Demand Control Ventilation

Design & Technology Series #20

Fig. 1: Why fully ventilate a half empty room?

What is Demand Control Ventilation?

All buildings, and spaces within them, experience fluctuations in occupancy throughout the day. To optimize energy efficiency, ventilation strategies have been developed to respond to these variations. ASHRAE Standard 90.1 defines Demand Control Ventilation (DCV) as:

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.

Differences between Standard 90.1 and NECB

Standard 90.1 includes a mandatory provision for DCV in high occupancy spaces. In contrast, the Canadian National Energy Code for Buildings (NECB) has only allowed energy savings from DCV to be claimed since 2017. This delay was due to the uncertainty on whether the projected savings were reflective of actual operation. As noted in A-8.4.3.(1) of the NECB regarding outdoor air:

"…Only demand control ventilation strategies that are known to reliably generate energy savings should be modeled, and this, in such a way as to avoid overestimating those savings."

The limitation has been reflected in the significant changes in ASHRAE documentation since 2016, aimed at clarifying industry understanding.

Industry Understanding of ASHRAE Standard 62.1

Standard 62.1 outlines the ventilation requirements based on the need to remove airborne contaminates that impact air quality. The requirements separate the occupant-based ventilation and area-based ventilation to address the different sources of contaminants.

From 1981 to 2016, Informative Appendix D of Standard 62.1 included a sample calculation for an open office space that resulted in a 700 ppm carbon dioxide (CO_2) setpoint. However, this value was often misapplied to all space types, leading ASHRAE to remove the appendix in Addendum d to Standard 62.1-2016:

"The committee is aware of misuse and confusion caused by the information in its present form and prefers to delete this misused appendix [for] now."

In its place, ASHRAE Guideline 36-2018 included the calculated CO_2 setpoints for different space types. The maximum CO_2 in Guideline 36-2018 is set at 90% of the steady state concentrations calculated as per the ASHRAE Journal, December 2008 (Volume 50, Issue 12).

Due to inconsistent industry knowledge of the Guideline 36, ASHRAE adopted Addendum ab to Standard 62.1-2022, incorporating CO_2 setpoints rounded to the nearest 300 ppm.

The Technical Design Requirements for Alberta Infrastructure Facilities (TDR) now reference Addendum ab to Standard 62.1-2022.

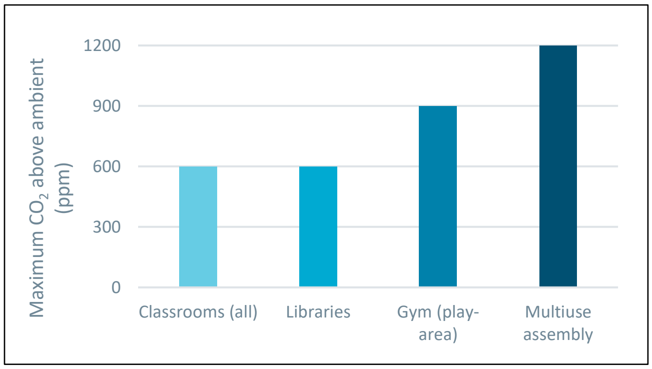

Fig. 2: Example space types for school projects. The CO_2 setpoints are from Addendum ab to Standard 62.1-2022, Table 6-1.

Design Considerations

Air Changes Per Hour

Air changes per hour (ACH) impact the feeling of comfort of occupants in a space. The TDR includes ACH rates for space types, distinct from Standard 62.1 ventilation rate requirements. Note that Standard 62.1-2019 clarifies locally recirculated air must be "treated" within the space.

(ACH) Refers to total mechanical air circulation provided to a space. May be comprised of outdoor air, return air or transferred air. Outdoor air for ventilation must be provided per applicable codes.

The TDR ACH requirements assume full occupancy. For DCV systems, the ACH can be reset in parallel to the outdoor air rates based on the CO_2 controls.

AHU System Selection

The type of air handling system affects how DCV can be implemented:

100% Outdoor Air Systems
These systems are often sized to maximize free cooling. This is a limiting factor for the effectiveness of DCV.

- The system fans and variable air volume (VAV) boxes have a limited turn-down ratio. The minimum fan speed is often the limiting factor in the minimum outdoor air rates possible.
- Meeting the TDR ACH requirements can lead to over-ventilation of spaces, resulting in an energy penalty.

Mixed Air Systems
The implementation of DCV in mixed air systems is more complicated for both design and system controls. ASHRAE acknowledged this through Research Projects 1547, 1747, and 1819.

- The "critical zone" in a mixed air system determines the fraction of outdoor air required for the system as a whole. An unbalanced design will result in significant over-ventilation of remaining zones.

While Guideline 36-2024 offers enhanced control strategies, it does not fully integrate findings from ASHRAE research project RP-1747.

Energy Management Control System

The implementation of effective controls is of ever greater importance due to the complexity of DCV systems.

- Standard 62.1-2022 addendum ab allows a fixed assumption of 400 ppm for outdoor CO_2, eliminating the need for outdoor CO_2 sensors.
- Guideline 36-2024 allows for the automatic background calibration of CO_2 space sensors. This may be limited during winter if purge mode is unavailable.
- The maximum ventilation rate is not required to exceed the Standard 62.1 calculated rates. The reset implemented should limit the maximum ventilation rate.

Energy Modeling Checks

When modeling DCV in energy compliance software, ensure the following:

- The minimum fan turndown should not be assumed. This must be based on system design limitations, accounting for system sizing of the AHU and the VAV box schedule.
- The appropriate occupancy schedules in the NECB should be used.
- The occupancy densities used in the Standard 62.1 calculations are to be adjusted where design occupancy is known.

Over-ventilation Penalty for Energy Models
Per Standard 90.1 Appendix G, if the design ventilation rate exceeds code minimums, the baseline must be modeled to the code minimum.

Further Considerations

There is further understanding and research on the impact of the CO_2 levels on occupant health and well-being. The Leadership in Energy and Environmental Design (LEED) rating system promotes increased ventilation, awarding credit for up to 30% above the minimum rates. However, this increased ventilation includes a significant energy penalty, even with advanced heat recovery systems. These are decisions that must be identified early in the design process.

Fig. 3: Health and well-being of occupants is becoming an increased focus in the ventilation of spaces.

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