Colorado Springs Utilities
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White Paper #17

Demand Controlled Ventilation

For buildings with large and variable occupancy, this may be for you.
By bringing in only enough outside air as is needed, the energy to heat and cool that air will be reduced proportionally.

Ventilation requirements vary with building type and use of the indoor space. Sometimes, ventilation is required solely to replace the exhausted air, or is used as the only source of cooling in a hot area. Sometimes ventilation is used to dilute a flammable agent to reduce the chance of fire, or to dilute a chemical sufficiently to create a safe working environment. For any of these cases, Demand Controlled Ventilation (DCV) does not apply.

But there are lots of buildings that house mostly people, lights, and computers. In these buildings, often the primary source of indoor pollution is the people. People breathe, people sweat, people eat their lunch, people track in dust, etc. Without some ventilation to dilute the indoor air, the air would quickly become stale and unpleasant. From the air we breathe, we take the oxygen; so another need for building ventilation is to replenish oxygen by pumping in outside air. From our metabolism our bodies create carbon dioxide and expel it through our lungs, so another use for building ventilation is to remove CO2 and replace it with outside air. Of the three people-related factors (odors, oxygen, and CO2), the first indicator to be noticed in a building without adequate ventilation is usually odors. Smells become offensive to us long before shortage of oxygen or excess buildup of CO2 occurs.

ASHRAE 62 “Standard for Acceptable Indoor Air Quality” is the de facto standard for ventilation recommendations in the United States. The prescriptive portion of this ASHRAE Standard lays down ventilation requirements in terms of Cubic Feet per Minute (CFM) of outside air Per Person. Tables in the standard give these CFM per Person values for many applications, including office buildings, hotels, shopping malls, and a host of other categories. And herein lies the impetus for DCV. Without knowing how many people are in a building at any given time, the designers will normally specify the outside air intake rates to be at a value corresponding to the expected maximum value of people. So, when the building is “at capacity” and full of people, it is properly ventilated.

But what about when the building is only half full? Or 25 percent full? What then? Using the worst-case values for ventilation, most buildings will be over-ventilated except when at design occupancy. By sensing the number of people, it is possible to automatically adjust the ventilation to suit, thereby keeping the ventilation just right; avoiding wasteful over-ventilation.

Ventilation air is cheap, but the energy to heat, cool, humidify, or de-humidify it can be very costly. In Colorado Springs, heating is the big concern for ventilation costs. Cooling is minimal, dehumidification is rare, humidification is rare. For a typical office building in Colorado Springs providing ventilation for occupants from 6am-6pm daily , the cost to heat the ventilation air is about $8.00 per year per occupant.** This may not sound like much, but it adds up quickly in large buildings that are full of people.

** = Using April 2005 gas costs, approximately $0.90 per therm.

When can DCV work for you?
Here are some basic criteria:
Must be accepted by the local building department. Some allow it, some don't. You'll need to ask.

- Ventilation rates for people must dominate exhaust make-up
- Must have people as the primary source of pollution.
- Must have highly variable occupancy.
- Must be sufficiently large to warrant the cost of the technology it takes to make it work.
- The area being controlled should be served by a single HVAC system, corresponding to that area, otherwise multiple sensors and additional complexity in control logic will be required, increasing the DCV implementation cost.

How does it work?
Where people are driving the need for ventilation, the key is to know how many people there are in a given area. It is an easy enough concept, but counting people is not easy to do automatically. Some theatres report using ticket sales to gage people counts, which seems very reasonable. But other than that, the "automatic people counter" device is elusive. Turnstiles are an absolute turn off. What can work is a CO2 detector. Since the more people there are, the more metabolism is going on and the more CO2 will start to build-up. This is an indirect measurement, but is the accepted method of a 'pseudo-people counter' that is in use today. An automatic control system looks at CO2 and increases ventilation as it rises – or more importantly ***reduces*** ventilation as it falls, based on the assumption that less CO2 means less people.

Some examples of DCV candidates:

- Theatre
- Ballroom
- Meeting Room
- Convention Center
- Shopping Mall
- Church
- Assembly Area

What are the savings?
The easy answer is "it depends." But with a little discussion, and the chart at the end of this paper, you should be able to determine your approximate savings potential from DCV. The initial assumption is that the existing condition is already ventilating at the prescribed rate for the maximum design-number of people. We should point out that this is not always a good assumption. Many buildings are not being ventilated at the prescribed rates, for one reason or another. For example, it is common to find outside air dampers closed or intake louvers boarded shut; often done as an energy savings measure. While this will immediately reduce utility costs, it is obviously not recommended. The point is to be sure of the baseline ventilation use, to avoid over-stating the savings of DCV. If the outside air intake is already too low, the DCV will not reduce it further, and may increase energy cost.

Watch-Outs:

1. Demand Controlled Ventilation is an Engineered Solution. That means it is strongly advised that a qualified engineer verify the application and design. Ventilation rates affect other systems, including pre-heating, VAV box minimums, exhaust and building pressurization. Changes to ventilation rates cannot be done in a vacuum. For DCV success, these other system parameters need to be considered and kept in balance.

2. Many commercial grade CO2 sensors "drift" out of calibration, causing the ventilation rates to be as inaccurate as the sensor. Buying sensors with a guaranteed "1 percent per year drift maximum" means you can set and forget it for about five years before re-calibration.
3. Attempting to control CO2 from a return air plenum can give false readings, especially if the plenum serves multiple areas. Just because the "average" conditions are satisfied for ventilation, there can still be pockets of high occupancy that are under-ventilated.

Demand Controlled Ventilation Annual Savings Matrix

Assumptions:
Colorado Springs area
6am-6pm operation
No humidification or dehumidification
Cooling season savings neglected.
20 cfm per person
$0.90 per therm (~~approximate 2005 gas rates~~)
$8.00 Annual Cost per person per year heating cost for ventilation air

Note: for this chart, "Diversity" means the time-weighted ratio of average-to-maximum occupancy. For example, a 25% diversity means that the annual average people density during occupied times is 25% of maximum.

		Diversity			
		25%	**50%**	**75%**	**100%**
# of people	**100**	$600	$400	$200	$0
	200	$1,200	$800	$400	$0
	300	$1,800	$1,200	$600	$0
	400	$2,400	$1,600	$800	$0
	500	$3,000	$2,000	$1,000	$0