors to detect if anyone is in the space or if the space is vacant. For occupancy sensing, either full ventilation or area ventilation is provided, so full ventilation will be provided whether there is one person in the space or the space is fully occupied.

2012 IECC

Demand Control Ventilation *(Continued)*

- Scheduled ventilation can work effectively with classrooms or scheduled meeting rooms. In this system, the occupancy is estimated based on a class or rental schedule and this information is input into the control system. To be effective, the system requires ongoing entry of schedule information or integration with a scheduling calendar system.
- Supply air CO_2 concentration maintenance can be applied to a large multi-zone variable air volume system. In this approach, the required ventilation rates are calculated for design conditions in each zone and the CO_2 concentration in the supply air needed to meet that design ventilation rate is determined. Then the outside air rate is adjusted based on a supply air CO_2 sensor to meet the pre-determined rate.

Any of these methods will meet the requirement for DCV. For a base-case ventilation system without DCV, the design ventilation required when the space is full would be determined, including both the area and people ventilation rates. We will refer to that as the full ventilation rate. (Some designers may use the term minimum ventilation for area ventilation and maximum ventilation for full ventilation.) Without DCV, that full ventilation rate is provided whenever the space is expected to be occupied. With DCV, the area ventilation rate is provided whenever the space is expected to be occupied. When occupancy is detected or scheduled with one of the methods described, the ventilation is increased from the area rate to either the full rate or somewhere between the area and full rate. Figure 1 shows how the different methods compare in the ventilation rate they provide (as a percentage of full ventilation) in response to changes in occupancy in the space.

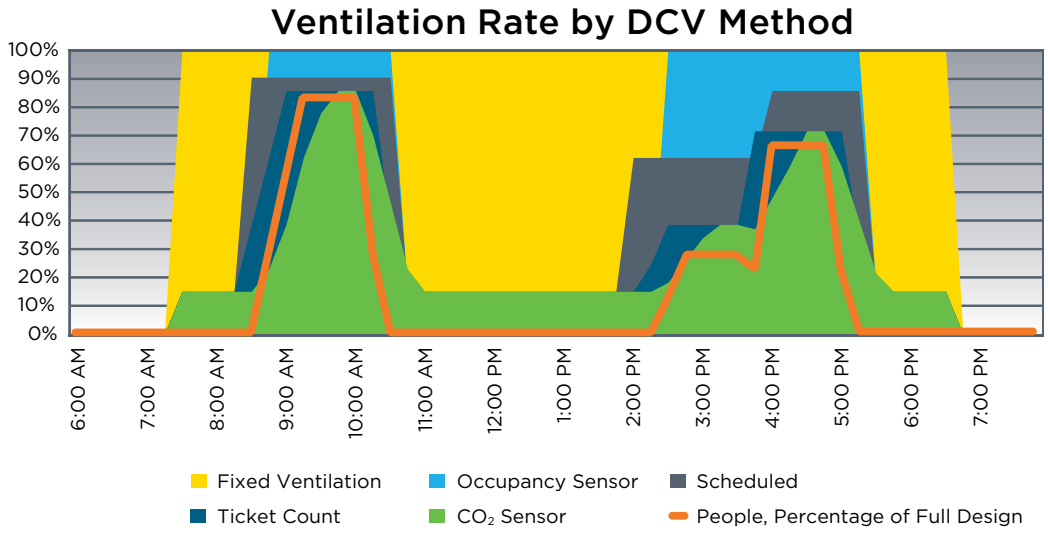

Figure 1. Ventilation rates provided with fixed ventilation and DCV alternatives

CODE NOTES

2012 IECC

Demand Control Ventilation *(Continued)*

Notice that all DCV methods have reduced ventilation and save energy compared with a fixed ventilation approach. The occupancy sensor saves the least energy, but is less expensive to install. CO_2 sensors have a slight lag in ventilation because the CO_2 levels in the space take a short time to build up. This is allowed under ventilation codes and is not a problem for air quality because the volume of air in the space provides a buffer and the CO_2 sensor DCV system continues ventilation after the space is vacated, restoring the buffer.

Plan Check

1. Determine which spaces require DCV. Table 1 provides steps through the review logic.
2. For those spaces, verify that the system is equipped with a DCV system in the schedules on the plans or in the specifications.
3. Verify that the sequence of operation for systems serving those spaces requires a reduction in ventilation rate when the space is unoccupied.

Inspection

1. Verify field installation of CO_2 sensor in the space or return air duct for CO_2 systems; verify the controls are set up for other DCV approaches.
2. Where commissioning; testing, adjusting, and balancing (TAB); or acceptance testing are required, review commissioning and setup information for DCV controls. There should be a listing of area and full (or minimum and maximum) ventilation in the TAB or commissioning report for zones where DCV is required.

2012 IECC

Demand Control Ventilation *(Continued)*

Table 1. Demand control ventilation review steps

Step	Verification Procedure (for each space)	90.1 -2010 Limit	2012 IECC Limit	Result
1	Review the list of high-density occupancies in Table 2 and note if any are present at the site.			
2	For the spaces identified in Step 1, do any have default occupant density above the limit stated?	>40 people/ 1,000 ft^2	≥25 people/ 1,000 ft^2	
3	For ASHRAE Standard 90.1 compliance, the requirement is related to design occupancy, not default occupancy. If design information is provided in the ventilation calculations or on the plans, use that density rather than the default from ASHRAE Standard 62.1-2010 or the 2012 IMC.	>40 people/ 1,000 ft^2 design		
4	Note any spaces from above that are larger than the area threshold.	>500 ft^2	>500 ft^2	
5	If the spaces that pass Steps 1-4 have DCV indicated, the check is complete; if not, check requirements and exceptions below.			
6	Does the system serving the space meet one of the three alternative requirements?	a. an air-side economizer b. automatic modulating control of the OSA damper c. design OSA > 3,000 cfm		
7	If a space **without** DCV has one of the requirements (Step 6) and meets Steps 1-4, then verify that one of the exceptions is met.			
7a	The system has an energy recovery system meeting:	6.5.6.1	C403.2.6	
7b	Multiple-zone systems without direct digital control of individual zones communicating with a central control panel.			
7c	Systems with a design outdoor airflow less than 1,200 cfm.			
7d	Spaces where the supply airflow rate minus any makeup or outgoing transfer air requirement is less than 1,200 cfm.			
7e	Ventilation is provided for process loads only.	n/a		
8	If the space passes Steps 1-6 and none of the exceptions apply, DCV is required.			

CODE NOTES

2012 IECC

Demand Control Ventilation *(Continued)*

Code Citation

ANSI/ASHRAE/IES Standard 90.1-2010*

6.4.3.9 Ventilation Controls for High-Occupancy Areas

Demand control ventilation (DCV) is required for spaces larger than 500 ft^2 and with a design occupancy for ventilation of greater than 40 people per 1000 ft^2 of floor area and served by systems with one or more of the following:

a. an air-side economizer,
b. automatic modulating control of the outdoor air damper,

or

c. a design outdoor airflow greater than 3000 cfm.

Exceptions:

a. Systems with the exhaust air energy recovery complying with Section 6.5.6.1.
b. Multiple-zone systems without DDC of individual zones communicating with a central control panel.
c. Systems with a design outdoor airflow less than 1200 cfm.
d. Spaces where the supply airflow rate minus any makeup or outgoing transfer air requirement is less than 1200 cfm.

2012 International Energy Conservation Code**

C403.2.5.1 Demand Controlled Ventilation

Demand control ventilation (DCV) shall be provided for spaces larger than 500 square feet (50 m^2) and with an average occupant load of 25 people per 1000 square feet (93 m^2) of floor area (as established in Table 403.3 of the International Mechanical Code) and served by systems with one or more of the following:

1. An air-side economizer;
2. Automatic modulating control of the outdoor air damper;

or

3. A design outdoor airflow greater than 3,000 cfm (1400 L/s).

Exception: Demand control ventilation is not required for systems and spaces as follows:

1. Systems with energy recovery complying with Section C403.2.6.
2. Multiple-zone systems without direct digital control of individual zones communicating with a central control panel.
3. System with a design outdoor airflow less than 1,200 cfm (600 L/s).
4. Spaces where the supply airflow rate minus any makeup or outgoing transfer air requirement is less than 1,200 cfm (600 L/s).
5. Ventilation provided for process loads only.

Occupant Density Reference

Table 2 lists the default occupant densities by occupancy category from the 2012 IMC and ASHRAE Standard 62.1-2010 for high-density occupancies. Greyed areas are blank where the category exists in one ventilation standard and not the other. Greyed areas with numbers show the values from separate “referred to” or similar category groups in the same standard.

2012 IECC

Demand Control Ventilation *(Continued)*

Table 2. 2012 IMC and ASHRAE Standard 62.1-2010 high-occupant density spaces

Default Occupant Density from the 2012 IMC and ASHRAE Standard 62.1-2010	Occupant Density People/1,000 ft²	
Occupancy Category	2012 IMC	ASHRAE 62.1-2010
Correctional facilities		
Cells	25	25
Dining halls (see food and beverage service)	100	100
Day room	30	30
Booking/waiting	50	50
Dry cleaners, laundries		
Commercial dry cleaner	30	
Storage, pickup	30	
Education		
Auditoriums	150	150
Media center	25	25
Music/theater/dance	35	35
Smoking lounges	70	
Day care (through age 4)	25	25
Classrooms (ages 5-8)	25	25
Classrooms (age 9 plus)	35	35
Lecture classroom	65	65
Lecture hall (fixed seats)	150	150
Science laboratories	25	25
Computer lab	25	25
Multiuse assembly	100	100
Food and beverage service		
Bars, cocktail lounges	100	100
Cafeteria, fast food	100	100
Dining rooms	70	70
General		
Break rooms (except office)		25
Conference/meeting	50	50
Hotels, motels, resorts, and dormitories*		
Multipurpose assembly	120	120
Conference/meeting	50	50
Gambling casinos	120	120
Lobbies/pre-function	30	30

*Hotel values missing from 2012 IMC table 403.3, so 2009 IMC values shown.

2012 IECC

Demand Control Ventilation *(Continued)*

Default Occupant Density from the 2012 IMC and ASHRAE Standard 62.1-2010	Occupant Density People/1,000 ft²	
Occupancy Category	2012 IMC	ASHRAE 62.1-2010
Offices		
Break rooms		50
Conference rooms	50	50
Reception areas	30	30
Telephone/data entry	60	60
Public spaces		
Auditoriums	150	150
Smoking lounges	70	
Places of religious worship	120	120
Courtrooms	70	70
Legislative chambers	50	50
Museums (children's)	40	40
Museums/galleries	40	40
Retail stores, sales floors, and showroom floors		
Mall common areas	40	40
Smoking lounges	70	
Specialty shops		
Barber	25	25
Beauty and nail salons	25	25
Sports and amusement		
Disco/dance floors	100	100
Bowling alleys (seating areas)	40	40
Spectator areas	150	150
Health club/aerobics room	40	40
Theaters		
Auditoriums (see Education)	150	150
Lobbies	150	150
Stages, studios	70	70
Ticket booths	60	
Transportation		
Platforms	100	
Transportation waiting	100	100

Demand Control Ventilation *(Continued)*

References

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