

DOCKETED

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Nonresidential Indoor Air Quality

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Building Standards Development Office

Efficiency Division

Pre-Rulemaking Workshop

Hearing Room B

June 6th, 2017



Acknowledgements

California Utilities Statewide Codes and
Standards Team

and

CASE Authors

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Ventilation and Indoor Air Quality (IAQ)

Purpose

- Dilute contaminants
- Ventilation rates address occupant bioeffluents and space building materials/equipment/furniture





Ventilation and Indoor Air Quality (IAQ)

California Air Resources Board (CARB) concluded in 2005 that impact of indoor air pollutions on health was far greater than outdoor pollutants

- Causal link between indoor air pollutants and:
 - Asthma
 - Cancer
 - Sick Building Syndrome (SBS)
 - Respiratory disease
 - Work loss and reduced productivity
 - Lung damage
 - Breathing difficulties
 - Nausea
 - Tremors
 - Drowsiness
 - Dizziness
 - Impacts to neurodevelopmental outcomes in unborn children
 - Dermal allergic sensitization
 - Headaches



Ventilation and Indoor Air Quality (IAQ)

Numerous studies have documented the health, productivity, and economic benefits of improving indoor air quality.

- Potential productivity gains from improved IAQ are orders of magnitude greater than the increased equipment and operating costs (Fisk, 1999)
- Lower ventilation rates results in decreases in decision making (Maddalena et al, 2014)
- When CO₂ concentrations increase to 3,000 ppm, mental tasks require more effort and capacity to concentrate attention declines (Kajtar, Herczeg, 2011)



Background

The Energy Commission has the expressed authority to regulate indoor air quality (IAQ)

The ventilation rates in Title 24, Part 6 Code)

- Unchanged since 1992
- Limited occupancies
- do not address exhaust or makeup air
- Minimum ventilation rate for supply only

STANDARDS / REGULATIONS

ENERGY EFFICIENCY STANDARDS FOR
RESIDENTIAL AND
NONRESIDENTIAL BUILDINGS



JULY 1999
CALIFORNIA
ENERGY
COMMISSION

Gray Davis, Governor

#405-99-001



Background

The California Mechanical Code, Title 24, Part 4 (CMC)

- ASHRAE 62.1
- Requirements for supply, exhaust and make-up air
- Many occupancies

2016 California Mechanical Code



California Code of Regulations
Title 24, Part 4

California Building
Standards Commission

Based on 2015 Uniform Mechanical Code®



Effective January 1, 2017

For Errata and Supplement effective
dates see the History Note Appendix



Background

- Industry confusion
 - Which code to follow
 - CASE Team survey

1.1.7 Order of Precedence and Use.

1.1.7.1 Differences. In the event of any differences between these building standards and the standard reference documents, the text of these building standards shall govern.

1.1.7.2 Specific Provisions. Where a specific provision varies from a general provision, the specific provision shall apply.

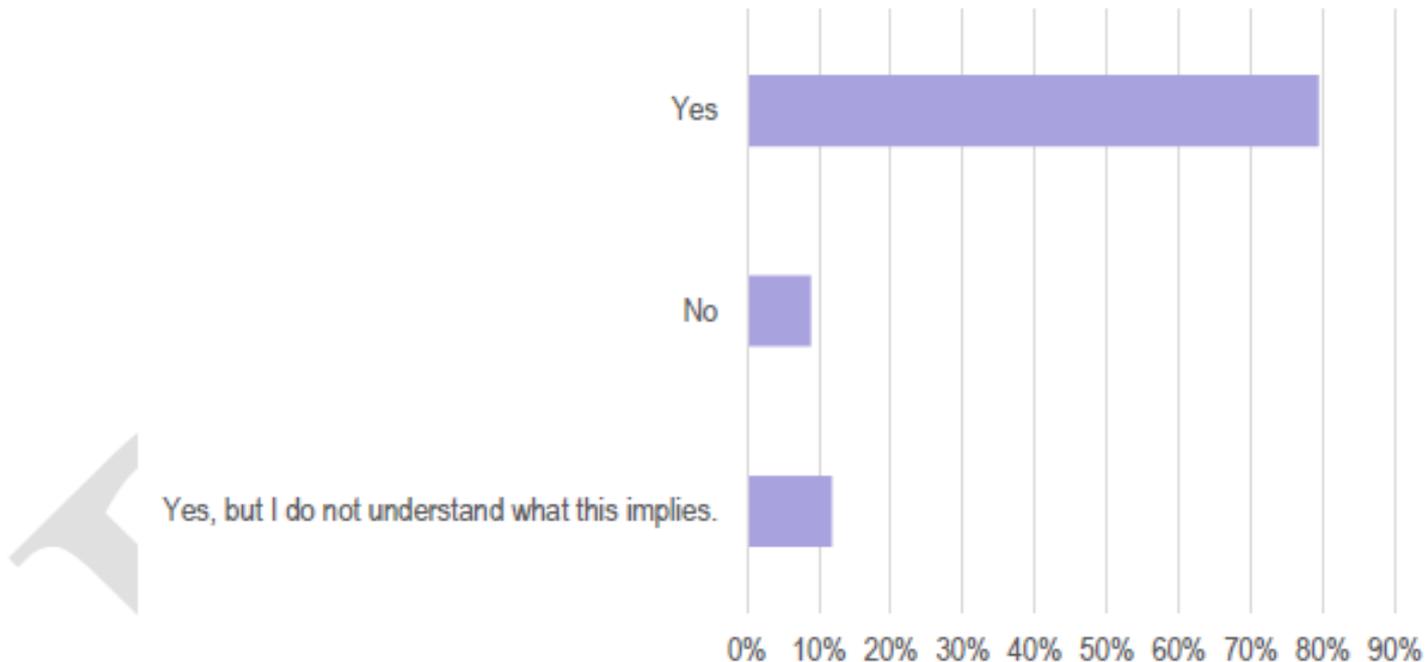
1.1.7.3 Conflicts. When the requirements of this code conflict with the requirements of any other part of the California Building Standards Code, Title 24, the most restrictive requirements shall prevail.

1402.1 General Requirements. *[Not permitted for OSHPD 1, 2, 3 & 4] Occupiable spaces listed in Table 402.1 shall be designed to have ventilation (outdoor) air for occupants in accordance with this chapter. Ventilation air supply requirements for occupancies regulated by the California Energy Commission are found in the California Energy Code.*



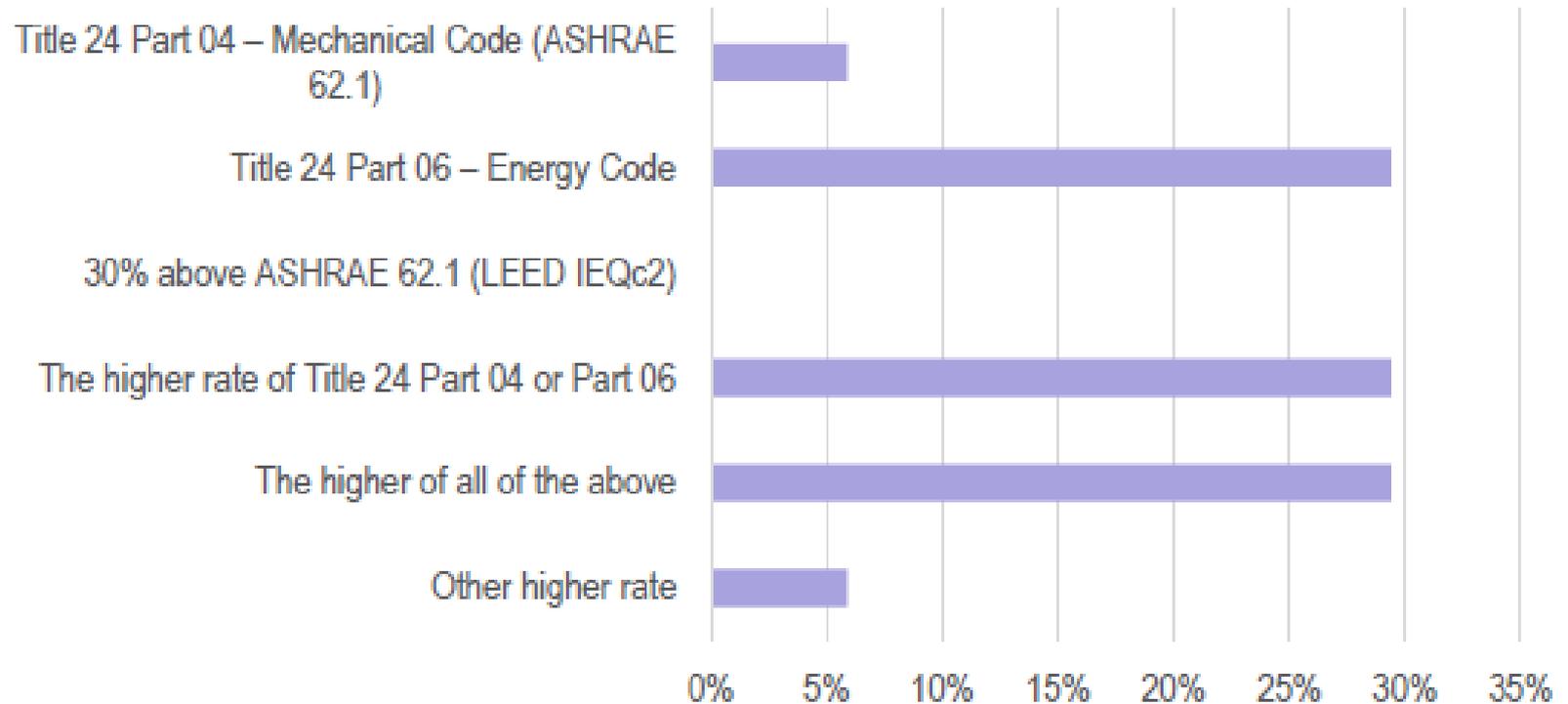
Question 1. Are you familiar with the code section 402.1 from Title 24, Part 4 – Mechanical Code, which states that "ventilation air supply requirements for occupancies regulated by the California Energy Commission are found in the California Energy Code"?

402.1 General Requirements. [Not permitted for OSHPD 1, 2, 3 & 4] Occupiable spaces listed in Table 402.1 shall be designed to have ventilation (outdoor) air for occupants in accordance with this chapter. *Ventilation air supply requirements for occupancies regulated by the California Energy Commission are found in the California Energy Code.*



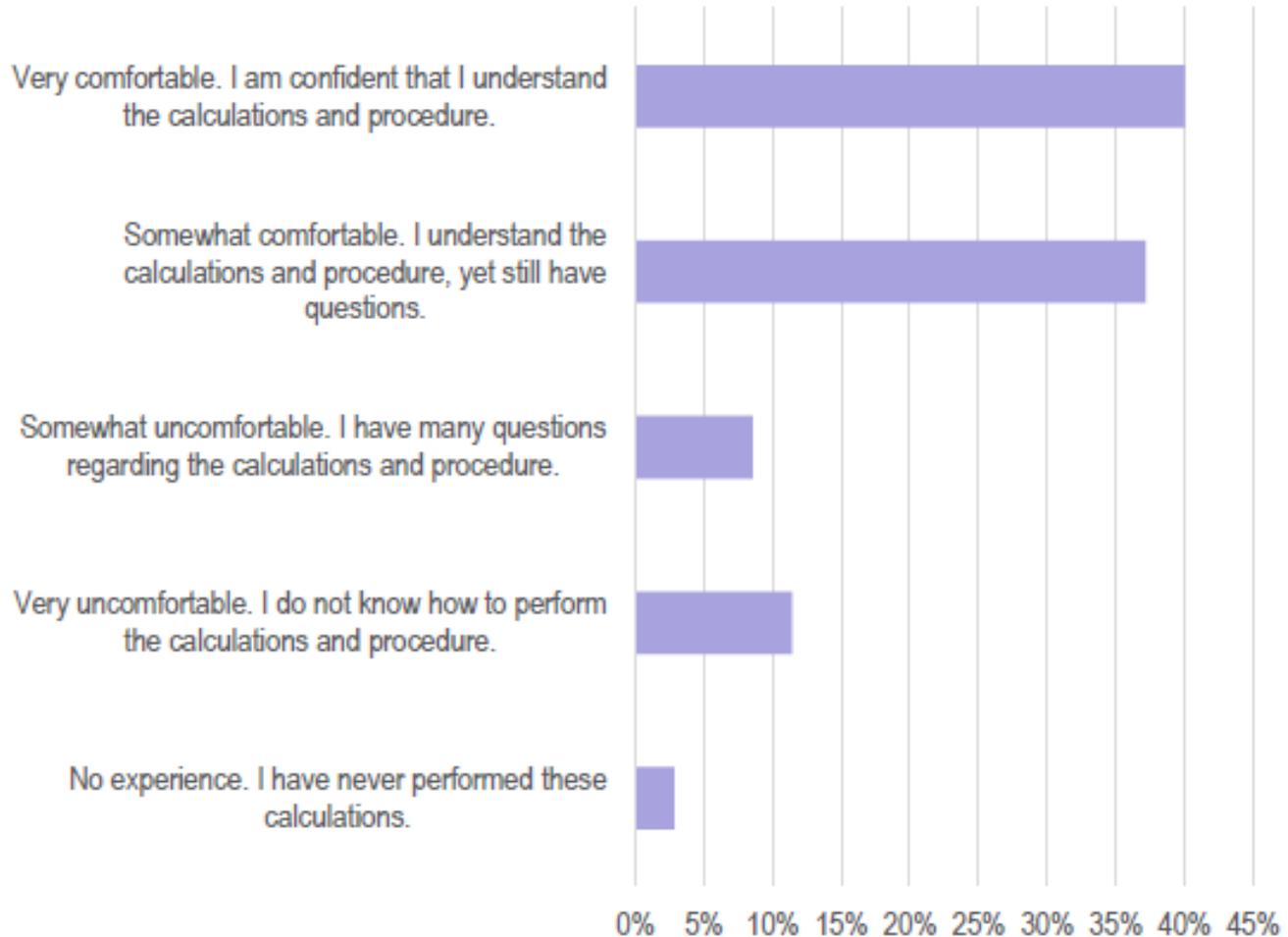


Question 2. Which ventilation air supply rate calculations do you (or your firm) currently design to for permitting?





Question 3. How comfortable are you with the Title 24, Part 4 – Mechanical Code (ASHRAE 62.1) ventilation rate procedure for multi-zone systems, including the “multiple spaces equation”?





CASE Team Proposal

Alignment of ventilation and indoor air quality requirements found in ASHRAE 62.1.

- Update the minimum ventilation rates for all Title 24, Part 6 nonresidential occupancy categories
- Harmonize with the full VRP found in ASHRAE 62.1 (including requirements for multiple zone recirculating systems)
- Revise requirements for natural ventilation
- Revise requirements for outdoor air treatment
- Move requirements for exhaust ventilation from Title 24, Part 4 to Title 24, Part 6



CASE Team Proposal

Update the minimum ventilation rates for all Title 24, Part 6 nonresidential occupancy categories

- Expand Title 24, Part 6 Table 120.1-A to include and specify ventilation rates for all Title 24, Part 6 occupancy categories, aligning with 130% of the ASHRAE 62.1 ventilation rates



CASE Team Proposal

Harmonize with the full VRP found in ASHRAE 62.1
(including the requirements for multiple zone recirculating systems)

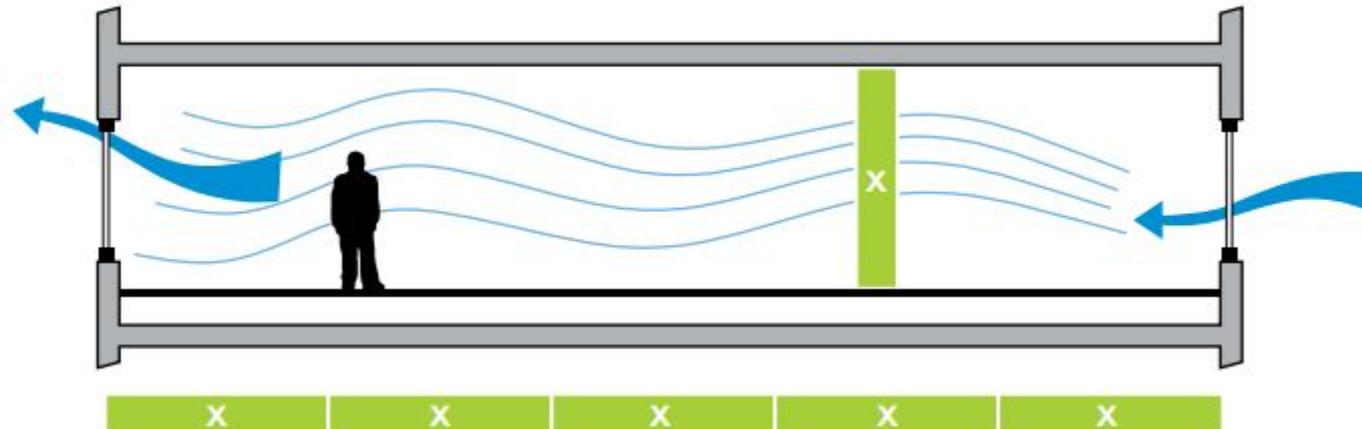
- Calculates ventilation rate as the sum of the ventilation required to control both people-related sources and building-related sources
- Accounts for ventilation efficiencies for zone air distribution and at the system level for multiple zone recirculating systems



CASE Team Proposal

Revise requirements for natural ventilation

- Include calculation that establishes floor area allowed to be naturally ventilated based on the size and types of openings
- Requires that a mechanical ventilation system still be installed
 - Multiple exceptions
- Allows a greater floor area of the building to be naturally ventilated (without mechanical ventilation) compared to Title





CASE Team Proposal

Revise requirements for outdoor air treatment

- Require outdoor air treatment of particulate matter (PM) if regional and/or local air quality where building is located is above threshold concentrations
 - MERV 13 for PM_{2.5}
 - There are existing filtration requirements in Title 24, Part 11 (CALGreen) for MERV 8 filters.

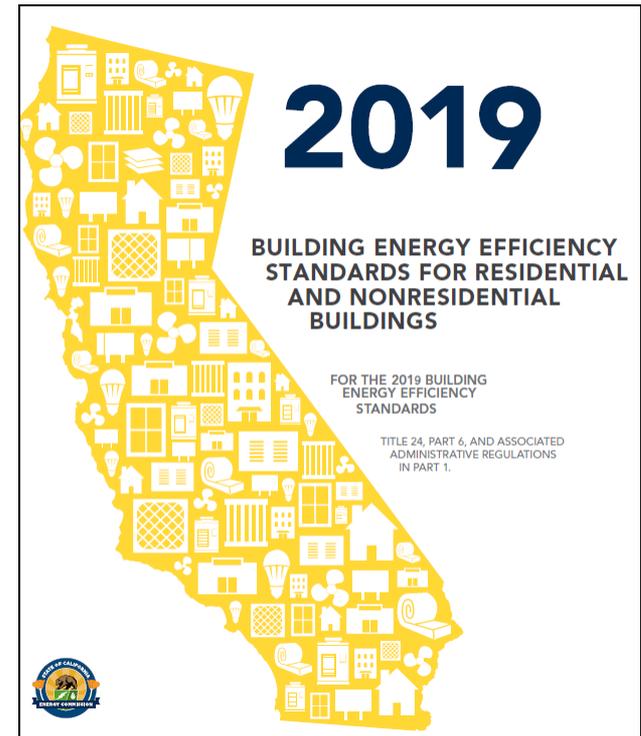




CASE Team Proposal

Move requirements for exhaust ventilation from Title 24, Part 4 to Title 24, Part 6

- Incorporate requirements for exhaust ventilation from ASHRAE 62.1 Section 6.5.1





CEC Staff Recommendation

Differences from CASE Team Proposal

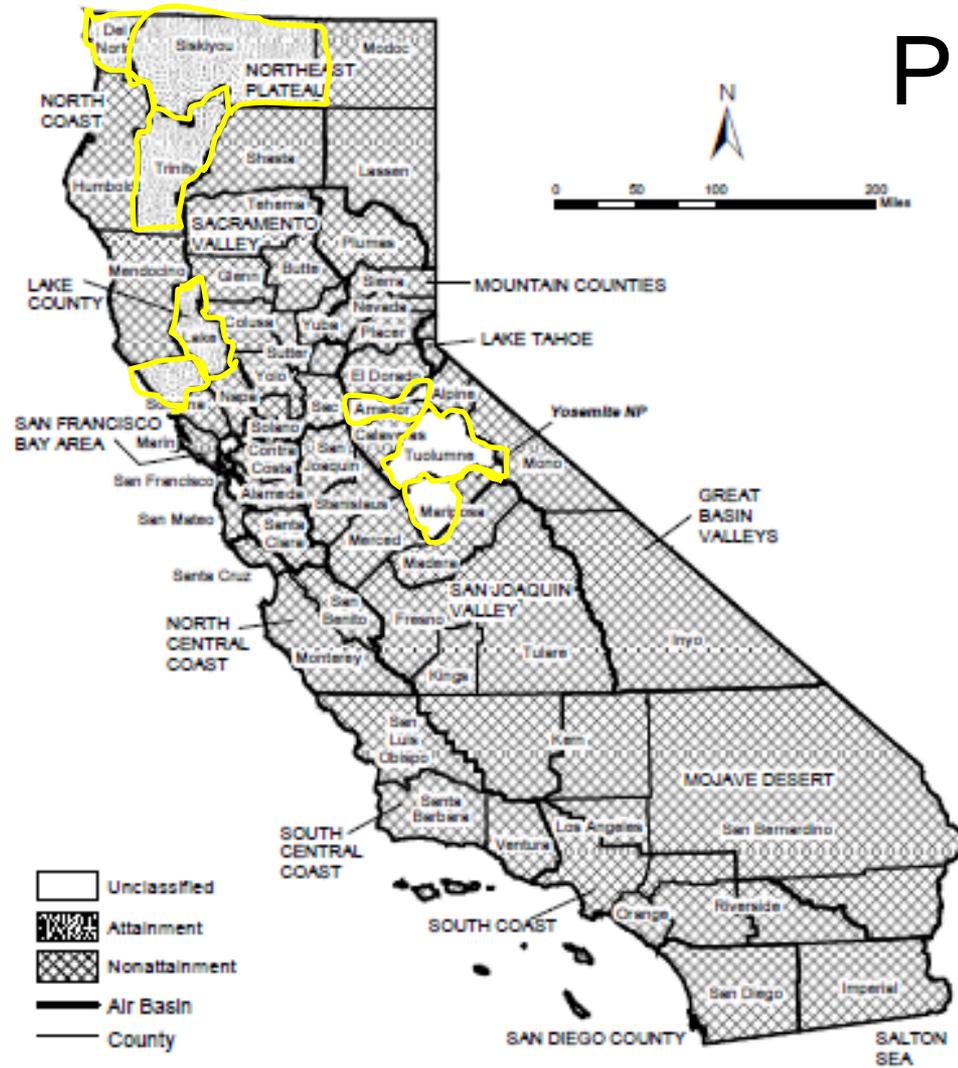
- Single outdoor air treatment requirement (MERV 13)
 - Simplifies enforcement
 - Will benefit most of the State
 - No Regional/Local air quality survey





CALIFORNIA ENERGY COMMISSION

PM10





MERV Table From ASHRAE 52.2

Standard 52.2 Minimum Efficiency Reporting Value (MERV)	Composite Average Particle Size Efficiency, % in Size Range, μm			
	Range 1 0.30 to 1.0	Range 2 1.0 to 3.0	Range 3 3.0 to 10.0	Average Arrestance, %
1	N/A	N/A	$E_3 < 20$	$A_{avg} < 65$
2	N/A	N/A	$E_3 < 20$	$65 \leq A_{avg}$
3	N/A	N/A	$E_3 < 20$	$70 \leq A_{avg}$
4	N/A	N/A	$E_3 < 20$	$75 \leq A_{avg}$
5	N/A	N/A	$20 \leq E_3$	N/A
6	N/A	N/A	$35 \leq E_3$	N/A
7	N/A	N/A	$50 \leq E_3$	N/A
8	N/A	$20 \leq E_2$	$70 \leq E_3$	N/A
9	N/A	$35 \leq E_2$	$75 \leq E_3$	N/A
10	N/A	$50 \leq E_2$	$80 \leq E_3$	N/A
11	$20 \leq E_1$	$65 \leq E_2$	$85 \leq E_3$	N/A
12	$35 \leq E_1$	$80 \leq E_2$	$90 \leq E_3$	N/A
13	$50 \leq E_1$	$85 \leq E_2$	$90 \leq E_3$	N/A
14	$75 \leq E_1$	$90 \leq E_2$	$95 \leq E_3$	N/A
15	$85 \leq E_1$	$90 \leq E_2$	$95 \leq E_3$	N/A
16	$95 \leq E_1$	$95 \leq E_2$	$95 \leq E_3$	N/A



CEC Staff Recommendation

Differences from CASE Team Proposal

- Considering an exception to the ventilation adjustment factor of 1.3 for select systems including:
 - Systems with an air economizer and DCV; or
 - Dedicated Outdoor Air Systems (DOAS); or
 - Where the ventilation rate would be less than current



CEC Staff Recommendation

Differences from CASE Team Proposal

- Considering a simplified multi-zone calculation method depending on the outcome of the summer ASHRAE meeting;



CEC Staff Recommendation

Intent on changing language in the CMC

401.0 General.

401.1 Applicability. This chapter contains requirements for ventilation air supply, exhaust, and makeup air requirements for occupiable spaces within a building.

Ventilation air requirements for occupancies regulated by the California Energy Commission are specified in the California Energy Code. {OSHPD J, 2, 3 & 4/ See Sections 404.0 through 418.0. {SFMJ Air filters shall comply with all requirements of Part 12. Title 24. Chapter 12- 71, SFM Standard 12-71-1.

402.0 Ventilation Air. *[Not permitted for OSHPD I. 2. 3 & 4)*

402.1 Occupiable Spaces. *[Not permitted for OSHPD I. 2. 3 & 4) Occupiable spaces listed in Table 402. 1 s hall be designed to have ventilation (outdoor) air for occupants in accordance with this chapter. ~~Ventilation air supply requirements for occupancies regulated by the California Energy Commission are found in the California Energy Code.~~*



Proposed Language

SECTION 120.1 – REQUIREMENTS FOR VENTILATION

Spaces intended for human occupancy within nonresidential, high-rise residential, and hotel/motel buildings shall comply with the requirements of Section 120.1(a) through 120.1(g).

EXCEPTION to Section 120.1: Spaces within dwelling units in residential occupancies in which occupants are nontransient shall comply with Section 150.0(o).

a) General Requirements.

1. All enclosed spaces in a building shall be ventilated in accordance with the requirements of this section and the California Building Code.

EXCEPTION to Section 120.1(a)1: Refrigerated warehouses and other spaces or buildings that are not normally used for human occupancy and work.

2. The outdoor air-ventilation rate and air-distribution assumptions made in the design of the ventilating system shall be clearly identified on the plans required by Section 10-103 of Title 24, Part 1.

~~b) Outdoor air quality shall be investigated in accordance with 120.1(b)1-2 prior to completion of ventilation system design. The results of this investigation shall be documented in accordance with 120.1(b)3.~~

~~1. Regional Air Quality. The status of compliance with national ambient air quality standards shall be determined for the geographic area of the building site. Compliance status shall be either in "attainment" or "nonattainment" with the National Ambient Air Quality Standards. Areas with no U.S. Environmental Protection Agency (USEPA) compliance status designation shall be considered "attainment" areas.~~

~~2. Local Air Quality. An observational survey of the building site and its immediate surroundings shall be conducted~~

SECTION 100.1 – DEFINITIONS AND RULES OF CONSTRUCTION

AIR, AMBIENT is the air surrounding a building; the source of outdoor air brought into a building.

AIR, EXHAUST air removed from a space and discharged to outside the building by means of mechanical or natural ventilation systems.

AIR, INDOOR is the air in an enclosed occupiable space.

AIR, MAKEUP is any combination of outdoor and transfer air intended to replace exhaust air and exfiltration.

AIR, OUTDOOR is ambient air and ambient air that enters a building through a ventilation system, through intentional openings for natural ventilation, or by infiltration.

AIR, PRIMARY is air supplied to the ventilation zone prior to mixing with any locally recirculated air.

AIR, RECIRCULATED is air removed from a space and reused as supply air.

AIR, RETURN is air removed from a space to be recirculated or exhausted.

AIR, SUPPLY is air delivered by mechanical or natural ventilation to a space and composed of any combination of outdoor air, recirculated air, or transfer air.

AIR, TRANSFER is air moved from one indoor space to another.

AIR, VENTILATION is that portion of supply air that is outdoor air plus any recirculated air that has been treated for the purpose of maintaining acceptable indoor air quality.

BREATHING ZONE is the region within an occupied space between planes 3 and 72 in. (75 and 1800 mm) above the floor and more than 2 ft (600 mm) from the walls or fixed air-conditioning equipment.

~~**COGNIZANT AUTHORITY** is an agency or organization that has the expertise and jurisdiction to establish and regulate concentration limits for airborne contaminants, or an agency or organization that is recognized as authoritative and has the scope and expertise to establish guidelines, limit values, or concentrations levels for airborne contaminants.~~

CONCENTRATION is the quantity of one constituent dispersed in a defined amount of another.

CONTAMINANT is an unwanted airborne constituent with the potential to reduce acceptability of the air.

CONTAMINANT MIXTURE is two or more contaminants that target the same organ system.

INDUSTRIAL SPACE is an indoor environment where the primary activity is production or manufacturing processes.

MECHANICAL VENTILATION is ventilation provided by mechanically powered equipment such as motor-driven fans and blowers but not by devices such as wind-driven turbine ventilators and mechanically operated windows.

NATURAL VENTILATION is ventilation provided by thermal, wind, or diffusion effects through doors, windows, or other intentional openings in the building.

NET OCCUPIABLE AREA is the floor area of an occupiable space defined by the inside surfaces of its walls but excluding shafts, column enclosures, and other permanently enclosed, inaccessible, and unoccupiable areas. Obstructions in the space, such as furnishings, display or storage racks, and other obstructions, whether temporary or permanent, are considered to be part of the net occupiable area.

NONTRANSIENT is occupancy of a dwelling unit or sleeping unit for more than 30 days. **ODOR** is a quality of gases, liquids, or particles that stimulates the olfactory organ **UNOCCUPIED MODE** is when a zone is not scheduled to be occupied.

VENTILATION is the process of supplying air to or removing air from a space for the purpose of controlling air contaminant levels, humidity, or temperature within the space.

VENTILATION, ZONE is any indoor area that requires ventilation and comprises one or more spaces with the same occupancy category, occupant density, zone air distribution effectiveness, and design zone primary airflow per unit area.

VOLUME, SPACE is the total volume of an occupiable space enclosed by the building envelope, plus that of

any spaces permanently open to the occupiable space, such as a ceiling attic used as a ceiling return plenum.

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2. The outdoor air-ventilation rate and air-distribution assumptions made in the design of the ventilating system shall be clearly identified on the plans required by Section 10-103 of Title 24, Part 1.

~~b) **Outdoor air quality** shall be investigated in accordance with 120.1(b)1-2 prior to completion of ventilation system design. The results of this investigation shall be documented in accordance with 120.1(b)3~~

~~1. **Regional Air Quality.** The status of compliance with national ambient air quality standards shall be determined for the geographic area of the building site. Compliance status shall be either in “attainment” or “nonattainment” with the National Ambient Air Quality Standards. Areas with no U.S. Environmental Protection Agency (USEPA) compliance status designation shall be considered “attainment” areas.~~

~~2. **Local Air Quality.** An observational survey of the building site and its immediate surroundings shall be conducted during hours the building is expected to be normally occupied to identify local contaminants from surrounding facilities that will be of concern if allowed to enter the building.~~

~~3. **Documentation.** Documentation of the outdoor air quality investigation shall be reviewed with building owners or their representative and shall include the following as a minimum:~~

~~A. **Regional air quality compliance status**~~

~~B. **Local survey information** (Date of observations, Time of observations, Site description, Description of facilities on site and on adjoining properties, Observation of odors or irritants, Observation of visible plumes or visible air contaminants, Description of sources of vehicle exhaust on site and on adjoining properties, Identification of potential contaminant sources on the site and from adjoining properties, including any that operate only seasonally)~~

~~C. **Conclusion** regarding the acceptability of outdoor air quality and the information supporting the conclusion~~

~~e)b) **Outdoor Air Treatment.** In addition to meeting Title 24, Part 11 MERV 8 filter requirements listed in Section 5.504.5.3, each ventilation system that provides outdoor air through a supply fan shall comply with the following:~~

EXCEPTION to Section 120.1(b): Systems supplying air for enclosed parking garages, warehouses, storage rooms, janitor’s closets, trash rooms, recycling areas, shipping/receiving/distribution areas.

1. **Particulate Matter Smaller than 2.5 Micrometers (PM_{2.5}).** In buildings located in an area where the national standard or guideline for PM_{2.5} is exceeded, particle filters or air-cleaning devices shall be provided to clean the outdoor air at any location prior to its introduction to occupied spaces. Particulate matter filters or air cleaners shall have an efficiency reporting value (MERV) of not less than 13.

~~e)c) **Design Requirements for Minimum Quantities of Outdoor Air.** Every space in a building shall be designed to have outdoor air ventilation according to Item (1) or (2) below:~~

1. **Natural ventilation.** Natural ventilation systems shall be designed in accordance with this section and shall include mechanical ventilation systems designed in accordance with Section 120.1(c)2.

EXCEPTION 1 to Section 120.1(c)1: The mechanical ventilation systems shall not be required where natural ventilation openings that comply with the requirements of Section 120.1(c)1 are permanently open or have controls that prevent the openings from being closed during periods of expected occupancy

EXCEPTION 2 to Section 120.1(c)1: The mechanical ventilation systems shall not be required where the zone is not served by heating or cooling equipment.

A. **Floor Area to Be Ventilated.** Spaces, or portions of spaces, to be naturally ventilated shall be located within a

distance based on the ceiling height, as determined by Sections 120.1(c)1.A.i-iii, from operable wall openings that meet the requirements of Section 120.1(c)1.B. For spaces with ceilings that are not parallel to the floor, the ceiling height shall be determined in accordance with Section 120.1(c)1.A.iv.

- i. **Single Side Opening.** For spaces with operable openings on one side of the space, the maximum distance from the operable openings shall be not more than $2H$, where H is the ceiling height.
- ii. **Double Side Opening.** For spaces with operable openings on two opposite sides of the space, the maximum distance from the operable openings shall be not more than $5H$, where H is the ceiling height.
- iii. **Corner Openings.** For spaces with operable openings on two adjacent sides of a space, the maximum distance from the operable openings shall be not more than $5H$ along a line drawn between the two openings that are farthest apart. Floor area outside that line shall comply with Section 120.1(c)1.A.iv.
- iv. **Ceiling Height.** The ceiling height (H) to be used in Sections 120.1(c)1Ai-iii shall be the minimum ceiling height in the space.

EXCEPTION to 120.1(c)1Aiv: For ceilings that are increasing in height as distance from the openings is increased, the ceiling height shall be determined as the average height of the ceiling within 20 ft from the operable openings.

- B. **Location and Size of Openings.** Spaces or portions of spaces to be naturally ventilated shall be permanently open to operable wall openings directly to the outdoors. The open- able area shall be not less than 4% of the net occupiable floor area. Where openings are covered with louvers or otherwise obstructed, openable area shall be based on the net free unobstructed area through the opening. Where interior rooms, or portions of rooms, without direct openings to the outdoors are ventilated through adjoining rooms, the opening between rooms shall be permanently unobstructed and have a free area of not less than 8% of the area of the interior room or less than 25 ft².
 - C. **Control and Accessibility.** The means to open required operable openings shall be readily accessible to building occupants whenever the space is occupied. Controls shall be designed to coordinate operation of the natural and mechanical ventilation systems.
2. **Mechanical ventilation.** Each space that is not naturally ventilated under 120.1(c)1 above shall be ventilated with a mechanical system capable of providing an outdoor air intake flow (V_{ot}) rate in accordance with the following sections: no less than the larger of:
- A. **Zone Calculations.** Ventilation zone parameters shall be determined in accordance with Sections 120.1(c)2 for ventilation zones served by the ventilation system.
 - B. **Breathing Zone Outdoor Airflow.** The outdoor airflow required in the breathing zone (V_{bz}) of the occupiable space or spaces in a ventilation zone shall be not less than the value determined in accordance with EQUATION 120.1-A.

$V_{bz} = 1.3 \times (R_p \times P_z + R_a \times A_z)$ (EQUATION 120.1-A) WHERE:

V_{bz} = volume of ventilation air required to be delivered to the breathing zone

R_p = outdoor airflow rate required per person as determined from Table 120.1-A

P_z = design zone population, the peak number of people in the ventilation zone during typical use. For spaces without fixed seating, the expected number of occupants shall be either the expected number specified by the building designer or one half of the maximum occupant load assumed for egress purposes in the CBC, whichever is greater. For spaces with fixed seating, the expected number of occupants shall be determined in accordance with the CBC

R_a = outdoor airflow rate required per unit area as determined from Table 120.1-A

A_z = zone floor area, the net occupiable floor area of the ventilation zone, ft²

- i. **Zone Air Distribution Effectiveness.** The zone air distribution effectiveness (E_z) shall be not greater than the default value determined using Table 120.1-B
- ii. **Zone Outdoor Airflow.** The zone outdoor air- flow (V_{Oz}) provided to the ventilation zone by the supply air distribution system shall be determined in accordance with Equation 120.1-B.

$$\underline{V_{OZ}} = \underline{V_{bz}}/E_z \quad \text{(EQUATION 120.1-B)}$$

- C. **Single-Zone Systems.** For ventilation systems wherein one or more air handlers supply a mixture of outdoor air and recirculated air to only one ventilation zone, the outdoor air intake flow ($\underline{V_{Ot}}$) shall be determined in accordance with EQUATION 120.1-C.

$$\underline{V_{Ot}} = \underline{V_{OZ}} \quad \text{(EQUATION 120.1-C)}$$

- D. **100% Outdoor Air Systems.** For ventilation systems wherein one or more air handlers supply only outdoor air to one or more ventilation zones, the outdoor air intake flow ($\underline{V_{Ot}}$) shall be determined in accordance with EQUATION 120.1-D.

$$\underline{V_{Ot}} = \sum_{\text{all zones}} \underline{V_{OZ}} \quad \text{(EQUATION 120.1-D)}$$

- E. **Multiple-Zone Recirculating Systems.** For ventilation systems wherein one or more air handlers supply a mixture of outdoor air and recirculated air to more than one ventilation zone, the outdoor air intake flow ($\underline{V_{Ot}}$) shall be determined in accordance with Sections 120.1(c)2Ei-iv

- i. **Primary Outdoor Air Fraction.** Primary outdoor air fraction ($\underline{Z_{pZ}}$) shall be determined for ventilation zones in accordance with EQUATION 120.1-E.

$$\underline{Z_{pZ}} = \underline{V_{OZ}}/\underline{V_{pZ}} \quad \text{(EQUATION 120.1-E)}$$

where

$\underline{V_{pZ}}$ is the zone primary airflow to the ventilation zone, including outdoor air and recirculated air.

For VAV-system design purposes, $\underline{V_{pZ}}$ is the lowest zone primary airflow value expected at the design condition analyzed

- ii. **System Ventilation Efficiency.** The system ventilation efficiency ($\underline{E_v}$) shall be determined in accordance with TABLE 120.1-C.
- iii. **Uncorrected Outdoor Air Intake.** The uncorrected outdoor air intake ($\underline{V_{Ou}}$) flow shall be determined in accordance with EQUATION 120.1-F

$$\underline{V_{Ou}} = D \sum_{\text{all zones}} (\underline{R_p} \times \underline{P_z}) + \sum_{\text{all zones}} (\underline{R_a} \times \underline{A_z}) \quad \text{(EQUATION 120.1-F)}$$

The occupant diversity ratio (D) shall be determined in accordance with Equation 120.1-G to account for variations in population within the ventilation zones served by the system.

$$D = \underline{P_s} / \sum_{\text{all zones}} \underline{P_z} \quad \text{(EQUATION 120.1-G)}$$

WHERE

$\underline{P_s}$ = design system population, the largest (peak) number of people expected to occupy all ventilation zones served by the ventilation system during use.

- iv. **Outdoor Air Intake.** The design outdoor air intake flow ($\underline{V_{Ot}}$) shall be determined in accordance with EQUATION 120.1-H.

$$\underline{V_{Ot}} = \underline{V_{Ou}}/\underline{E_v} \quad \text{(EQUATION 120.1-H)}$$

- F. **Multiple-Zone Systems.** This section presents an alternative procedure for calculating the system ventilation efficiency ($\underline{E_v}$) where values in TABLE 120.1-C are not used. $\underline{E_v}$ is equal to the lowest calculated value of the zone ventilation efficiency $\underline{E_{vz}}$, as shown below:

$$\underline{E_v} = \text{minimum} (\underline{E_{vz}}) \quad \text{(EQUATION 120.1-I)}$$

- i. **Average Outdoor Air Fraction.** The average outdoor air fraction ($\underline{X_s}$) for the ventilation system shall be calculated using EQUATION 120.1-J

$$\underline{X_s} = \underline{V_{Ou}} / \underline{V_{ps}} \quad \text{EQUATION 120.1-J}$$

The uncorrected outdoor air intake ($\underline{V_{Ou}}$) shall be determined in accordance with Section 120.1(c)2Eiv, and the system primary airflow ($\underline{V_{ps}}$) shall be determined at the condition analyzed.

- ii. **Zone Ventilation Efficiency.** The zone ventilation efficiency shall be calculated using section 120.1(c)2F1 or 120.1(c)2F2

1. **Single Supply Systems.** EQUATION 120.1-K shall be used for “single supply” systems, where all the ventilation air is a mixture of outdoor air and recirculated air from a single location (e.g. reheat, single-duct VAV, single-fan dual-duct, and multizone).

$$E_{vz} = 1 + X_s - Z_{pz} \text{ (EQUATION 120.1-K)}$$

2. **Secondary Recirculation Systems.** EQUATION 120.1-L shall be used for systems that provide all or part of their ventilation by recirculating air from other zones without directly mixing it with outdoor air (e.g., dual-fan dual-duct, fan-powered mixing box, and transfer fans for conference rooms).

$$E_{vz} = (F_a + X_s * F_b - Z_{pz} * E_p * F_c) / F_a \text{ (EQUATION 120.1-L)}$$

- E_p ≡ Primary air fraction to the zone: $E_p = V_{pz} / V_{dz}$ ($E_p = 1.0$ for single-duct and single-zone systems).
- E_r ≡ In systems with secondary recirculation of return air, fraction of secondary recirculated air to the zone that is representative of average system return air rather than air directly recirculated from the zone.
- F_a ≡ Fraction of supply air to the zone from sources outside the zone: $F_a = E_p + (1 - E_p) * E_r$
- F_b ≡ Fraction of supply air to the zone from fully mixed primary air: $F_b = E_p$
- F_c ≡ Fraction of outdoor air to the zone from sources outside the zone: $F_c = 1 - (1 - E_z) * (1 - E_r) * (1 - E_p)$.
- V_{dz} ≡ Zone Discharge Airflow: The expected discharge (supply) airflow to the zone that includes primary airflow and locally recirculated airflow.
- V_{ps} ≡ System Primary Airflow: The total primary airflow supplied to all zones served by the system from the air handling unit at which the outdoor air intake is located: $V_{ps} = \sum V_{pz}$
- X_s ≡ Average outdoor Air Fraction: At the primary air handler, the fraction of outdoor air intake flow in the system primary airflow: $X_s = V_{oz} / V_{ps}$.
- Z_{pz} ≡ Primary Outdoor Air Fraction required in the primary air supplied to the ventilation zone prior to the introduction of a secondary recirculation air: $Z_{pz} = V_{oz} / V_{pz}$.

- G. **Exhaust Ventilation.** The design exhaust airflow shall be determined in accordance with the requirements in Table 120.1-D. Exhaust makeup air shall be permitted to be any combination of outdoor air, recirculated air, or transfer air.

EXCEPTION to Section 120.1(c)2: Transfer air. The rate of outdoor air required by Section 120.1(b)2 may be provided with air transferred from other ventilated spaces if:

1. None of the spaces from which air is transferred have any unusual sources of indoor air contaminants;
and
2. The outdoor air that is supplied to all spaces combined, is sufficient to meet the requirements of Section 120.1(f) for each space individually.

- (b) ~~Design Requirements for Minimum Quantities of Outdoor Air.~~ Every space in a building shall be ~~designed to have outdoor air ventilation according to Item 1 or 2 below:~~

1. ~~Natural ventilation.~~

- A. ~~Naturally ventilated spaces shall be permanently open to and within 20 feet of operable wall or roof openings to the outdoors, the openable area of which is not less than 5 percent of the conditioned floor area of the naturally ventilated space. Where openings are covered with louvers or otherwise obstructed, openable area shall be based on the free unobstructed area through the opening.~~

~~**EXCEPTION to Section 120.1(b)1A:** Naturally ventilated spaces in high rise residential dwelling units and hotel/motel guest rooms shall be open to and within 25 feet of operable wall or roof openings to the outdoors.~~

- B. ~~The means to open required operable openings shall be readily accessible to building occupants whenever the space is occupied.~~

2. **Mechanical ventilation.** Each space that is not naturally ventilated under Item 1 above shall be ventilated with a mechanical system capable of providing an outdoor air rate no less than the larger of:

- A. The conditioned floor area of the space times the applicable ventilation rate from TABLE 120.1 A; or
- B. 15 cfm per person times the expected number of occupants.

For meeting the requirement in Section 120.1(b)2B for spaces without fixed seating, the expected number of occupants shall be either the expected number specified by the building designer or one-half of the maximum occupant load assumed for egress purposes in the CBC, whichever is greater. For spaces with fixed seating, the expected number of occupants shall be determined in accordance with the CBC.

EXCEPTION to Section 120.1(b)2: Transfer air. The rate of outdoor air required by Section 120.1(b)2 may be provided with air transferred from other ventilated spaces if:

- i. None of the spaces from which air is transferred have any unusual sources of indoor air contaminants; and
- ii. The outdoor air that is supplied to all spaces combined, is sufficient to meet the requirements of Section 120.1(b)2 for each space individually.

(d) Operation and Control Requirements for Minimum Quantities of Outdoor Air.

This code section is unchanged and omitted for brevity.

(e) Ducting for Zonal Heating and Cooling Units.

This code section is unchanged and omitted for brevity.

(f) Design and Control Requirements for Quantities of Outdoor Air

This code section is unchanged and omitted for brevity.

TABLE 120.1 A - MINIMUM VENTILATION RATES

TYPE OF USE	CFM PER SQUARE FOOT 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
Hotel guest rooms (less than 500 ft ²)	30 cfm/guest room
Hotel guest rooms (500 ft ² or greater)	0.15
Retail stores	0.20
All others	0.15

TABLE 120.1-A MINIMUM VENTILATION RATES

TYPE OF USE	People Outdoor Air Rate, Rp (cfm/person)	Area Outdoor Air Rate, Ra (cfm/ft²)	Occupied Standby Controls
All Others (including unleased tenant space in multi-tenant facilities)	5	0.06	
Assembly (Concentrated) - Auditorium Area	5	0.06	Y
Assembly (Concentrated) - Lobby, Main Entry	5	0.06	Y
Assembly (Concentrated) - Religious Worship Area	5	0.06	Y
Assembly (Concentrated) - Theater, Motion Picture	10	0.06	Y
Assembly (Concentrated) - Theater, Performance	10	0.06	Y
Assembly (Concentrated) - Waiting Area	7.5	0.06	

<u>Assembly (non-Concentrated) - Bar, Cocktail Lounge and Casino Areas</u>	<u>7.5</u>	<u>0.18</u>	
<u>Assembly (non-Concentrated) - Convention, Conference, Multipurpose and Meeting Center Areas</u>	<u>5</u>	<u>0.06</u>	<u>Y</u>
<u>Assembly (non-Concentrated) - Dining Area</u>	<u>7.5</u>	<u>0.18</u>	
<u>Assembly (non-Concentrated) - Exhibit, Museum Areas</u>	<u>7.5</u>	<u>0.06</u>	<u>Y</u>
<u>Assembly (non-Concentrated) - Gymnasium/Sports Arena</u>	<u>20</u>	<u>0.18</u>	
<u>Assembly (non-Concentrated) - Lounge, Recreation</u>	<u>7.5</u>	<u>0.18</u>	
<u>Auto Repair Area</u>	<u>10</u>	<u>0.18</u>	
<u>Beauty Salon Area</u>	<u>20</u>	<u>0.12</u>	
<u>Civic Meeting Place Area</u>	<u>5</u>	<u>0.06</u>	<u>Y</u>
<u>Classrooms, Lecture, Training, Vocational Areas</u>	<u>10</u>	<u>0.12</u>	
<u>Commercial and Industrial Storage Areas (conditioned or unconditioned)</u>	<u>5</u>	<u>0.06</u>	
<u>Commercial and Industrial Storage Areas (refrigerated)</u>	<u>10</u>	<u>0</u>	
<u>Computer Room (Data Center)</u>	<u>5</u>	<u>0.06</u>	<u>Y</u>
<u>Corridors, Restrooms, Stairs, and Support Areas</u>	<u>0</u>	<u>0.06</u>	<u>Y</u>
<u>Dry Cleaning (Coin Operated)</u>	<u>7.5</u>	<u>0.12</u>	
<u>Dry Cleaning (Full Service Commercial)</u>	<u>7.5</u>	<u>0.12</u>	
<u>Electrical, Mechanical, Telephone Rooms</u>	<u>5</u>	<u>0.06</u>	
<u>Exercise Room</u>	<u>20</u>	<u>0.06</u>	
<u>Financial Transaction Area</u>	<u>7.5</u>	<u>0.06</u>	<u>Y</u>
<u>Garage, Parking - Parking Garage Area Daylight Adaptation Zones</u>	<u>7.5</u>	<u>0.18</u>	
<u>Garage, Parking - Parking Garage Area Dedicated Ramps</u>	<u>7.5</u>	<u>0.18</u>	
<u>Garage, Parking - Parking Garage Building, Parking Area</u>	<u>7.5</u>	<u>0.18</u>	
<u>General Commercial and Industrial Work Areas, High Bay</u>	<u>10</u>	<u>0.06</u>	
<u>General Commercial and Industrial Work Areas, Low Bay</u>	<u>10</u>	<u>0.06</u>	
<u>General Commercial and Industrial Work Areas, Precision</u>	<u>10</u>	<u>0.06</u>	
<u>Hotels and Apartments - Hotel Function Area</u>	<u>5</u>	<u>0.06</u>	
<u>Hotels and Apartments - Hotel/Motel Guest Room</u>	<u>5</u>	<u>0.06</u>	<u>Y</u>
<u>Hotels and Apartments - Lobby, Hotel</u>	<u>7.5</u>	<u>0.06</u>	<u>Y</u>
<u>Housing, Public and Common Areas: Multi-family, Dormitory</u>	<u>0</u>	<u>0.06</u>	<u>Y</u>
<u>Housing, Public and Common Areas: Senior Housing</u>	<u>0</u>	<u>0.06</u>	<u>Y</u>
<u>Kitchen, Commercial Food Preparation</u>	<u>7.5</u>	<u>0.12</u>	
<u>Kitchenette or Residential Kitchen</u>	<u>5</u>	<u>0.12</u>	
<u>Laboratory, Equipment Room</u>	<u>5</u>	<u>0.06</u>	
<u>Laboratory, Scientific</u>	<u>10</u>	<u>0.18</u>	
<u>Laundry</u>	<u>5</u>	<u>0.12</u>	
<u>Library - Library, Reading Areas</u>	<u>5</u>	<u>0.12</u>	
<u>Library - Library, Stacks</u>	<u>5</u>	<u>0.12</u>	
<u>Locker/Dressing Room</u>	<u>7.5</u>	<u>0.12</u>	
<u>Medical and Clinical Care</u>	<u>5</u>	<u>0.06</u>	
<u>Nurseries for Children - Day Care</u>	<u>10</u>	<u>0.18</u>	
<u>Office (250 square feet in floor area or less)</u>	<u>5</u>	<u>0.06</u>	<u>Y</u>
<u>Office (Greater than 250 square feet in floor area)</u>	<u>5</u>	<u>0.06</u>	<u>Y</u>
<u>Police Station and Fire Station</u>	<u>7.5</u>	<u>0.12</u>	

<u>Retail - Grocery Sales Areas</u>	<u>7.5</u>	<u>0.06</u>	<u>Y</u>
<u>Retail - Malls and Atria</u>	<u>7.5</u>	<u>0.06</u>	<u>Y</u>
<u>Retail - Merchandise Sales, Wholesale Showroom</u>	<u>7.5</u>	<u>0.12</u>	
<u>Transportation Function</u>	<u>7.5</u>	<u>0.06</u>	<u>Y</u>
<u>Transportation Function, Concourse & Baggage</u>	<u>7.5</u>	<u>0.06</u>	<u>Y</u>
<u>Transportation Function, Ticketing</u>	<u>7.5</u>	<u>0.06</u>	<u>Y</u>
<u>Unleased Tenant Area</u>	<u>5</u>	<u>0.06</u>	<u>Y</u>
<u>Unoccupied-Exclude from Gross Floor Area</u>	<u>0</u>	<u>0</u>	
<u>Unoccupied-Include in Gross Floor Area</u>	<u>0</u>	<u>0</u>	
<u>Videoconferencing Studio</u>	<u>5</u>	<u>0.06</u>	

NOTES: Ventilation air for occupancy categories noted with a Y in the column “Occupied Standby Controls” are permitted to be reduced to zero when the space is in occupied-standby mode.

TABLE 120.1-B ZONE AIR DISTRIBUTION EFFECTIVENESS

<u>AIR DISTRIBUTION CONFIGURATION</u>	<u>E_z</u>
<u>Ceiling supply of cool air</u>	<u>1</u>
<u>Ceiling supply of warm air and floor return</u>	<u>1</u>
<u>Ceiling supply of warm air 15°F (8°C) or more above space temperature and ceiling return</u>	<u>0.8</u>
<u>Ceiling supply of warm air less than 15°F (8°C) above space temperature and ceiling return provided that the 150 fpm (0.8 m/s) supply air jet reaches to within 4.5 ft (1.4 m) of floor level</u>	<u>1</u>
<u>Floor supply of cool air and ceiling return, provided that the vertical throw is greater than 50 fpm (0.25 m/s) at a height of 4.5 ft (1.4 m) or more above the floor</u>	<u>1</u>
<u>Floor supply of cool air and ceiling return, provided low-velocity displacement ventilation achieves unidirectional flow and thermal stratification, or underfloor air distribution systems where the vertical throw is less than or equal to 50 fpm (0.25 m/s) at a height of 4.5 ft (1.4 m) above the floor</u>	<u>1.2</u>
<u>Floor supply of warm air and floor return</u>	<u>1</u>
<u>Floor supply of warm air and ceiling return</u>	<u>0.7</u>
<u>Makeup supply drawn in on the opposite side of the room from the exhaust, return, or both.</u>	<u>0.8</u>
<u>Makeup supply drawn in near to the exhaust, return, or both locations</u>	<u>0.5</u>

NOTES: “Cool air” is air cooler than space temperature. “Warm air” is air warmer than space temperature. “Ceiling supply” includes any point above the breathing zone. “Floor supply” includes any point below the breathing zone. For lower velocity supply air, E_z = 0.8

TABLE 120.1-C SYSTEM VENTILATION EFFICIENCY

<u>Max (Z_{pz})</u>	<u>E_v</u>
<u>≤0.15</u>	<u>1</u>
<u>≤0.25</u>	<u>0.9</u>
<u>≤0.35</u>	<u>0.8</u>
<u>≤0.45</u>	<u>0.7</u>
<u>≤0.55</u>	<u>0.6</u>

TABLE 120.1-D MINIMUM EXHAUST RATES

<u>OCCUPANCY CATEGORY</u>	<u>CFM PER SQUARE FOOT</u>
<u>Arenas</u>	<u>0.5</u>
<u>Art classrooms</u>	<u>0.7</u>
<u>Auto repair rooms</u>	<u>1.5</u>
<u>Barber shops</u>	<u>0.5</u>
<u>Beauty and nail salons</u>	<u>0.6</u>
<u>Cells with toilet</u>	<u>1</u>
<u>Copy, printing rooms</u>	<u>0.5</u>
<u>Darkrooms</u>	<u>1</u>
<u>Educational science laboratories</u>	<u>1</u>
<u>Janitor closets, trash rooms, recycling</u>	<u>1</u>
<u>Kitchenettes</u>	<u>0.3</u>
<u>Kitchens—commercial</u>	<u>0.7</u>
<u>Locker rooms for athletic, industrial, and health care facilities</u>	<u>0.5</u>
<u>All other locker rooms</u>	<u>0.25</u>
<u>Shower rooms</u>	<u>20/50 cfm/unit</u>
<u>Paint spray booths</u>	<u>=</u>
<u>Parking garages</u>	<u>0.75</u>
<u>Pet shops (animal areas)</u>	<u>0.9</u>
<u>Refrigerating machinery rooms</u>	<u>=</u>
<u>Residential kitchens</u>	<u>50/100 cfm/unit</u>
<u>Soiled laundry storage rooms</u>	<u>1</u>
<u>Storage rooms, chemical</u>	<u>1.5</u>
<u>Toilets—private</u>	<u>25/50 cfm/unit</u>
<u>Toilets—public</u>	<u>50/70 cfm/unit</u>
<u>Woodwork shop/classrooms</u>	<u>0.5</u>



Questions/Comments

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