ADDENDA

ASHRAE Addendum q to
ASHRAE Guideline 36-2021

High-Performance Sequences of Operation for HVAC Systems

Approved by ASHRAE on August 30, 2024.

This addendum was approved by a Standing Guideline Project Committee (SGPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the guideline. Instructions for how to submit a change can be found on the ASHRAE® website (www.ashrae.org/continuous-maintenance).

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FOREWORD

Note: In this addendum, changes to the current guideline are indicated in the text by underlining (for additions) and strikethrough (for deletions) unless the instructions specifically mention some other means of indicating the changes. Only these changes are open for review and comment at this time. Additional material is provided for context only and is not open for comment except as it relates to the proposed substantive changes.

The current CO_2 demand controlled ventilation calculation for zones complying with Standard 62.1 Ventilation Rate Procedure (VRP) was modeled after California Title 24 language where ventilation does not start to increase until CO_2 concentration is within 200 ppm of the maximum CO_2 limit, which typically is the setpoint included in Informative Table 3.1.1.3. But while this approach is consistent with the Title 24 ventilation rate calculation method which uses the larger of the occupant- and area-based components, it is not consistent with Standard 62.1 VRP for which the room ventilation rate, Voz, is equal to the sum of the two components. With the VRP, zone ventilation must be increased right when zone CO_2 concentration exceeds ambient, and when the maximum CO_2 limit is reached, the zone ventilation rate must be the design rate calculated in accordance with Standard 62.1 when the space is fully occupied.

This addendum also eliminates Table 3.1.1.3 Standard 62.1 CO_2 setpoints and instead directs the designer to use the maximum CO_2 differential now included in Standard 62.1 Table 6-1 per addendum ab to the 2022 version (https://www.ashrae.org/file%20library/technical%20resources/standards%20and%20guidelines/standards%20addenda/62_1_2022_ab_20231031.pdf).

Note that the SGPC expects to develop further CO_2 DCV addenda regarding multiple zone recirculating systems based on ASHRAE Research Projects 1547, 1747, and 1819.

This addendum also changes the term CO_2 "setpoint" to CO_2 "maximum" to match Standard 62.1 addendum ab and associated addendum o to Standard 90.1-2022. The term "setpoint" in the context of controls implies that the controlled variable, CO_2 concentration in this case, can oscillate around this value using control logic such as proportional + integral logic. But these CO_2 values are actually limits that the control system must always maintain space concentration to be at or below. This is true for both Title 24 and Standard 62.1 procedures. This is the reason why P-only logic is used for CO_2 DCV – it ensures zone ventilation is at its design maximum when the CO_2 maximum is reached.

Another change is to break out the ambient CO_2 concentration to readily allow the option of using ambient CO_2 sensors, although that is not generally recommended as indicated in the informative text herein. This also allows the ΔCO_2 values from code to be used without making the designer add the ambient value.

Addendum q to Guideline 36-2021

(IP and SI Units)

Modify Section 3.1.1.3 as follows:

3.1.1.3. CO_2 ~~Setpoints~~Maximum Concentration

Space CO2 ~~setpoints~~ sensors are used for demand-controlled ventilation (DCV) as required by energy standards such as ASHRAE Standard 90.1 and California Title 24, ~~and~~ as well as for indoor air quality monitoring/alarming as required by LEED and other green building standards.

It is the designer's responsibility to determine maximum ΔCO_2 ~~CO2 setpoints~~, the maximum difference between zone and ambient CO_2 concentration. The maximum ~~setpoint~~ varies ~~by~~ depending on the applicable ventilation standard, ~~Some guidance is provided below for~~ Standard 62.1 and Title 24. The designer may also decide to set lower, more conservative setpoints for improved indoor air quality but at the expense of higher energy use.

For Standard 62.1, ΔCO_2 maximums vary by occupancy type and design occupant density, so the easiest way to include this info is by including a column in VAV box and SZ unit schedules and entering the setpoint individually for each zone.

For both Standard 62.1 and Title 24, ambient CO_2 concentration (Camb) may be determined with ambient CO_2 sensors but is allowed to be assumed to be 400 ppm for the following reasons:

- *400 ppm is conservative from a ventilation standpoint since few areas have consistently lower average ambient concentrations.*
- *Using a fixed value avoids the first cost and recurring calibration costs of an ambient CO_2 sensor.*
- *Automatic Background Calibration (ABC) logic, which is very commonly used with commercial CO_2 sensors to automatically maintain calibration, uses 400 ppm as the ambient concentration targeted by the logic, so ambient concentration is effectively indicated as 400 ppm regardless of actual ambient concentration. Therefore, when CO_2 sensors with ABC logic are used, ambient concentration should always be assumed to be 400 ppm.*

The engineer must select between ventilation logic options:

If the project is to comply with ASHRAE Standard 62.1 ventilation requirements, keep subsection (a) and delete subsection (b).

If the project is to comply with California Title 24 ventilation requirements, keep subsection (b) and delete subsection (a).

~~*Standard 62.1 CO2 Setpoint Guidance*~~

a. Standard 62.1 Maximum CO_2 Concentration

1. For each zone, maximum ΔCO_2 concentration, ΔC

The ΔC value must include the occupancy density adjustment per Standard 62.1, where applicable.

2. Ambient CO2 concentration, Camb = 400 ppm

If an ambient CO_2 sensor is installed, Camb will be an analog input point rather than a fixed value.

~~*Recommended maximum CO2 is 90% of the steady state concentration per Lawrence[1]:*~~

~~1. Source: Lawrence, T. 2008. Selecting CO2 criteria for outdoor air monitoring. ASHRAE Journal 50(12).~~

$$CO_2 setpoint = 0.9\left(C_{OA} + \frac{8400 E_z m}{R_p + \frac{R_a A_z}{P_z}}\right)$$

where COA is the outdoor air CO2 concentration in ppm, Ez is the zone ventilation effectiveness, m is the metabolic rate of occupants, Rp is the people-based component of the ventilation rate, Ra is the area-based component of the ventilation rate, Az is the zone floor area, and Pz is the number of occupants.

See ASHRAE Standard 62.1-2022 Addendum ab for maximum CO_2 concentration above ambient (ΔCO_2) for each occupancy type. These are not repeated here to avoid conflicts with future Standard 62.1 revisions.

The CO2 setpoints in Informative Table 3.1.1.3 assume an ambient concentration of 400 ppm in lieu of using an ambient CO2 sensor. These sequences are based on not having an ambient sensor. This will be conservative in areas with high ambient CO2 concentrations; few areas have lower concentrations.

Setpoints vary by occupancy type, so the easiest way to include this info is by including a column in VAV box and SZ unit schedules and entering the setpoint individually for each zone.

Demand controlled ventilation (DCV) is an active area of research under ASHRAE RP-1747, "Implementation of RP-1547 CO2 Based Demand Controlled Ventilation for Multiple Zone HVAC Systems in Direct Digital Control Systems."

Informative Table 3.1.1.3 Default CO_2 Setpoints per ASHRAE Standard 62.1

Occupancy Category	*CO_2 Setpoint (ppm)*	*Occupancy Category*	*CO_2 Setpoint (ppm)*
Correctional Facilities		*Office Buildings*	
Cell	*965*	*Office Space*	*894*
Dayroom	*1,656*	*Reception Areas*	*1,656*
Guard Stations	*1,200*	*Telephone/Data Entry*	*1,872*
Booking/Waiting	*1,200*	*Main Entry/Lobbies*	*1,391*
Educational Facilities		*Miscellaneous Spaces*	
Day Care (Through Age 4)	*1,027*	*Bank Vaults/Safe Deposit*	*805*
Day Care Sickroom	*716*	*Computer (Not Printing)*	*738*
Classrooms (Age 5—8)	*864*	*Pharmacy (Preparation Area)*	*820*
Classrooms (Age 9+)	*942*	*Photo Studios*	*983*
Lecture Classroom	*1,305*	*Transportation Waiting*	*1,305*
Lecture Hall (Fixed Seats)	*1,305*	*Public Assembly Spaces*	
Art Classroom	*837*	*Auditorium Seating Area*	*1,872*
Science Laboratories	*894*	*Place of Religious Worship*	*1,872*
University/College Lab	*894*	*Courtrooms*	*1,872*
Wood/Metal Shop	*1,156*	*Legislative Chambers*	*1,872*
Computer Lab	*965*	*Libraries*	*805*
Media Center	*965*	*Lobbies*	*2,628*
Music/Theater/Dance	*1,620*	*Museums (Children's)*	*1,391*
Multiuse Assembly	*1,778*	*Museum/Galleries*	*1,620*
Food and Beverage Service		*Retail*	
Restaurant Dining Rooms	*1,418*	*Sales (Except Below)*	*1,069*
Cafeteria/Fast-Food Dining	*1,536*	*Mall Common Areas*	*1,620*

~~Occupancy Category~~	~~CO_2 Setpoint (ppm)~~	~~Occupancy Category~~	~~CO_2 Setpoint (ppm)~~
~~Bars, Cocktail Lounges~~	~~1,536~~	~~Barbershop~~	~~1,267~~
~~General~~		~~Beauty and Nail Salons~~	~~723~~
~~Break Rooms~~	~~1,267~~	~~Pet Shops (Animal Areas)~~	~~709~~
~~Coffee Stations~~	~~1,185~~	~~Supermarket~~	~~1,116~~
~~Conference/Meeting~~	~~1,620~~	~~Coin-operated Laundries~~	~~1,322~~
~~Hotels, Motels, Resorts, Dormitories~~		~~Sports and Entertainment~~	
~~Bedroom/Living Area~~	~~910~~	~~Spectator Areas~~	~~1,778~~
~~Barracks Sleeping Areas~~	~~1,116~~	~~Disco/Dance Floors~~	~~1,440~~
~~Laundry Rooms, Central~~	~~1,249~~	~~Health Clubs/Aerobics Room~~	~~1,735~~
~~Laundry Within Dwelling~~	~~983~~	~~Health Clubs/Weight Room~~	~~1,232~~
~~Lobbies/Prefunction~~	~~1,494~~	~~Bowling Alley (Seating)~~	~~1,232~~
~~Multipurpose Assembly~~	~~2,250~~	~~Gambling Casinos~~	~~1,368~~
		~~Game Arcades~~	~~894~~
		~~Stages, Studios~~	~~1,391~~

~~*California Title 24 CO2 Setpoint Guidance*~~

b. Title 24 Maximum CO2 Concentration

1. For each zone, maximum ΔCO_2 concentration, ΔC = 600 ppm

Title 24 stipulates the setpoint for all occupancies must be 600 ppm above ambient. ~~*Ambient concentration may be assumed to be 400 ppm, or an ambient sensor may be provided. These sequences are currently based on not having an ambient sensor, so the CO2 setpoint for all occupancy types is 1000 ppm.*~~

2. Ambient CO_2 concentration, Camb = 400 ppm

If an ambient CO_2 sensor is installed, Camb will be an analog input point rather than a fixed value.

Modify Section 5.2.1.3f.4, which applies to systems complying with Standard 62.1, as follows:

4. If the zone has a CO_2 sensor:

   i. See Section ~~3.1.1.2.b.3~~3.1.1.3.a for ~~CO_2 setpoints~~maximum CO_2 concentration above ambient, ΔC, and ambient CO_2 concentration, Camb.

   ii. Cmax = ΔC + Camb

   iii. During Occupied Mode, a P-only loop shall ~~maintain~~ limit CO_2 concentration ~~at setpoint~~to Cmax; loop output shall range ~~reset~~ from 0% at ~~setpoint~~ Camb ~~minus 200 PPM and~~ proportionally up to 100% at ~~setpoint~~Cmax.

   iv. Loop is disabled and output set to zero when the zone is not in Occupied Mode.

CO_2 DCV is ~~not yet~~ well defined for Standard 62.1 since Addendum ab was adopted for single zone and 100% outdoor air systems, but it is not well defined for multiple zone recirculating systems. For those systems, Addendum ab includes

an exception that states "Other DCV control logic shall be permitted to be used where it can be demonstrated to comply with Section 6.2.6.1.1 under all expected operating conditions." Examples are the results of RP-1747 and RP-1819 which include detailed Standard 62.1 compliant DCV sequences for single duct recirculating systems, and for systems with multiple recirculation paths (e.g. fan-powered boxes), respectively. These sequences require additional sensors and are very complex, so they have not yet been adopted into Guideline 36 verbatim. ~~is under way and should provide a detailed procedure.~~ In the meantime, sequences have been included at the zone level that mimic the SOOs from these research projects as well as ~~, matching~~ California's DCV approach as a first step. Because outdoor air rates at the AHU level dynamically calculate outdoor air rates using the Standard 62.1 multiple-spaces procedure, compliance with the standard is assured. Doing no DCV at all is not an option, because it is required by Standard 90.1 ~~2016~~.

Modify Section 5.2.1.4d.3, which applies to systems complying with California Title 24, as follows:

3. If the zone has a CO_2 sensor:

   i. See Section ~~3.1.1.2.b.3~~ 3.1.1.3.b for ~~CO_2 setpoints~~ maximum CO_2 concentration above ambient, ΔC, and ambient CO_2 concentration, Camb~~.~~

   ii. Cmax = ΔC + Camb

   iii. During Occupied Mode, a P-only loop shall ~~maintain~~ limit CO_2 concentration ~~at setpoint~~to Cmax; ~~reset~~ loop output shall range from 0% at ~~setpoint~~ (Cmax minus 200 PPM) ~~and~~ proportionally up to 100% at ~~setpoint~~Cmax.

Modify Section 5.2.3 as follows:

5.2.3. Zone Alarms

5.2.3.1. For zones with CO_2 sensors:

a. If the CO_2 concentration is less than 300 ppm, or the zone is in Unoccupied Mode for more than 2 hours and zone CO_2 concentration exceeds 600 ppm, generate a Level 3 alarm. The alarm text shall identify the sensor and indicate that it may be out of calibration.

b. If the CO_2 concentration exceeds ~~setpoint~~ Cmax plus 10% for more than 10 minutes, generate a Level 3 alarm.

Note that in some cases, alarms may be generated that do not necessarily indicate an indoor air quality problem or noncompliance with Standard 62.1. Cmax determined in accordance with Standard 62.1, including occupancy density adjustment, also depends on activity level, gender, body mass, and age. The CO_2 values in Table 6-1 of Standard 62.1 are based on assumptions of these values that are typical of the occupancy type. The activity level (met) has the greatest impact to the steady state CO_2 values. It is therefore possible that the differential CO_2 values in the space may exceed the concentrations listed in Table 6-1 even if the occupancy density and the ventilation rate meet the values listed in Table 6-1.

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ASHRAE is concerned with the impact of its members' activities on both the indoor and outdoor environment. ASHRAE's members will strive to minimize any possible deleterious effect on the indoor and outdoor environment of the systems and components in their responsibility while maximizing the beneficial effects these systems provide, consistent with accepted Standards and the practical state of the art.

ASHRAE's short-range goal is to ensure that the systems and components within its scope do not impact the indoor and outdoor environment to a greater extent than specified by the Standards and Guidelines as established by itself and other responsible bodies.

As an ongoing goal, ASHRAE will, through its Standards Committee and extensive Technical Committee structure, continue to generate up-to-date Standards and Guidelines where appropriate and adopt, recommend, and promote those new and revised Standards developed by other responsible organizations.

Through its *Handbook*, appropriate chapters will contain up-to-date Standards and design considerations as the material is systematically revised.

ASHRAE will take the lead with respect to dissemination of environmental information of its primary interest and will seek out and disseminate information from other responsible organizations that is pertinent, as guides to updating Standards and Guidelines.

The effects of the design and selection of equipment and systems will be considered within the scope of the system's intended use and expected misuse. The disposal of hazardous materials, if any, will also be considered.

ASHRAE's primary concern for environmental impact will be at the site where equipment within ASHRAE's scope operates. However, energy source selection and the possible environmental impact due to the energy source and energy transportation will be considered where possible. Recommendations concerning energy source selection should be made by its members.

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